DRAFT ENVIRONMENTAL IMPACT ASSESSMENT REPORT
&
ENVIRONMENTAL
MANAGEMENT PLAN
FOR
ENVIRONMENT CLEARANCE
(Under Clause 6 of S.O.1533 of EIA Notification, 2006 & it's Subsequent Amendments)

SOLID WASTE TREATMENT PROJECT FOR MANGAN IN SIKKIM

At Ringdang, Mangan, North Sikkim (Sikkim)

Total Area: - 2.0 Ha.

Toposheet No. – G45E10

Proposal No : SIA/SK/MIS/69921/2021
File No : 214/E &SC

Category of Project - "B" Project

schedule 7(i) - CMSWMF Project Cost: 15.99 Crores

Processing Facility: -16.0 TPD

Baseline Period – Dec., 2021-Feb. 2022

For

URBAN DEVELOPMENT & HOUSING DEPARTMENT (UD&HD), GOVT. OF SIKKIM

QCI Certificate no. NABET/EIA/2023/IA0063

Prepared By

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Quality Council of India

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4.	Highways,	34	7 (f)	A
5.	Common Municipal Solid Waste Management Facility (CMSWMF)	37	7 (i)	B
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LIST OF ABBREVIATIONS

AAQ	Ambient Air Quality
ADS	Air Density Separator / De-stoner
AMSL	Above Mean Sea Level
bgl	Below Ground Level
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CMSWMF	Common Municipal Solid Waste Management Facilities
CPHEEO	Central Public Health and Environmental Engineering Organization
CSI	City Sanitary Inspector
CSR	Corporate Social Responsibility
D2D	Door-to-door
CPCB	Central Pollution Control Board
dB	Decibel
DO	Dissolved Oxygen
EAC	Expert Appraisal Committee
EIA	Environmental Impact Assessment
EAC	Expert Appraisal Committee
ETP	Effluent Treatment Plant
EMC	Environmental Management Cell
EMP	Environment Management Plan
EPA	The Environment Protection Act
GLC	Ground Level Concentration
GOI	Government Of India
GIS	Geographic Information System
Ha	Hectare
HH	Households
HDPE	High-Density Polyethylene
HMV	Heavy Motor Vehicle
HFL	High Flood Level
IMD	Indian Meteorological Department
IS	Indian Standards

SWTP	Solid Waste Treatment Plant
JIR	Joint Inspection Report
KLD	Kilo litre Per Day
Km	Kilo Meter
Leq	Equivalent Noise Level
LFL	Low Flood Level
LCS	Leachate Collection System
LDPE	Low-density polyethylene
LOS	Level of Service
LoI	Letter of Intent
LTP	Leachate Treatment Plant
MoEF&CC	Ministry of Environment, Forest and Climate Change
MSW (M&H)	Municipal Solid Waste (Management and Handling)
MT	Metric tone
O&M	Operation and Maintenance
NABET	National Accreditation Board for Education and Training
NH	National Highway
NOC	No Objection Certificate
OSHA	Occupational Safety and Health Administration
PCU	Passenger Car Unit
PFR	Pre- feasibility Report
PF/RF	Protected Forest/Reserve Forest
$PM_{10/2.5}$	Particulate Matter
PP	Project Proponent
PPE	Personal Protective Equipment
QCI	Quality Council of India
RL	Reduced Level
R & R Plan	Resettlement & Rehabilitation plan
RDF	Refuse Derived Fuel
SEAC	State Level Environment Assessment Committee
SEIAA	State Environmental Impact Assessment Authority
SH	State Highway
SHW	Solid Hazardous Waste
SLF	Sanitary Landfill Facility
SS	Street Sweeping

STP	Sewage Treatment Plant
SPCB	State Pollution Control Board
ToR	Terms of Reference
TPA	Tonnes Per Annum
TPD	Tonnes Per Day
PCB	Pollution Control Board
USEPA	United State Environmental Protection Agency
ULB	Urban Local Body
WPLF	Waste Processing & Landfill
N	North
E	East
W	West
S	South

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

INTRODUCTION

The Urban development & housing department, government of Sikkim has proposed Solid Waste Treatment Plant due to absence of any proper scientific solid waste treatment facility in entire north Sikkim under Swachhata Action Plan (SAP) of NLCPR Scheme and in order to comply with Solid Waste Management (SWM) Rules, 2016 and its subsequent amendments, project is proposing waste collection system, processing unit and engineered sanitary landfill Facility.

This project is a solid waste Treatment project and proposed for the setting up of processing facilities and sanitary landfill facility. The proposed project is planned in accordance to the Solid Waste Management rules, 2016 and its subsequent amendments which consist of waste collection & transportation system, segregation facility, waste processing unit and a sanitary landfill.

The objective of the project is to design a solid waste treatment system for Mangan town in an environmentally and economically sustainable manner.

The Urban Development & Housing Department proposed to setup a Solid Waste Management System for Mangan at **Ringdang, Mangan, Sikkim** in an area of 2.0Ha with total processing capacity of 16.0 TPD of municipal solid waste which includes Bio Methanation and sanitary landfill.

The proposed project is categorized under Item "7(i) Common Municipal Solid Waste Management Facility (CMSWMF)" in the EIA Notification, dated September 14, 2006 issued by Ministry of Environment Forest & Climate Change (MoEF & CC), New Delhi and needs prior Environmental Clearance. The proposed project falls under Category 'B', and thus, being appraised by the SEIAA at SEIAA, Sikkim. SEAC,

PROJECT DETAILS

The proposed Solid Waste Management Facility will be established in a land of 2.0 Ha located approximate 68 km from gangtok and 1.6 km from mangan. The proposed land belongs to Urban Development & Housing Department (UD&HD), Govt. of Sikkim and the proposed design for Solid waste management (SWM) treatment & disposal facility shall cover a period of 20 years. The project will be developed as in accordance with local development plan. The proposed site proves to be the suitable location

considering both the environmental and economic factors. The nearest town from the proposed site is Mangan (approx. 1.6 Km South East direction w.r.t site). Nearest railway station is New Jalpaiguri Railway Station (approx. 92 Km South) and nearest airport is Pakyong Airport at aerial distance of 32 Km at South East direction with respect to proposed project site.

LAND DETAILS

The proposed land will be developed as Municipal Solid Waste Management Facility with the combination of following technologies:

- Composting (Bio methanation plant)
- Sanitary Landfill Facility with leachate treatment plant

The project will be developed as Solid Waste Treatment Plant & Disposal Facility at Ringdang, Mangan, North Sikkim (Sikkim).

The government has given approval for use of two (2) hectares of land from plot No. 2 recorded in the name of "Sarkar" as per the survey operation of 1979-80 at Kazor Revenue Block under Singhik-Sentam GPU of Lachen-Mangan Constituency.

Table: 1 Site Features

Key Details of the Project	
Project Capacity (Proposed)	16.0 TPD
Current & Expected Waste Generation	The per capita garbage generation is taken from the data provided by the Department as 363 gm per person per day after adding for Municipal wastes, road sweepings, institutions etc., the per capita generation is 443 gm (for 2015). This is projected to **482 gm/day for 2021 and 636 g/day for 2041** with 1.40 % annual growth as per data provided.
New/Expansion/Modernization	New Project
Design Landfill Life	20 Years
Land Area	2.0 Ha
Land Ownership & Land Lease Agreement	The proposed land belongs to Forest the Urban development & housing department, government of Sikkim.
Project Cost (Crores)	INR 15.99 Crore

The water requirement during construction phase is about 4 KLD and for operating the proposed Solid Waste Management Plant is about 5 KLD. Water Requirement will be sourced from nearby river or small runoff.

Table: 2 Water Requirements

Sr. No.	Description	Water Requirement (KLD)	Waste Water Generation (KLD)	Treated Water (KLD)
1.	Domestic Purpose	1.8	1.6	1.4
2.	Vehicle/Tier Washing	0.5	0.3	0.2
3.	Dust Suppression	0.5	-	-
4.	Green Belt Development	2.2	-	-
5.	Process water	1.6	1.5	1.2
Total		**6.6 (5KLD +1.6KLD)**	**3.4**	**2.8**

- Domestic Wastewater will be in STP & reused for greenbelt purpose.
- Leachate will be treated in LTP of 2 5 KLD capacity.
- Treated water from LTP & STP will be used for green belt development, dust suppression & horticulture activities.
- 1.6 KLD of treated water will be recirculated in the process. Hence, the water requirement for the proposed project is 5 KLD which will be sourced from nearby river or small runoff.

The energy requirement for the operation of proposed facility will be 250 KVA and D.G set of 250 KVA will be utilized for power during construction phase. Sufficient capacity of DG set (250 KVA) is proposed in emergency use during power failure as backup.

During construction phase approx. 30 workers (skilled & semi-skilled workers), rest will be outsourced based on need. During operation phase the Swachha team will be consists of approx 42 Workers (skilled & semi-skilled workers, contract labour, drivers, sweepers & supporting staff) with 33 permanents, 2 Supervisors, 7 contractual. Rest will be outsourced as per requirement of ULB (Urban Local Body).

Proposed municipal waste Management system:

The following design criteria are adopted and salient features are:

Table 3 : SWM Strategy/ Concept for Sikkim (Urban)

STAGE	Description

(STAGE I) Waste Segregation & Storage & Storage	1. First level of Waste Segregation at source (household level) – Wet waste and Dry waste 2. Separate Storage of waste at Source – Wet waste Bin and Dry wasteBags
[STAGEII] Waste Collection system	1. Residents handover garbage to Waste Collection Centers (WCC) 2. WCC operating hours is 3 Hrs in the morning (6 am to 9 am) 3. One WCC for every 300 Households, to be located nearer to road where vehicles are accessible, Size of WCC is 5 feet x 5 feet x 8 feet,made of MS grill with door and window. 4. Primary Collection Vehicles pick up garbage from WCC and transport it for treatment. Waste to be collected during morning.
[STAGEIII] Transportation	1. Refuse Compactor Vehicle shall transport to nearest Landfill
[STAGEIV] Treatment & Disposal Facilities	1. Further segregation at Landfill. 2. Organic Waste – Biomethanation Plant (proposed) 3. Recyclables to be pressed and packed for sale. 4. Other inert to go to Landfill. 5. Regional Facility shall have Weigh Bridge, Scientific Landfill and Leachate Treatment Plant.

Detailed descriptions of above processes are well furnished in Chapter 2 of this EIA/EMP report.

BASELINE ENVIRONMENTAL STATUS

Field investigations were undertaken for collecting the existing baseline environment for air, water, noise, soil, ecological and socio-economic conditions. A study area of 10 Km radius from the project site is identified to establish the present environmental conditions for the above environmental components. The main aim of the EIA study is to identify the critical environmental attributes which will be affected and have adverse impacts on the surrounding environment due to the proposed Solid Waste Management Facility at Mangan. The baseline data generation has been carried out in the winter season (Dec. 2021 – Feb. 2022).

The metrological data is collected from the IMD station at Gangtok the pre-dominant wind direction recorded is from South followed by South South East (SSE). Average wind speed observed for the winter season is around 4.0 m/s.

<u>Ambient Air Quality</u>

Ambient air quality monitoring stations were set up for 5 different locations. The locations were selected in downwind, cross wind and up wind of the proposed project. The common air pollutants namely Particulate matter (PM_{10} & $PM_{2.5}$), Sulphur dioxide (SO_2), the oxides of nitrogen (NO_X), Carbon Monoxide (CO), Ammonia (NH_3), Benzene (C_6H_6), Methane (CH_4), Lead (Pb), Nickel (Ni), Ozone (O_3), Arsenic (As), Hydrogen sulfide (H_2S) and Benzo (a) Pyrene (BaP) were sampled on 8/24 hourly and results were averaged to 24 hours to meet the requirements of the MoEF&CC and compared with the standards stipulated by CPCB.

The 98thpercentile of above mention pollutants were assessed and calculated as mention below:

- PM_{10} value recorded during the study period ranges between 38.2 to 83.8 µg/m^3.
- $PM_{2.5}$ value recorded during the study period ranges between 15.5 to 37.3 µg/m^3.
- SO_2 value recorded during the study period ranges between 5.2 to 9.1 µg/m^3
- NO_2 value recorded during the study period ranges between 7.5 to 19.6 µg/m^3
- CO value recorded during the study period ranges between 0.21 to 0.55 mg/m^3

From the baseline monitoring result, it is observed that the monitored parameters (PM_{10}, $PM_{2.5}$, SO_2, NO_2,) are within the permissible limits as per NAAQS, 2009 during the study period.

Water Quality Monitoring

Ground water samples were collected from different sources within the study area and analyzed for all important physico-chemical and biological parameters to establish the quality of water prevailing in the project surroundings. Around 3 ground water and 3 surface water samples were collected.

Ground Water Quality:

- The pH limit fixed for drinking water samples as per IS 10500-2012 is 6.5 to 8.5 beyond this range the water will affect the mucus membrane and or water supply system. During study period the pH in the ground water samples was varying from 7.36to 7.46. The pH's of all samples were falling within the acceptable limit.
- The acceptable limit for total dissolved solids as per IS 10500:2012 is 500 mg/l, whereas the permissible limit in absence of alternate source is 2000 mg/l, beyond this palatability decreases and may cause gastro intestinal irritation. In water samples collected from the study area, the total dissolved solids in groundwater are varying from 132 to 165 mg/l. The TDS of all samples were falling within the acceptable limit.
- The acceptable limit for chloride is 250 mg/l as per IS 10500:2012 whereas the permissible limit of the same is 1000 mg/l beyond this limit taste, corrosion and palatability are affected. The Chloride levels in the ground water samples collected in the study area were ranging from 24 to 28 mg/l. All samples are falling within acceptable limit.
- The acceptable limit as per IS 10500:2012 for hardness is 200mg/l whereas the permissible limit for the same is 600mg/l beyond this limit encrustation in water supply structure and adverse effects on domestic use will be observed. In the water samples collected from the study area, the hardness is varying from 76 to 94 mg/l.

Surface water:

- Phosphates were found below detectable limit of 0.1 mg/l.

Hence, the above analysis results of surface water quality are indicating & meets the Class 'A'

norms as per IS: 2296-1992.

Noise Monitoring

The values of noise observed in some of the rural areas are primarily owing to vehicular traffic and other anthropogenic activities. In rural areas wind blowing and movements of birds would contribute to noise levels especially during the nights. The day equivalents during the study period are range between 49.2 to 60.2 dB (A), whereas the night equivalents were in the range of 35.7 to 53.6 dB (A). From the results it can be seen that the day equivalents and the Night equivalents were within the Ambient Noise standards of residential.

Soil Quality

The analytical soil samples results collected during the study period is summarized below. The pH of the soil is an important property; plants cannot grow in low and high pH value soils. The normal range of the soils is 6.0 to 8.5 are called as normal to saline in soils. Most of the essential nutrients like N, P, K and Cl are available in plants at the neutral pH except for zinc and manganese which are available at low pH range. The soils having pH below 7 are considered to be acidic from the practical stand point, those with pH less than 5.5 and which respond to limiting may be considered to qualify to be designated as acidic soils. On the basis of pH measurements, the degree of soil acidity may be indicated.

- The pH values in the study area are varying from 7.34 to 7.45 indicating that all soils are falling in normal to saline class.
- The electrical conductivity in the study area is varying from 224 to 270 μs/cm indicating that all samples are falling in normal range.
- The other important parameters for characterization of soil for irrigation are N, P and K are known as primary nutrients and Ca, Mn and S as secondary nutrients. The primary and secondary nutrients are known as major elements. The classification is based on their relative abundance, and not on their relative importance.
- The available potassium in the study area is varying between 187 to 238 Kg/Ha indicating that all samples are falling in medium range.

Ecological Environment

Survey of Ecology and Biodiversity of the proposed Solid Waste Processing Facility at Mangan was carried out during study period. The expert has carried out flora and fauna survey by collecting the information of biological environment of Sikkim, their forests, type of forest and forest cover in District & the floral species from the government and forest website. Further details of type of

flora, botanical name, family use & fauna of the area have been studied by collecting the details by forest department. The secondary data so collected were also verified by the field survey.

The Ecological and Biological study of terrestrial flora, fauna and aquatic biota has been carried with an aim to establish different transects in the 10 K.M radius. An insight of terrestrial fauna was carried out to gain required knowledge about species of carnivores, ungulates, non-human primates, birds, reptiles and invertebrates etc.

The biological study of the area has been conducted in order to understand the ecological status of the existing flora and fauna to generate baseline information and evaluate the probable impacts on the biological environment. There is khangchendzonga national park in approx. 3.5 km in NNW direction of the project site and is in the 10 km periphery of the project area.

Green belt development

The proposed project area is 2.0 ha. and more than 33% of the total project area is proposed to be developed and maintained as green belt. The green belt will be developed considering the native species and CPCB/SPCB guidelines will be followed.

Socio – Economic Environment

As per Census 2011 the population of Mangan is 4644 assuming a floating population of 2000, the base figure for design is kept as 6644 for Mangan. Similarly, for other areas are under consideration.

ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

The potential impacts on the environment from the proposed project are identified based on the nature of the various activities associated not only with the project implementation and operation, but also on the current status of the environmental quality at the project site. The proposed project may cause impact on the environment in two phases.

- Impact during construction phase
- Impact during operation phase

a) Impacts during development phase:

Construction phase works include site clearance, site formation, excavation, material handling, building works, infrastructure provision and any other infrastructure activities. The impacts due to construction activities are short term and area limited to the construction phase.

b) Impacts during Operation Phase:

During the operation phase of the proposed project there would be impacts on the air environment, water

environment, land environment and socio-economic aspects.

Impact on Air Quality

The air environment may be described in terms of parameters of ambient air quality such as ground level concentration of particulate matter (PM10) representing suspended particulates which are less than 10-micron size which easily get into our respiratory tracts. Further the particulate matter (PM2.5) denotes that fraction of finer particulates which can get deposited in our lungs and cause respiratory diseases and also affect metabolism. The gaseous pollutants namely CO, SO2, and NOx released due to construction vehicular exhausts are noxious in nature.

The proposed mitigation measure:

1. The haulage trucks and tractors involved for garbage transportation shall be mechanically covered and shall be prevented from spillage of dirt during transit.
2. The trucks and tractors to be deployed for haulage of garbage shall be ensured to be Bharat-IV stage compliant for the exhaust emissions.
3. Periodic maintenance of the machineries and equipment as well as the haul trucks/tractors involved shall be done as per the manual requirement.
4. The operators, semi-skilled workers and drivers of the vehicles and machinery involved shall be trained for the job requirements and their skills shall be updated and monitored regularly for smoother functioning for maintaining clean environment.
5. A dense green belt with fast growing floral species as recommended by CPCB with climatological adaptability shall be developed along the periphery of the landfill site.
6. The development of the green belt shall be such that bushes, herbs, creepers and grasess shall be placed inwards the site while the taller species shall be placed on the outer area towards the boundary. This shall ensure development of a barrier both for noise and dust particulates. The fully developed green belt shall present an appealing landscape and would be scientific also in purpose.
7. Compaction of haulage road within the landfill site by using water bowser on the haul road both in morning and afternoon hours during winters and one additional trip in the evening in winter season which shall suppress the fine fraction of soil clay on the haul roads.

Impact on Water Quality

Ground water: During operational phase, there is a potential threat for the contamination of ground water due to the generation of leachates particularly during rains when the surface runoff infiltrate down the surface of finished and the operational cells of the landfills.

Sewage generated from domestic activities of workers at the site can be potential source of ground water contamination if not managed properly. As per the management plan recommended, the ground water quality shall be monitored at regular intervals in the operational phase of the project to check for contamination.

Surface Water: During the operational phase, an equal potential of contamination of surface water exists. This is due to the runoff caused by monsoon from the waste. The surface runoff carries away the dissolved solids and the suspended solids along with it and deposit at other places of lower gradient or ground surfaces and eventually reach the surface water body. The occasional Mild to heavy rainfall makes it altogether vulnerable to even small developmental activities. The landfill site development and other development activities recommended are a full-fledged building activity comprising of excavations, loading/unloading operations which generate loose soil particles and promote soil erosion.

Proposed mitigation measures –

1. Excavation to be avoided during monsoon season.
2. The leachate generated from the landfill & compost area is collected in the leachate holding tank and will be treated in proposed LTP. Treated wastewater will be used for greenbelt/horticulture & dust suppression.
3. During monsoon season there is no waterlog regime using check dams to prevent construction runoff from the site to the surrounding water bodies.
4. Mobile toilets will used in site during construction phase to prevent wastewater from entering the ground water or surrounding water bodies.
5. To prevent surface and ground water contamination by oil/grease, leak proof containers will be used for storage and transportation of oil/grease. The floors of oil/grease handling area will be kept effectively impervious by laying a sheet of plastic over the ground surface.
6. All stacking and loading areas should be made impervious and provided with proper garland drains equipped with baffles to prevent run off from the site to contaminate surface or ground water resources.
7. Rainwater running off slopes above and outside the landfill area are intercepted and channelled to water courses without entering the operational area of the site. This diversion channel may require a low permeability lining to prevent leakage into the landfill.

8. A leachate collection and control facility which collects and extracts leachate from within and from the base of the landfill site & Compost platform.
9. An environmental monitoring system which periodically collects and analyses air, surface water, soil and ground water samples around the landfill site.

Construction activities for the proposed development can have minor impact on hydrology and water quality of the area as the construction waste will not be leached into ground or any surface water body. Natural drains will not be affected due to proposed project development. Potential impacts on the hydrology and water quality have been discussed as under-

- Soil runoff from the site leading to off-site contamination (particularly during rainy season).
- Improper disposal of construction debris leading to off-site contamination of water resources.
- Unaccounted disposal of domestic wastewater from temporary labour camps.
- Spillage of oil and grease from the vehicles and wastewater stream generated from onsite activities such as vehicles washing, workshop etc.

Sources of effluent during operation phase

- Leachate from MSW processing plant

The proposed mitigation measure:

- During the construction phase, a septic tank /soak pit system shall be provided to treat the domestic wastewater generated due to labour settlements.
- Runoff water and equipment washed water from the site will be collected to working pit to arrest the suspended solids and if any over flow is, it will be diverted to nearby greenbelt/plantation area. The settled water will be reused for construction purposes, and for sprinkling on roads to control the dust emission, etc.
- The leachate will be sent for treatment in proposed leachate treatment plant.

Impact of Noise Level

The major activities, which produce periodic noise, during construction phase, are foundation works, fabrication of structures, plant erection, operation of construction equipment, movement of vehicles etc. During operation phase the major source of noise in proposed project will be from rotating equipment in the plant, DG set, etc.

The proposed mitigation measure:

- Proper enclosures will be used for reduction in noise levels, where ever possible the noise generating equipment will be kept away from the human habituation.

- All vehicles entering into the project will be informed to maintain speed limits, and not blow horns unless it is required.
- Noise level specifications for various equipment's as per Occupational Safety and Health Association (OSHA) standards.
- Employees will be provided with PPE like ear plugs, helmets, safety shoes, etc.
- Development of greenbelt all along the boundary and along the roads within the project.

Impact on Land Environment

At MSW site, soil would be excavated at project site for development. This excavated soil shall be used to fill up low lying area in the project site and rest shall be transported to authorized vendors for its reuse. The impact on soil during construction phase will be marginal and reversible in the nature.

Proposed Mitigation Measures

- The top soil will be stripped from constructional areas and stockpiled for later reuse in landscaping.
- The number, frequency and area of movement of heavy machinery will also be restricted as adequate parking space would be provided to avoid traffic load on the roads.
- Greenbelt development in the premise as well as roadside avenue plantation will also be done.
- It is proposed to remove vegetative cover only from the specific site on which construction is to take place and allowing minimal disturbance to the vegetation in adjacent areas.
- Land clearing activities only confined and restricted to proposed project site.
- Proper drainage system shall be provided at site to prevent erosion due to rain.

Impact on Topography

Due to proposed project activities minor impact on account of topography is envisaged as the project area has undulating terrain and for establishment partial leveling of the site is required.

Hence, no significant impact is anticipated on the topography and physiographic from project.

Proposed Mitigation Measures –

Since there is little or low significant impact on topography from the project, no detailed mitigation measures are proposed. It is however proposed that apart from the proposed plantation greens, turfing with local species will be carried out extensively. It is further proposed to maintain area as green through

plantation of various local and aesthetic species as to improve the vegetation covers of the area.

Post closure of landfill, If is intended to be used for a specific purpose e.g. park or golf course or vehicle parking area, then the cover shall be stabilized in such a manner that the end –use is achieved. However, if no specific end –use is envisaged, then long – term vegetative stabilization will be undertaken to return the land to its original and natural vegetative landform.

All topography would be used as in natural topo type with minor scientific & environmental sustainable modifications.

Impact on Land Use Pattern

The land use of the area is likely to change due to new premises development of project and in process of construction activities. Due to this, marginal influx of population is likely to take place and would result in establishment of temporary camps consisting of hutments. However, these would be confined to limited period of construction phase only. Hence, no significant impact except the change in land use of proposed project site. Only during operation phase it would be altered to waste processing siteas per SWM rule 2016.

Impact on Ecology

There is khangchendzonga national park in approx. 3.5 km in NNW direction of the project site and is in the 10 km periphery of the project area.

The proposed mitigation measure:

Due to the development and maintenance of green belt at the project vicinity the impact on the ecology will be minimal.

Impact on Socio Economics

The proposed facility is likely to provide direct and indirect employment and likely to increase the socio-economic status of the nearby villages in the study area. Due to proposed project the facilities for public transport, water supply telecommunications, education, public wealth etc., are likely to improve.

ENVIRONMENT MANAGEMENT PLAN

The Environmental Management Plan (EMP) is required to ensure a sustainable development of the plant area and the surrounding areas of the plant. The EMP will be integrated in all the major activities of the project, with clearly defined policies, to ensure that the ecological balance of the area is maintained and the adverse effects are minimized. EMP requires multidisciplinary approach with mitigation, management, monitoring and institutional measures to be taken during implementation and operation, to eliminate

adverse environmental impacts or reduce them to acceptable levels. In order to ensure sustainable development in the study area; it needs to be an all-encompassing plan for which the plant authorities, government, regulating agencies, and the population of the study area need to extend their cooperation and contribution. Total project capital investment is Rs 15.99 crore and on environmental improvement works is envisaged Rs. 25.00 lakhs/- and recurring expenditure during the stage of operation is Rs. 4 lakhs/- as recurring investment is earmarks for EMP and as per the directions given in the MoEF&CC Office Memorandum, F.No. 22-65/2017-IA-III on 30th September 2020, all the proposed activities will be part of Environmental Management Plan (EMP) instead of CER.

Addition to above the project proponent has proposed to invest amount of 2.55 Lakhs per year on Labours safety, proper sanitation facilities at site, Health checkup facilities, awareness & recreation programs etc. below table is the breakup proposed for budget investment for labours working in this proposed project.

The mitigation measures are planned for construction and operation phases and the overall management plan helps to improve the supportive capacity of the receiving bodies. The EMP aims to control pollution at the source level to the possible extent with the available and affordable technology followed by the standard treatments before getting discharged. The recommended mitigation measures will synchronize the economic development of the study area with the environmental protection of the region.

ENVIRONMENT MONITORING PROGRAM

Environmental monitoring program describes the processes and activities that need to take place to characterize and monitor the quality of the environment. Environmental monitoring is used in the preparation of environmental impact assessments, as well as in many circumstances in which human activities carry a risk of harmful effects on the natural environment. Different activities involved in the proposed project and their impact on various environmental attributes have been taken into account while designing a detailed environmental monitoring program. Environmental monitoring program has been prepared for the proposed project for assessing the efficiency of implementation of Environment Management Plan and to take corrective measures in case of any degradation in the surrounding environment. A comprehensive monitoring mechanism has been devised for monitoring of impacts due to proposed project.

All monitoring strategies and program have reasons and justifications which are often designed to establish the current status of an environment or to establish trends in environmental parameters. In all cases the results of monitoring will be reviewed, analyzed statistically and submitted to concerned authorities. The design of a monitoring program must therefore have regard to the final use of the data before monitoring starts. The monitoring program will have three phases:

- Construction phase

- Monitoring phase
- Post monitoring phase

PROJECT BENEFITS

The contribution of the proposed project on local social infrastructure is expected to be significant. This Project will provide a significant amount of direct and indirect employment opportunities to the local people. From the proposed project the major benefits, include improving the degraded environment by establishing an Solid Waste Management Facilities. From the proposed project the major benefits, include improving the degraded environment by establishing Municipal Solid Waste Processing and Disposal Facility.

- It will be the showcase for other states for management of solid waste with additional benefit of green and clean environment.
- It minimizes the pollution load on environment from municipal solid waste.
- Compliance with prescribed regulatory norms which in turn avert the risk of closure on account of violation of rules.
- It reduces the number of Municipal Solid Waste dump sites in the area and also eliminates the pollution potential.
- The management of wastes is relatively easier & economically viable at common facility.
- Cost of environmental monitoring is less at common facility.
- Prevention of natural resource contamination thereby improving overall environmental status of the region.

CONCLUSION

The EIA study has made an overall assessment of the potential environmental impacts likely to arise from the proposed Solid waste Management Facility. Baseline data was collected for various environmental attributes so as to compute the impacts that are likely to arise due to proposed developmental activity. The potential impacts on the environment from the proposed project are identified based on the nature of the various activities associated not only with the project implementation and operation, but also on the current status of the environmental quality at the project site. Mitigation measures are proposed to minimize the adverse impacts if any due to the project in the form of Environment Management Plan. The costing for each of the plant has been done based on land cost with respective civil, building and plant and machineries. Overall cost of the project has been worked out at Rs.

15.99 Crores for proposed plant.

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CHAPTER-I
INTRODUCTION

CHAPTER-I

INTRODUCTION

1.1 Purpose of the report

The purpose of this report is to prepare an environmental statement on assessment of likely environmental impacts of proposed Municipal Solid Waste Management Facility with total processing capacity of **16.0 TPD** for **Mangan at Ringdang, Mangan, Sikkim.**

It comprises of evaluation of existing MSWM practices, identifying deficiencies/gaps in the present system and assessing adequacies of inbuilt pollution mitigation measures included in the engineering design of proposed SWM to be created in accordance with the requirements of Solid Waste Management (SWM) Rules 2016 and its subsequent amendments.

The proposed project is categorized under Item "7(i) Common Municipal Solid Waste Management Facility (CMSWMF)" in the EIA Notification, dated September 14, 2006 issued by Ministry of Environment Forest & Climate Change **(MoEF & CC),** New Delhi and needs prior Environmental Clearance. The proposed project falls under Category **'B',** and thus, being appraised by the SEIAA" at SEAC, Sikkim

In this regard, **Atmos Sustainable Solutions Pvt. Ltd.,** a QCI-NABET accredited consultancy organization, has been engaged by **Urban development & housing department, government of Sikkim** to carry out an Environmental Impact Assessment (EIA) study and to seek prior environmental clearance as per the process defined in the EIA Notification, dated September 14, 2006 and the amendments thereafter.

Accordingly, project proposal was submitted to SEIAA Sikkim on for Terms of References (ToR) under Category 'B' (Proposal no. SIA/SK/MIS/69921/2021) for obtaining environment clearance & SEAC, Sikkim has granted ToR for preparation of an Environment Impact Assessment (EIA)- Environmental Management Plan (EMP) report. The EIA studies have been carried out complying all the conditions of granted ToR and being presented here in the stipulated structure of EIA document as per Appendix III of EIA Notification, 2006 andits subsequent amendments.

1.2 Identification of Project & Project Proponent

With growing population and increasing waste generation, the nation as a whole is facing challenges in handling and disposal of municipal solid waste viz., lack of public awareness for waste segregation, poor collection efficiency, lack of adequate financial and human resources, non-availability of landfill site has led to crude open dumping method posing threat to environment and public health.

Presently there is no treatment of waste and mixed waste is being dumped in the dumping ground at Urban Development & Housing Department (UD&HD), Govt. of Sikkim

Chandey. The mixed waste collected from Mangan is dumped at Chandey, 8 km away from the Municipality. The present practice of disposal is unscientific, unhealthy and environmentally unsafe. Therefore, The Urban Development & Housing Department (UD&HD), Government of Sikkim has proposed development of Solid Waste Treatment Project, Mangan, Sikkim.

Land that shall be made available is 2.0 ha. at **Ringdang, Mangan, Sikkim** Such area of land shall be utilized for setting up of waste management plant and development of sanitary landfill facilities.

Identification of project proponent

Applicant	Authorize signatory
The Urban Development & Housing Department Sikkim	Secretary Urban Development & Housing Department, Sikkim Address: Paljor Stadium Rd, Arithang, Gangtok, Sikkim 737101

1.3 Site Features

Nature of the Project	Solid Waste Treatment Project
Location	Ringdang, Mangan, Sikkim
Land Area	3.25 Acres (1.31 Hectares approximately)
Land Ownership	The Urban Development & Housing Department
Nearest Town and Habitation	Mangan (1.6 Km approx..) South- East
Nearest Railway Station	New Jalpaiguri Railway Station (92 km) S
Nearest Airport	Pakyong Airport – 32 Km South East direction (Aerial distance from the proposed site)
Nearest Highway	NH-310A- 1.0 km (E)

The proposed plant is designed to process 16.0 TPD Municipal Solid Waste (MSW) and is able to process different kind of waste types. Based on the waste characteristics, proposed process consists of -:

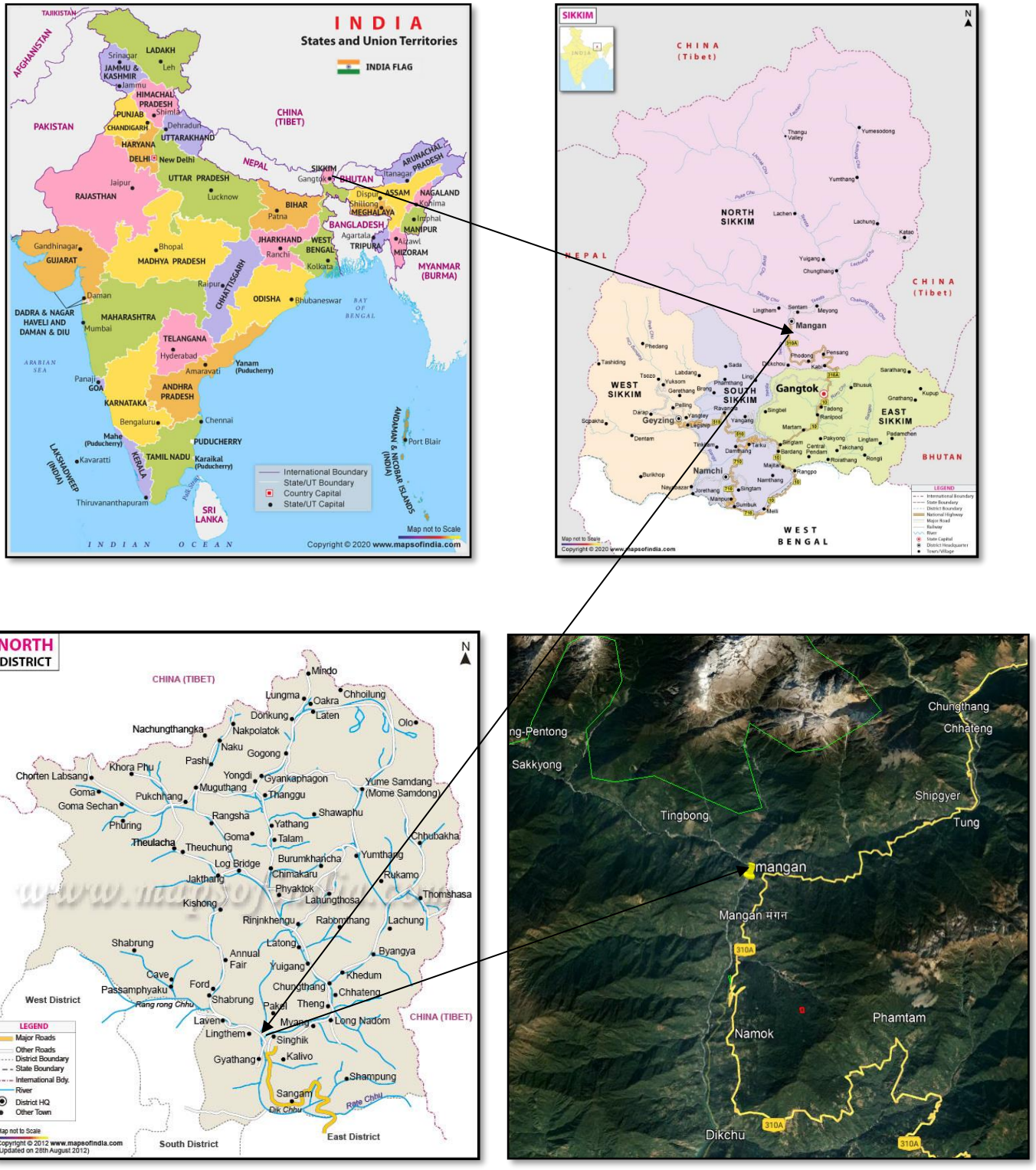
- Bio methanation plant
- Sanitary Landfill Facility with leachate treatment plant

1.4 Brief Description of Nature, Size, Location of the Project & Its Importance to the Country, Region.

	Particulars	Details
A.	**Nature of the Project**	Solid Waste Management Plant for Mangan
B.	**Project Type**	New
C	**SIZE OF THE PROJECT**	
1.	Expected Waste Quantity	482 gm/day for 2021 and 636 g/day for 2041 with 1.40 % annual growth
2.	Proposed Plant Capacity	16.0 TPD
3.	Power requirement	250 KVA
4	Power Backup	1DG Set (250 KVA) backup during power failure
4.	Sanitary Landfill	Design Life of Landfill is 20 Years
D	**LOCATION DETAILS**	
1.	Village	Ringdang, Singhik
2.	Tehsil	Mangan
3.	District	North
4.	State	Sikkim
E	**ENVIRONMENTAL SETTINGS OF THE AREA**	
1.	**Ecological Sensitive Areas**	khangchendzonga national park is at a distance of 3.45 km in NNW direction from Eco sensitive zone notified in khangchendzonga national park final ESZ notification S.O. 2166(E). —dated 27.08.2014. And as per OM dated 08.08.2019 of MoEF & CC, NBWL Clearance is not applicable.
2.	**River / water body**	The nearest water body is Teesta River adjacent to the project site in East from Project Site.

3.	**Nearest Town**	Mangan is nearest town densely populated area which is about 1.6 Km from project site. (SE)
4.	**Nearest Habitation**	Mangan is nearest town densely populated area which is about 1.6 Km from project site. (SE)
5.	**Nearest Railway Station**	New Jalpaiguri Railway Station (92 km) S
6.	**Nearest Road**	NH-310A- 1.0 km (E)
8.	**Nearest Airport**	Pakyong Airport – 32 Km South East direction (Aerial distance from the proposed site)
9.	**State Boundary**	Not Applicable
10.	**Seismic Zone**	Zone – IV [as per IS 1893 (Part-I): 2002]
F	**COST DETAILS**	
1.	**Project capital cost**	INR 15.99 crores
G	**REQUIREMENTS OF THE PROJECT**	
1.	Water Requirement	Construction: 4 KLD Operation Phase: 5 KLD
		Sourced from Municipal Corporation
3.	Ground water Level	The landfill is a sloping terrain and exposed surfaces with open ditches with various depths and ground water is not observed.
4.	Workers in Construction Phase	Approx. 40 workers (skilled & semi-skilled workers), rest outsourced based on need.
5.	Workers in Operation Phase	The swacchhta team consists of 42 karmacharis, rest outsourced based on need. With 33 permanent, 2 Supervisor, 7 on contractual. Rest Outsourced as per requirement of ULB.

FIGURE 1.1: LOCATION MAP



1.5 Importance to country and region:-

There is no practice followed for segregation of MSW at source in to biodegradable (wet) and non-biodegradable (dry) waste in the town. The waste is collected by the waste collectors in the mixed form only. However, the waste collectors separate valuables from the waste during the collection of waste. Moreover, rag-pickers unofficially do the segregation & pick recyclables like polythene; plastics etc. at the secondary collection points and sell to scrap dealers.

As of now, there is no scientific disposal method being followed, the garbage is left open for the natural decomposition. Since existing open trenches are not engineered landfills, therefore they are prone to ground water and soil pollution, vector nuisance, odour problem, besides becoming breeding grounds for mosquitoes, flies, etc. The leachate generated may cause unsanitary condition in the surroundings. To avoid all above, this project has the prime requirement in the area.

The importance of effective Municipal Solid Waste Management (MSWM) services is to protect public health, the environment and natural resources (Water, Land, and Air). To promote the ecological management of solid waste in compliance with the principle of the 4 R: Reduce, Reuse, Recycle, Recover and safe disposal. An effective MSWM service can be achieved only by improving the efficiency of MSWM activities, thereby leading to the reduction of waste generation, separation of MSW and recycling and recovery of materials, and generation of compost and energy.

- Reduction, reuse and recycle of the waste.
- Source Segregation & collection of waste (Systematic Door to Door collection has been proposed in the project).
- Transportation of waste in covered /closed vehicles to the site.
- Processing of waste through composting..
- Conversion of waste into a useful and marketable product (Manure) as recirculation of soil nutrients.
- Good market for compost sale.
- Only inert/processing rejects to be land filled which is about 15- 20% of total waste quantity shall be disposed of into the landfill. This would save upon the future requirements of area for land filling.
- Commercially viable project and long term sustainability.
- Systematic approach for integrated solid waste management.
- Clean, hygienic and better infrastructure of the city.
- Increase in employment opportunities in collection and transportation, door to door collection and in processing and disposal facility.
- Organized and a scientific land fill site with 20 years of life in order to prevent Water & Soil Contamination.

1.6 Objective of EIA Study:-

Urban Development & Housing Department (UD&HD), Govt. of Sikkim

The scope of work consists of:-

- Door to Door collection of waste and segregation at source.
- Implementation of 3 bins system (Blue, Green & Black coloured bins) for secondary storage facility (waste storage depots).
- Improvement of existing transportation system.
- Semi mechanized segregation system for separation of recyclable materials.
- Construction of sanitary landfill facility.
- Review of applicable national and international legal environmental requirements.
- Discuss justification for development of the project;
- Establish environmental baseline condition within a study area of 10km radius of the project site.
- Develop Environmental Management Plan (EMP) and Environmental Monitoring Plan;
- Undertake hazard identification and develop Disaster Management Plan; and identify project benefit.
- Predict and evaluate of potential environmental and socio-economic impacts and identify.

1.7 Scope of EIA Study:-

The Scope of the study is to carry out the Environmental Impact Assessment (EIA) studies to identify, predict and evaluate potential environmental and socio-economic impacts which may result from the proposed Solid Waste Treatment project and to develop suitable Environment Management Plan (EMP) to mitigate the undesirable effects**.**

Secondary Data Collection:

Collection of secondary data comprising of information on project conception, planning and development, land details, physical, biological, geological and land use information of the project area, socioeconomic data.

Investigations and surveys:

Environmental investigations and laboratory testing for samples (Air, Water, and Noise and Soil quality) and analysis of meteorological, Ecological and social surveys were also conducted in the immediate surrounding area.

Legal framework, statutory requirements and international guidelines:

As per EIA Notification S.O. No 1533 dated 14th Sep 2006 and its subsequent amendments the proposed project is falling under Project / Activity 7 (i) Common Municipal Solid Waste Management Facility (CMSWMF) under Category 'B', and thus, being appraised by the State Level Expert Appraisal Committee (SEAC) Sikkim.

Solid Waste Management Regulation in India

At present the solid waste management practices in India are governed by the following sets of regulations/rules of the Ministry of Environment and Forests (MOEF).

- Hazardous & Other Waste (Management & Transbounadry Movement) Rules, 2016 and its amendments therafter.
- Biomedical Waste Management & Handling Rules 2016 and its amendments therafter.
- Solid Waste Management Rules, (2015 & 2016) and its amendments therafter.
- Construction & Demolition Waste Management Rules, 2016.
- Plastic Waste Management Rules 2016 and its amendments therafter.
- E- Waste Management Rules, 2016 and its amendments therafter.

Public consultations and disclosure:

A public consultation will be done, as per the procedure prescribed in EIA Notification 2006 and its subsequent amendments. Also, during Public Consultration all the applicable COVID-19 protocols (appropriate behavior protocols) will be followed issued by central & state government in admit pandemic due to Corona Virus outbreak in the country.

Impact Assessment:

Assessment of the potential impacts with respect to environmental and social aspects has been carried out and their significance determined.

Environmental Management Plan (EMP) along with Monitoring Plan:

Appropriate mitigation and monitoring measures are suggested to minimize any potential damaging effects or any lasting negative consequence.

1.8 Legal Framework, Statutory Requirements and International Guidelines.

TABLE 1.1 LEGAL FRAMEWORK, STATUTORY REQUIREMENTS AND INTERNATIONAL GUIDELINES

Sr. No.	Applicable Rules & Regulations for proposed project	Responsible Agencies
1	The Environment (Protection) Act 1986, as amended in April 2003; EPA Rules 1986, as amended in 2002.	SPCB/CPCB MoEF&CC
	EIA Notification 2006, and its subsequent amendments	MoEF&CC /SEIAA

2	The Water (Prevention and Control of Pollution) Act, 1974, amended in 1988	SPCB/CPCB
3	The Air (Prevention and Control of Pollution) Act, 1981, amended in 1987.	SPCB/CPCB
4	The Water (Prevention and Control of Pollution), Cess Act, 1977 including Rules 1978 and 1991	SPCB/CPCB
5	The Noise (Regulation & Control) Rules, 2000 as amended in October 2002	SPCB/CPCB
6	Hazardous Wastes (Management Handling and Trans boundary Movement) Rules, 2008 as amended up to 2016	SPCB/CPCB
7	Plastic Waste Management Rules 2016 and its subsequent amendments in 2018 **In Short:** Plastic Waste Management (Amendment) 2018	SPCB/CPCB
8	The Solid Waste Management Rules, 2016 and its amendment	SPCB/CPCB
9	Construction and Demolition Waste Management Rules, 2016	SPCB/CPCB
10	The Contract Labour (Regulation and Abolition) Act, 1970 Contract Labour (Regulation and Abolition) Rules, 1970	Chief Labour Commissioner, Mangan
11	Central Ground Water Authority Notification The Central Ground Water Authority (CGWA) has notified 43 areas for control and regulation of groundwater. If required	SPCB/CPCB
12	Sikkim Sewerage and sewage disposal act, 1987	Public Health & Engineering Department Sikkim
13	The Sikkim Non-Biogegradable Garbage (Control). Act, 1997	Sikkim Government
14	National Environmental Policy 2006	SPCB/CPCB

1.9 Generic Structure of EIA report

The EIA report comprises of the following sections:

- **Chapter 1 Introduction** - Purpose of the report, Identification of project & project proponent, Brief description of nature, size, location of the project and its importance to the country & region, Scope of the study.
- **Chapter 2 - Project Description** Condensed description of those aspects of the project (based on project feasibility study), likely to cause environmental effects.
- **Chapter 3 - Description of the Environment** Study area, period, components & methodology, Establishment of baseline for valued environmental components, as identified in the scope, Base maps of all environmental components.
- **Chapter 4 – Anticipated Impacts and Mitigation Measures** Details of Investigated Environmental impacts due to project location, possible accidents, project design, project construction, regular operations, final decommissioning or rehabilitation of a completed project, measures for minimizing and/or offsetting adverse impacts identified, irreversible and irretrievable commitments of environmental components, assessment of significance of impacts, mitigation measures.
- **Chapter 5 - Analysis of Alternatives (Technology & Site)** In case, the scoping exercise results in need for alternatives, description of each alternative, summary of adverse impacts of each alternative, mitigation measures proposed for each alternative and, selection of alternative.
- **Chapter 6 - Environmental Monitoring Program** Technical aspects of monitoring the effectiveness of mitigation measures
- **Chapter 7 - Additional Studies** Public consultation, risk assessment, social impact assessment, R& R action plans.
- **Chapter 8 - Project Benefits** Improvements in the physical infrastructure, improvements in the social infrastructure, employment potential –skilled; semi-skilled and unskilled other tangible benefits.
- **Chapter 9 – Cost Benefit Analysis** Details of Environmental Cost Benefit Analysis, if recommended at scoping stage i. ToR
- **Chapter 10 - Environmental Management Plan** Description of the administrative aspects, ensuring that mitigation measures are implemented and their effectiveness monitored, after approval of the EIA.
- **Chapter 11 - Summary & Conclusion** Overall justification for implementation of the project, explanation of how, adverse effects have been mitigated.
- **Chapter 12 - Disclosure of Consultants** Details of consultants involved in the proposed project.

TABLE-1.2 COMPLIANCES FOR TERMS OF REFERENCE

Standard Terms of Reference		
S.No.	**Terms of Reference**	**Compliance**
1	The project should be designed based on the population projections as by Master Plan.	The project has been designed based on Population projections. Present waste quantity, based on average per capita waste generation in service area i.e. Mangan is about 482 gm/day for 2021. Considering the population projection and the waste generation forecast, the total wastequantity is expected to reach 16.0 TPD.

<table>
<tr><td></td><td></td><td><u>Population and Waste Generation Details of Mangan</u>

<table>
<tr><th>Locality</th><th>Population on 2011</th><th>FP 2011</th><th>Total 2011</th><th>PP on 2021</th><th>PP on 2031</th><th>PP on 2041</th></tr>
<tr><td>Mangan</td><td>4644</td><td>2000</td><td>6644</td><td>6886</td><td>7336</td><td>7815</td></tr>
</table>
FP – Floating Population
PP – Projected Population</td></tr>
<tr><td>2</td><td>Submit a 10km. radius map(on survey of India Toposheet) showing co-ordinates of project site, national highway, state highway ,district road/approach road, river, canal, natural drainage; protected areas, under Wild Life (Protection) Act, archaeological site ,natural lake, flood area, human settlements (with population), industries, high tension electric line, prominent wind direction(summer and winter), effluent drain, if any and ponds etc. should be presented and impacts assessed on the same assessed on the same.</td><td>Chapter no. 2 in the EIA-EMP report presents the latest topographical map from Survey of India (SoI) covering 10km radius from the project location showing co-ordinates of project site, national highway, state highway, district road/approach road, river, canal, natural drainage etc. all the significant site features such as distance from nearest town/Railway station/airport etc.
No negative impacts have been envisaged due to the proposed MSW project activity.</td></tr>
<tr><td>3</td><td>Examine and submit details of alternative technologies viz. RDF shall also be evolved.</td><td>Various alternatives have been evaluated based on waste characteristics (physico-chemical), waste quantity, local environmental factors etc. The scheme for the SWT processing and disposal facility has been finalized based on Detailed Project Report.</td></tr>
</table>

		The segregated solid waste (Dry & Wet) will be collected from door to door in designated bins and will be transported at proposed MSW treatment facility for further segregation, processing & disposal. The received municipal solid waste at site will be further segregated and processed to produce compost and rejects will be sold to recycler & reuse vendors and left out inerts will be finally disposed in propose landfills.
4	Examine and submit details of stormwater/ leachate collection from the compost area	Separate drainage systems are proposed for storm water and for sewage to avoid run off contamination as well as any contamination of surface water sources. Proper storm water drainage and garland canal will be constructed fitted with screens so that the potentially contaminated runoff water traversing the facility does not get mixed with the rainwater. Leachate drain and leachate collection tank are proposed to collect the leachate generated in compost & landfill area for recycling and treatment. Proposed plant Layout in Chapter no. 2 of figure no. 2.4 showing surface water drains and leachate collection system.
5	Examine and submit details of monitoring of water quality around the landfill site. Water analysis shall also include for nitrate and phosphate.	Waters samples were collected from 3 representative locations for ground water & 3 locations for surface water from study area around the proposed site within 10 km radius. All samples were analyzed for physical and chemical characteristics including nitrates and phosphates. The samples of Ground & surface water were collected from the study area of 10 km around the project site to assess the water quality during the study period of Dec. 2021 to Feb. 2022 Nitrates & phosphates in groundwater samples were

		analysed and found: • Nitrates Varying from 2.7 to 4.7 mg/l. • Phosphates were found below detectable limit of 0.1 mg/l. • All samples are falling within acceptable limit. **Surface water:** • Phosphates were found below detectable limit of 0.1 mg/l. • All the Surface water samples were meeting the Class 'A' norms as per IS: 2296-1992. Details of water (ground & surface) sampling location and analysis results are presented in of Chapter no. 3.
6	Examine and submit details of the odour control measures.	Following are the control measure are proposed for project: - • Spray of herbal sanitizers and inoculums will be done to reduce & remove odour. • The waste & processed compost is stored in sheds so as to avoid attraction to birds and runoff due to rain or windblown entrainment of particles. • Green belt Development will also help to get rid from foul smell. • The proposed project proposes to cover the wastes with daily and intermediate covers of soil on a regular basis to ensure that odour generation is minimized. • Adequate compaction • Speedy segregation and disposal of malodorous wastes • Effective use of covering material • Progressive capping and restoration • Effective leachate and gas management • Foul smelling gases like CH4 and H2S creates major impact if Biomethanation operation is not done properly.

		• Waste storage & processing of waste is in a completely cover shed, this complete shed area is maintained under negative pressure by sucking odour gases so that the foul smell can't escape outside. • Foul smelling gases like CH4 and H2S creates major impact if Biomethanation operation is not done properly. • Spray of herbal sanitizers and inoculums will be done to remove odour. The compost facilities, roads, equipment and the surrounding area shall also be cleaned regularly to remove the odor generating wastes. The processed compost is stored in sheds so as to avoid attraction to birds and runoff due to rain or windblown entrainment of particles. • Plantation will also help to get rid from foul smell. Proper ventilation and moisture in the compost plant and Biomethanation area to be maintained and herbal insecticides to be sprayed around odour generation areas at regular intervals. No open dumping will be carried out during the course of this project. This will reduce the chances of air, water & soil contamination and also will reduce odour emission. This will improve the living standards of society & will provide safe & hygienic surroundings.

7	Examine and submit details of impact on water bodies/rivers/ponds and mitigative measures during rainy season	Separate drainage systems are proposed for storm water and for sewage to avoid run off contamination as well as any contamination of surface water sources. Hence, No negative impacts on water bodies/rivers/ponds have been envisaged. The impact is generally confined to the project area and is expected to be negligible outside the project site boundaries. The disposal site will be designed and operated as a sanitary landfill to protect people and the environment from the negative impact of waste.

8	Submit the criteria for assessing waste generation. Any segregation of hazardous and bio-medical wastes.	Present waste quantity, based on average per capita waste generation in service area i.e Mangan is about 1.94 mtpd in 2021. However, Considering the population projection and the waste generation forecast, the total waste quantity in 2041 is expected to reach 16.0 TPD and it is proposed to establish the Solid Waste Treatment Plant to handle about 1.94 mtpd as per Solid Waste Management Rule 2016 and its subsequent amendments. Chapter no. 2 present the criteria adopted for assessing waste generation. Hazardous waste and biomedical wastes are not expected to be a part of MSW stream; however, if received same should be handed over to the authorized vendor for its safe disposal as per Hazardous & other waste (management & Transboundary movement) Rule 2016 & Biomedical Waste management Rule 2016 and its subsequent amendments.
9	Sumit the details of sanitary landfill site impermeability and whether it would be lined, if so deatails thereof.	Details regarding sanitary landfill is provided in the chapter 2 of the EIA/EMP report.

10	Submit a copy of the layout plan of project site showing solid waste storage, green belt (width & length, 33% of the project area), all roads, prominent wind direction, processing plant & buildings etc should be provided.	The detailed layout of the project including proposed green belt, roads, processing facilities (Sanitary Landfill, Compost Sheds, biomethanation etc) is given in Chapter no. 2.
11	Submit a copy of the land use certificate from the competent authority.	In-Principle (Stage-I) Approval Obtained. MoEF file no. – SK/UDHD-70/2021/FC/314 dated 29/11/2021 for 2 ha of land. Letter attached.

12	Submit a copy of the status of ambient air quality and surface, groundwater quality, soil type, cropping pattern, land use pattern, population, socio-economic status, anticipated air and water pollution.	The status of ambient air quality, surface and ground water quality, soil type, noise levels, cropping pattern, landuse pattern, socio-economic condition around the project of 10 Km study area were studied which are detailed in chapter no.3 Anticipated impacts on ambient air quality, water quality, land, noise levels were assessed and mitigation measures are well furnished in chapter no. 4.
13	Submit a copy of the topography of the area indicating whether the site requires any filling, if so, the details of filling, quantity of fill material required, its source and transportation, etc.	Chapter 2 presents the topographical map and Key map of study area of the proposed site. The project has been designed with focus on balancing the earth work such that the fill volumes are equal to or less than the cut volumes. Excavated soils (cut volumes) shall be reused for leveling the low lying areas to avoid transport of fill material.
14	Examine and submit the details of impact on the drainage and nearby habitats/settlement (surroundings).	The details of Impact on water quality with mitigation measure are given in Chapter-4 in section no. 4.2.3 .
15	Examine and submit the details of surface hydrology and water regime and impact on the same.	Details of surface hydrology and water regime of the study area was examined and well-furnished in chapter no. 7. Impacts on surface water quality was assessed and expected to be negligible as there is no surface water or drainage network at the proposed project site.
16	Examine and submit the details of one complete season AAQ data (except monsoon) with the dates of monitoring ,impact of the project on the AAQ of the area (including H2S,CH4)	Ambient Air Quality of the site and study area was monitored and analyzed for winter season i.e from Dec. 2021 to Feb. 2022 which is well furnished in Chapter no. 3
17	As per MoM 09/02/2021, the construction of landfill is be restricted on the	Agreed will be complied.

	uphill side of the road strictly	
18	Construction of project road and other work components of the project can be done downhill side of the road, however, only lightweight structures are permitted.	Agreed will be complied.
19	Duration of the project shall be restricted to 10 years and if the scope of the project extends then additional land should be acquired.	Agreed will be complied
20	The user Agency shall comply with all the specific conditions as above in addition to all applicable acts, rules, notifications & guidelines issued by MoEF&CC, Government of India and the state Government, any violation of which shall be liable for revocation/cancellation.	Agreed will be complied
21	The user agency will have to obtain Forest (Conservation) Act, 1980 clearance for the proposed project area before development and construction of	**Forest NOC Obtained**

	work.	
22	The strict monitoring should be conducted by the SEAC and concerned Divisional Foresr Officer (Environment) during construction phase to ensure compliance of the stipulatd conditions of ToR	Agreed
23	Any other conditions as may be found appropriate in future for the protection and conservation of Environment & Wildlife, may be imposed by SEIAA.	Agreed
24	The approval may be revoked if the above conditions of prior EC are not complied to the satisfaction of SEIAA/SEAC.	Agreed.

Note: The study area shall comprise of radial distance of 10km from the projects site and the study period is three months. The impact on each of the above parameter as a result of proposed project site shall be assessed through appropriate modeling and prediction methods considering base line data.

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CHAPTER-II
PROJECT DESCRIPTION

CHAPTER – II

PROJECT DESCRIPTION

2.1 TYPE OF PROJECT

This project is setting up of a solid waste treatment plant comprising processing facilities and regional sanitary landfill. The proposed project is planned in accordance to the Solid Waste Management (SWM) Rules 2016 and it consists of waste collection, segregation, waste processing and a sanitary landfill.

The current municipal waste management practice in Mangan and surrounding Nagar Palikas does not comply with Solid Waste Management Rules, 2016. Non-compliances to MSW Rules include:

a. Unmanaged and insufficient primary and secondary collection,
b. There is no segregation of waste,
c. Most waste dumped in open areas,
d. There is no recovery of resources from waste before disposal and
e. Indiscriminate dumping and no sanitary landfill.

2.2 NEED FOR THE PROJECT

Govt. of India has launched Swachh Bharat Mission to improve the environment, sanitation condition, and SWM services etc. in all ULB of India. Municipal solid waste management is the need of the day to keep the city clean and improve the hygienic condition and environment of the town.

There is no scientific disposal method being followed, the garbage is left open for the natural decomposition. Since existing open trenches are not engineered landfills, therefore they are prone to ground water and soil pollution, vector nuisance, odor problem, besides becoming breeding grounds for mosquitoes, flies, etc. The leachate generated may cause unsanitary condition in the surroundings. To avoid all above and to improve environment & sanitary condition, this project has the prime requirement in the area.

2.3 LOCATION OF THE PROJECT

As per MoEF&CC norms and SWM rules 2016, it is mandatory to set up an efficient management of Municipal Waste Including: Waste Collection, Transportation, Processing and Disposal of Inert Waste through Sanitary Landfill by each ULB but the proposed ULB does not have technical and financial strength to set up the management system on their own, hence to make SWM services financially sustainable and efficient, the project is designed on Mangan.

2.3.1 CONNECTIVITY OF THE PROJECT

The proposed Solid Waste Treatment Facility is situated at Rangdang, Mangan, Sikkim.

2.3.1.1 BY ROAD

The site is easily approachable by NH-310A which is 1.0 km away in East from project site.

2.3.1.2 BY RAIL

The nearest railway station is New Jalpaiguri Railway Station which is 92.0 km (S) away from project site.

2.3.1.3 BY AIR

The nearest Airport is Pakyong Airport – 32 Km South East direction (Aerial distance from the proposed site)

Connectivity Map of Proposed Poject site is shown in Figure 2.4.

COORDINATE OF THE PROPOSED AREA
Latitude- 27°30'43.96"N
Longitude- 88°31'49.46"E

FIGURE 2.1: GOOGLE IMAGE OF THE AREA

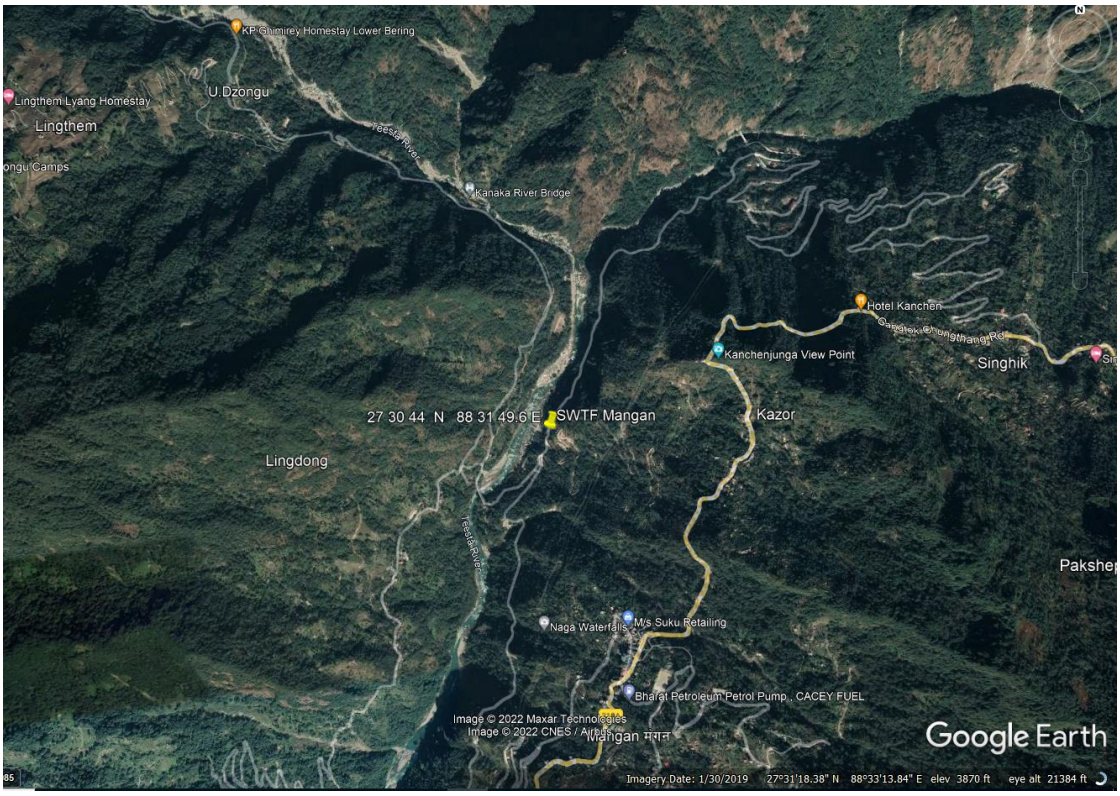
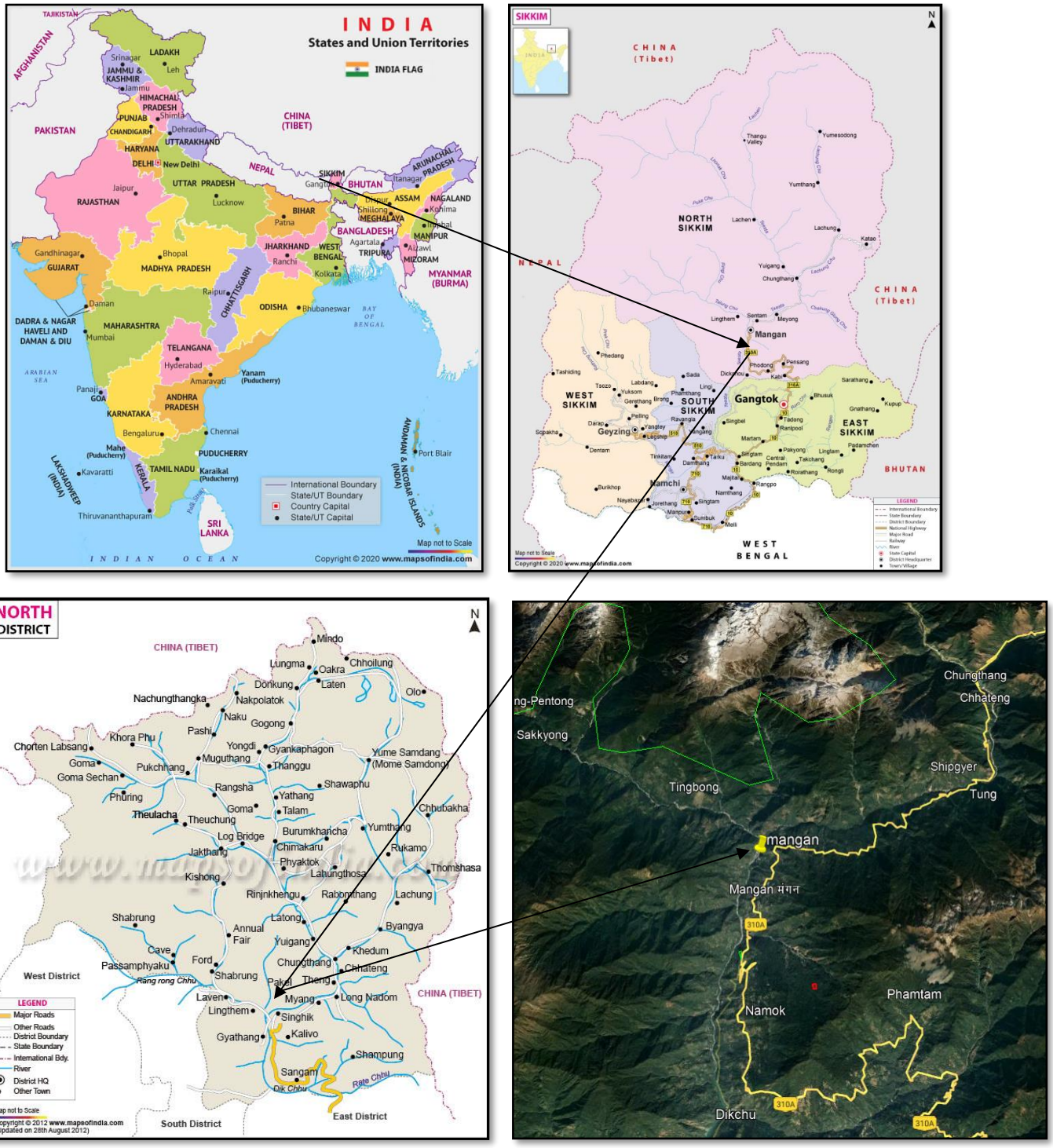


FIGURE 2.2: LOCATION MAP



2.4 PROJECT BACKGROUND

Mangan is the capital of the North District of Sikkim. The town is connected to the capital city Gangtok at a distance of 68 km. Mangan is located at 27.52°N 88.53°E. It has an average elevation of 956 meters (3136 feet). As per census 2011 the population is 4644.

The Urban development & housing department, government of Sikkim has proposed Solid Waste Treatment Plant due to absence of any proper scientific solid waste treatment facility in entire north Sikkim under Swachhata Action Plan (SAP) of NLCPR Scheme and in order to comply with Solid Waste Management (SWM) Rules, 2016 and its subsequent amendments, project is proposing waste collection system, processing unit and engineered sanitary landfill Facility.

This project is a solid waste Treatment project and proposed for the setting up of processing facilities and sanitary landfill facility. The proposed project is planned in accordance to the Solid Waste Management rules, 2016 and its subsequent amendments which consist of waste collection & transportation system, segregation facility, waste processing unit and a sanitary landfill.

FIGURE 2.3: MAP OF NORTH DISTRICT, SIKKIM

Urban Development & Housing Department (UD&HD), Govt. of Sikkim

The Urban Development & Housing Department proposed to setup a Solid Waste Management System for Mangan at **Ringdang, Mangan, Sikkim** in an area of 2.0Ha with total processing capacity of 16.0 TPD of municipal solid waste which includes Bio Methanation and sanitary landfill.

Locality	Population o n 2011	FP 2011	Total 2011	PP on 2021	PP on 2031	PP on 2041
Mangan	4644	2000	6644	6886	7336	7815

FP – Floating Population, PP – Projected Population

- Estimated MSW generation in mangan is about 1.94 mtpd (2021) and it is expected to reach 2.93 mtpd by 2041.
- The proposed solid waste treatment plantof 16.0. TPD capacities willbe set up in 2.0 Ha. of site in Managan

The project seeks to improve and develop a socially and environmentally sustainable system of municipal solid waste management which will reduce the associated environmental and public health risks.

2.5 SIZE OR MAGNITUDE OF PROJECT

The proposed Solid Waste Management Facility will be established in a land of 2.0 Ha located approximate 68 km from gangtok and 1.6 km from mangan. The proposed land belongs to Urban Development & Housing Department (UD&HD), Govt. of Sikkim and the proposed design for Solid waste management (SWM) treatment & disposal facility shall cover a period of 20 years. The project will be developed as in accordance with local development plan. The proposed site proves to be the suitable location considering both the environmental and economic factors. The nearest town from the proposed site is Mangan (approx. 1.6 Km South East direction w.r.t site). Nearest railway station is New Jalpaiguri Railway Station (approx. 92 Km South) and nearest airport is Pakyong Airport at aerial distance of 32 Km at South East direction with respect to proposed project site.

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Criteria for MSW Site Selection

The main criteria for the site selection of Municipal Solid Waste management facility are as following;

- The area which contains low permeability formation.
- Shallow hard rock basement which prevents the groundwater percolation.

- Shallow thick clay zone, which does not allow the surface water recharge.
- Protect surface water body and visual corridors of scenic & wild rivers.
- Avoid watersheds and reservoirs for the protected water supply (PWS).
- Areas of poor groundwater potential.
- Areas of deep-water table.

Detailed Site selection criteria for proposed site are well furnished in chapter no. 5 as per SWM, 2016 & CPHEEO Manual.

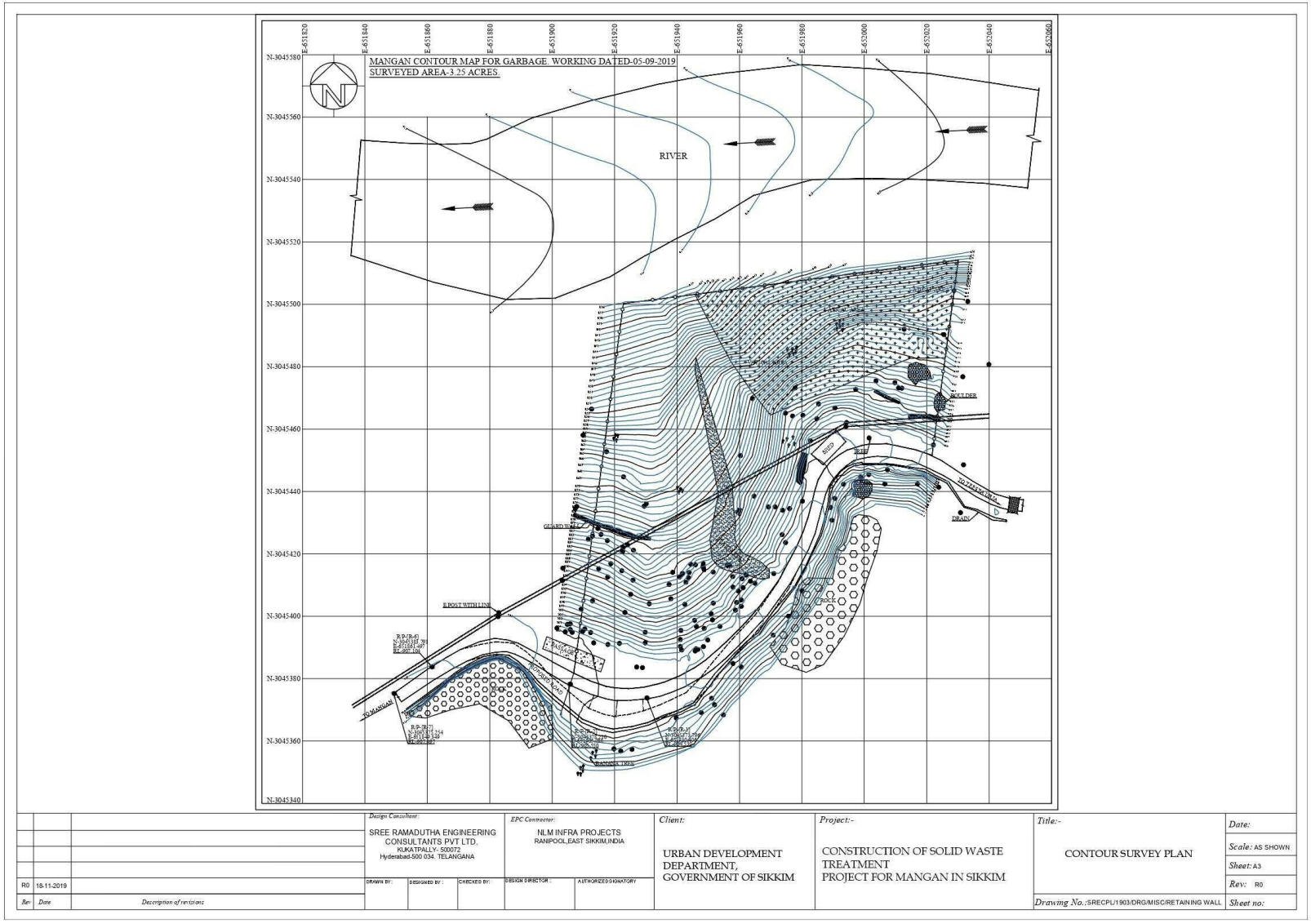
2.5.1 Proposed land breakup for project

The proposed municipal solid waste project is planned on a 2.0 Ha of the land, for which land permission has been obtained.

FIGURE 2.4: LAYOUT OF PROPOSED PROJECT

Urban Development & Housing Department (UD&HD), Govt. of Sikkim

FIGURE 2.5: CONTOUR MAP OF PROPOSED PROJECT



Urban Development & Housing Department (UD&HD), Govt. of Sikkim

2.5.2 Description of Proposed Site Facility

- **Water Requirement**

Construction Phase- During construction phase water will be requiring about 4 KLD.

Operational Phase- Total water requirement in the project during operational phase will be about 5 KLD which will be sourced from Rural Management and Development Department Sikkim.

TABLE - 2.1 WATER REQUIREMENT

Sr. No.	Description	Water Requirement (KLD)	Waste Water Generation (KLD)	Treated Water (KLD)
1.	Domestic Purpose	1.8	1.6	1.4
2.	Vehicle/Tier Washing	0.5	0.3	0.2
3.	Dust Suppression	0.5	-	-
4.	Green Belt Development	2.2	-	-
5.	Process water	1.6	1.5	1.2
Total		6.6 (5KLD +1.6KLD)	3.4	2.8

- Domestic Wastewater will be in STP & reused for greenbelt purpose.
- Leachate will be treated in LTP of 25 KLD capacity and treated water will be reused for greenbelt purpose.
- Treated water from LTP & STP will be used for green belt development, dust suppression & horticulture activities.
- 1.6 KLD of treated water will be recirculated in the process. Hence, the water requirement for the proposed project is 5 KLD.

- **Power requirement**

D.G set of 250 KVA will be utilized for power during construction phase and in emergency use during power failure.

During operation phase of proposed facility will be 250 KVA and it will be sourced from Energy and power department, Sikkim and for emergency 1 D.G set of 250 KVA will be utilized as backup.

- **Manpower requirement**

During construction phase approx. 40 workers (skilled & semi-skilled workers), rest will be outsourced based on need.

During operation phase the Swachha team will be consists of approx 42 Workers (skilled & semi-skilled workers, contract labour, drivers, sweepers & supporting staff) with 33 permanents, 2 Supervisors, 7 contractual. Rest will be outsourced as per requirement of ULB.

2.5.3 Current Scenario of municipal solid waste management

Waste collected from Households & community bins or from the roadside kerbs via Auto-tippers by private contractor. Source segregation is not yet active although recently colour coded twin dustbins were distributed to households. Street sweeping is done daily on almost all the internal and the main roads. Wards wise road cleaning, drain de-silting & grass cutting is assigned to the safai Karmachari by safai nayaks which turns reports to the Sanitary Inspector.

The waste is collected via Auto tippers, truck tipper, & tractor trolley in 7-8 trips and transferred to the dumping site. Vertical Compactor is for bailing of plastic & paper then sold to recyclers. No proper PPE also in use. Present scenario of solid waste management based on different component is given below.

TABLE- 2.2 PRESENT SCENARIO OF SOLID WASTE MANAGEMENT BASED ON DIFFERENT COMPONENT

SNo.	Functional Element	Present Scenario
1.	Waste Generation	1.94 MTPD aaprox. in present year (2021)
2.	Segregation at Source	Currently some extend of source segregation is done; due to huge awareness programmes ULB has distributed 2 colour coded dustbins to most households.
3.	Storage at Source	Most of the household now has twin dustbin though source segregation is slowly picking up, awareness is also taken up in the entire city motivate people to store and segregate properly. Secondary dustbins are there in the city, for secondary storage from Households and from commercial areas.
4.	Primary Collection	Collection vehicles starts early in the morning covering the residential areas in the wards, , half of the vehicles are not in good condition & can be scrapped for new one.
5.	Street Sweeping	Early morning sweeping 6-12 AM & 2 pm - 5 pm is done to cover all the main roads. Internal roads are alsoswept on alternate days.
6.	Drain Cleaning	Daily on main drain and alternate days on internal drains.
7.	Secondary Collection	Collection is also done from secondary storage concrete bins +

		Tin bins daily via tripper trucks.
8.	Transportation	The ULB currently has Auto tippers, truck tipper. ULB has wheel barrow. It makes 2-3 trips daily to ferry the waste to the dumpsite.
9.	Removal Frequency	Street sweeping is done daily and drain cleaning is done twice a week. Secondary bin is cleaned at least once in daily or when its full whichever is earlier. Any other issue is executed on need basis.
10.	Processing	Dry waste is directly dumping at Chandey current site although some fraction of plastic bottels & recycles items pick up by rag pickers are sold to recylers.
11.	Disposal	Currently it is collected waste is open dumped at Chandey.
12.	Vehicles Tools & Equipment	The ULB currently has TATA Ace, truck tipper & tractor trolley ULB has wheel barrows. The workers have formal PPE with them but not used frequently. Basic cleaning equipment is provided to workers.
13.	Workshop & Repair Facility	No such facility exists
14.	Manpower	The swacchhta team consists of karmacharis and Supervisior.
15.	O&M Cost	Salary of workers mostly & fuel & few chemicals & equipment purchase.
16.	Cost Recovery	User Charges notified & collected accordingly.
17.	Community Partnership	Under Process
18.	Recycling Activity	Under Process
19.	SHG/NGO/CBO partnership	Under Process
20.	Private Sector Partnership	Under Process
21.	Management	Safai workers report to safai nayaks and they then given update to the sanitary inspector and to the chairman & EO.
22.	Planning	Planning is done mostly by the safai nayaks based on daily requirements and in face of any public event. EO & officers take review and plan accordingly.
23.	Solid waste bye laws & user charges	Bye-laws & User charges gazette notification done. User charges collected as per the bye laws.

2.5.4 Waste Generation Forecast & MSW Management

The current total waste generation is 1.94 MTPD in 2021. However, estimated MSW generation in mangan for 2041 is about 2.93 MTPD which will reach the landfill.

Table-2.3 presents the waste generation forecast from the project area.

TABLE- 2.3 POPULATION AND WASTE GENERATION DETAILS OF MANGAN

Locality	Population 2011	Floating Population	Total 2011	Projected Population 2021	Projected Population 2031	Projected Population 2041
Mangan	4644	2000	6644	6886	7336	7815
Chungthang	4400	1000	5400	5753	6128	6528
Ranthang, Namok, Swayem, Mangshila, Tingchim, Chandey, Toong, Naga, Singhik, Sentam, Ringhim Nampatam	13766	1000	15266	16263	17325	18456
Dzongu S/Division: Lum Gor Santok, Hee Gyathang, Lingdong, Lingthme, Passingdang, Saffo, Tingvong, Sakyoong Pentong	7762	1500	9262	9867	10511	11197
NHPC Colony	1000	667	1667	1776	1891	2015
TOTAL			**38059**	**40545**	**43191**	**46011**

Waste Composition	Waste Composition (Weight in Kg)					
	Residential	Commercial	Institutional	Road Sweeping	Total	%
Biodegradable Waste	2431.1	211.1	27.5	173.6	2843.3	68.5
Metal	71.2	0.0	0.0	0.0	71.2	1.7
Glass	99.4	71.2	0.0	4.2	174.7	4.2
Ceramics	184.8	0.0	0.0	22.9	207.8	5.0
Paper	4.1	8.1	0.0	1.0	13.3	0.3
Textiles	1.4	1.5	20.5	0.8	24.2	0.6
Plastics	19.7	29.6	0.0	1.0	50.4	1.2
Rubber	1.7	0.0	0.8	0.0	2.5	0.1
Miscellaneous combustible (Wood, Leather)	48.8	1.7	0.0	25.9	76.4	1.8
Miscellaneous Non combustible (dust/dirt, ashes)	103.9	7.2	0.2	24.9	136.3	3.3

Inert (Street sweeping - Soil/Stones, bricks, ash, coal)	437.5	9.8	18.1	86.0	551.3	13.3
Total	**1730.8**	**173.1**	**34.2**	**173.1**	**2111.2**	**100.0**

The waste projections are carried out by considering a daily per capita waste generation of 443 grams and furnished below;

Daily Quantity of Waste: From the above data the calculation of the daily quantity of waste that will reach the landfill is done as below:

2021

Daily waste Generation = Population x Per capita generation

= 40545 x 482 gm/1000

= 19542.69 kg

= 19.54 mtpd out of which 10%* reach the land fill Say

= 1.94 mtpd

2041

Daily waste Generation = Population x Per capita generation

= 46011 x 636 gm/1000

= 29263.00

= 29.26 mtpd out of which 10%* reach the land fill Say

= 2.93 mtpd

Qty of waste at beginning of design period : 1.94 mtpd

Qty of waste at the end of design period : 2.93 mtpd

2.5.5 Waste Management Plan

Nagar Palika aspires to be cleanest and free of any unwanted littering in the town and want to create clean and hygienic place for its residents. It is already trying to reach 100% door to door collection in all of its wards.

FIGURE 2.6: WASTE CHARACTERIZATION

Biodegradable	Recyclable	Inert
53%	30%	17%

(As per DPR – SWT Project)

A. Source segregation is key aspect and 2 color sided dustbins will be provided to each household on one-time basis. The commercial shops will also be encouraged to adopt segregation. User charges is also advised to be differential i.e. take double the amount of user charges from the non-segregating households and take half the user charges from the segregating households for first six months. Also same is advised for the commercial shops and restaurants.

B. Waste from households and commercial places will be collected by the **pushcart/tricycle**, **auto tippers & pickup vehicles.** It is advised to have very few collection points in the city, the primary collected waste can be directly unloaded into the auto tippers and they can further unload it in the processing site.

C. The waste will be further segregated at the processing site into various material streams. The wet waste will be shredded and sent to compost yard for making compost. A rapid mechanical composter is also proposed for making quick and good quality compost.

D. The dry waste will be segregated on various material types like plastic, paper, glass etc. and materials like plastic bottles, hard papers are sent to compactor machine for volume reduction & further to shredder for shredding the plastic caps and hard plastics. This process increases the selling price of the plastics and due to presence of huge industrial area the ULB will get buyers for the same. The segregated and processed inorganic waste then will be sold to various recyclers in the supply chain like the vendor in Haldwani on fortnightly basis for plastic materials.

E. The rejects from the processing of compost, inert materials and the non-recyclable materials will be sent to the proposed sanitary landfill site.

FIGURE 2.7 PROCESS FLOW AT THE PROCESSING FACILITY

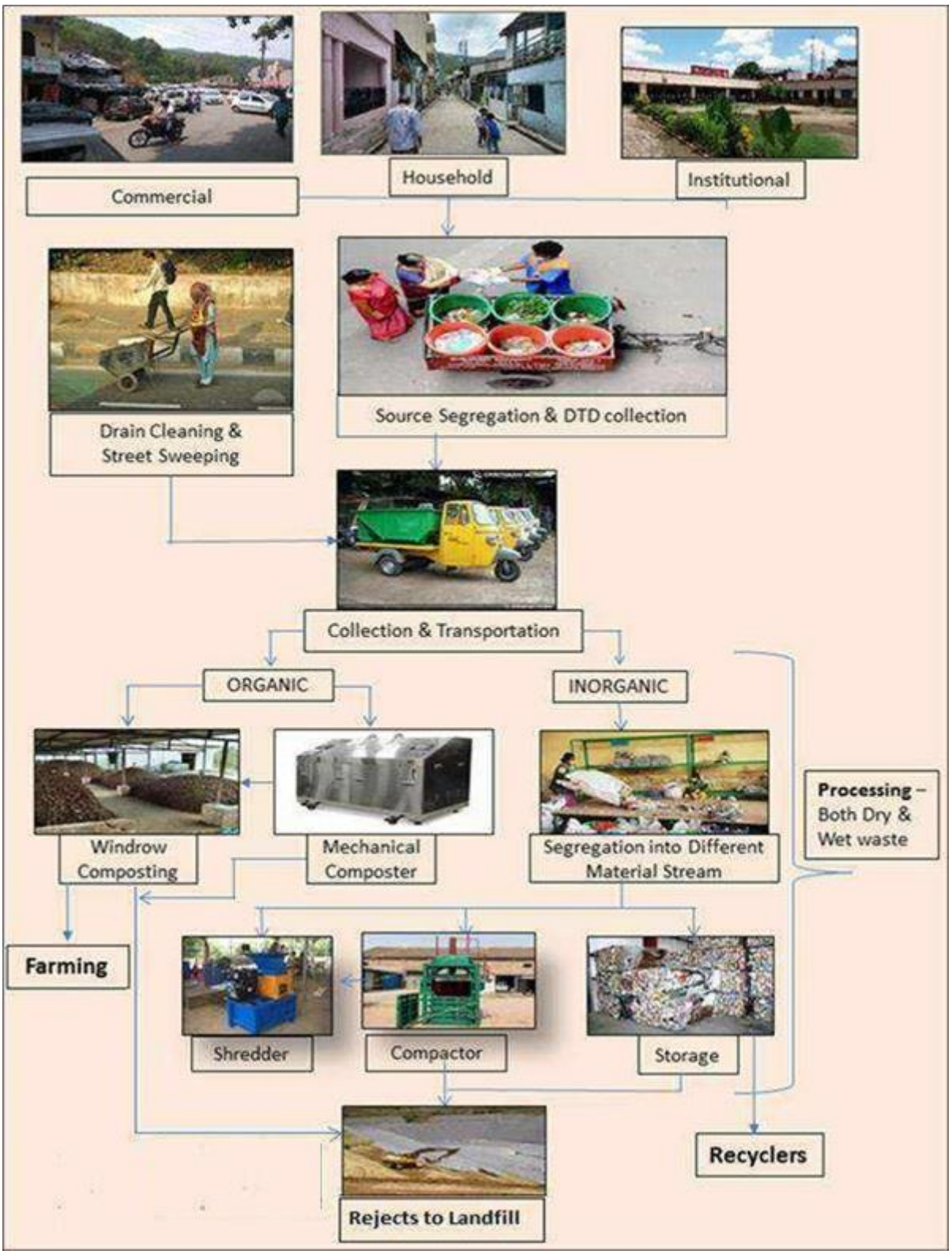


TABLE-2.4 SOURCE SEGREGATION OF WASTE

Wet Waste (Green bin)	**Dry Waste (Blue bin)**				**Special Waste (Black Bin)**
	With Further Sub-Segregation Basic				
Food wastes of all kinds, Cooked and uncooked, including eggshells and bones, flower and fruit wastes including juice peels and house-plant wastes Soiled tissues, Food wrappers Paper towels	Paper Cardboard and cartons	Containers & packaging of all kinds excluding those containing hazardous materials Compound packaging (tetrapak, blisters etc.) and plastics Packaging of all kind	Rags Rubber Wood Discarded clothing Furniture	Metals Glass (all kinds) Inerts House sweepings and inerts (not garden, yard or street sweepings)	Printer & printer cartridges Electronic parts and equipment Batteries from flashlights and buttons cells. Lights bulbs, tube lights and Compact Fluorescent Lamps (CFL) bleaches and household kitchen & drain cleaning agents Car batteries, oil filters and car care products and consumables Thermometers and other mercury containing products Discarded medicines

Waste should be stored at the source of waste generation till it is collected for disposal by ULB staff or appointed contractors. It is essential to segregate wastes into wet waste (kitchen waste) and dry waste (recyclable waste and others), commonly referred to as primary segregation. Segregation of municipal solid waste needs to be linked to primary collection of waste from the door step and given high priority by the ULBs; the local community should be educated and enthused to perform the following actions to ensure collection of segregated waste:

- At the household level MSW should be segregated into wet and dry fractions, at a minimum, and stored in separate containers.

- Ensure domestic bio-medical waste and other special wastes (e.g. batteries, used CFLs, tube lights, chemical/paint/insecticide containers etc.,) are handed over separately at the door step or at special pick-up points specified by the municipal authority or through the relevant retail trade (e.g. for batteries). As long as there are no specific pick-up points/services for collecting such waste, these wastes may be handed over along with the dry waste fraction as an interim solution. Bo-weekly programme & two no. of recycling stations also suggested for collection of such waste.

- Diapers and sanitary napkins should be wrapped securely before being put in the bin meant for dry waste, for the protection of the waste handlers and should be marked with a "Red Cross" to enable further segregation and disposal in municipal sanitary landfills, as applicable to the local context.

2.5.3 Storage of Waste

Household Storage:

- At the household level dry waste and wet waste should be stored in separate garbage bins.
- Wet waste is to be placed in a covered green bin and dry waste in a covered blue bin.
- A container of 12-liter capacity with paddle for a family of 5 members should be adequate for dry and wet waste each, if collection takes place daily.
- Wet waste collection bins should be washed by the household each time they are emptied.

Commercial storage		**Household storage**
		
Commercial (60L& 120L)	**Vegetable Mandi (240L)**	**Household 15L bins**

- Shops, commercial establishments and businesses will store segregated waste on- site and designated auto tippers will collect at fixed time every day, whereas vegetable and flower market waste generators should deposit their waste in conveniently located large green bins.
- Typically, four wheeled, HDPE, injection molded, international standard, UV tested bins or metal bins of 60L capacity to be used.

Public places:

- With a view to ensure that streets and public places are not littered with waste, designer litter bins will be provided on important streets, markets, public places, tourist spots, bus and railway stations, etc. adding to aesthetic beauty.
- The distance ranging of 50m to 100 depending on the local condition. The waste collected should be segregated into wet and dry waste with collection vehicles having separate compartments for both.
- Due to presence of floating population there adding to the aesthetics of the place. Daily emptying of Bins is necessary by the collection workers.

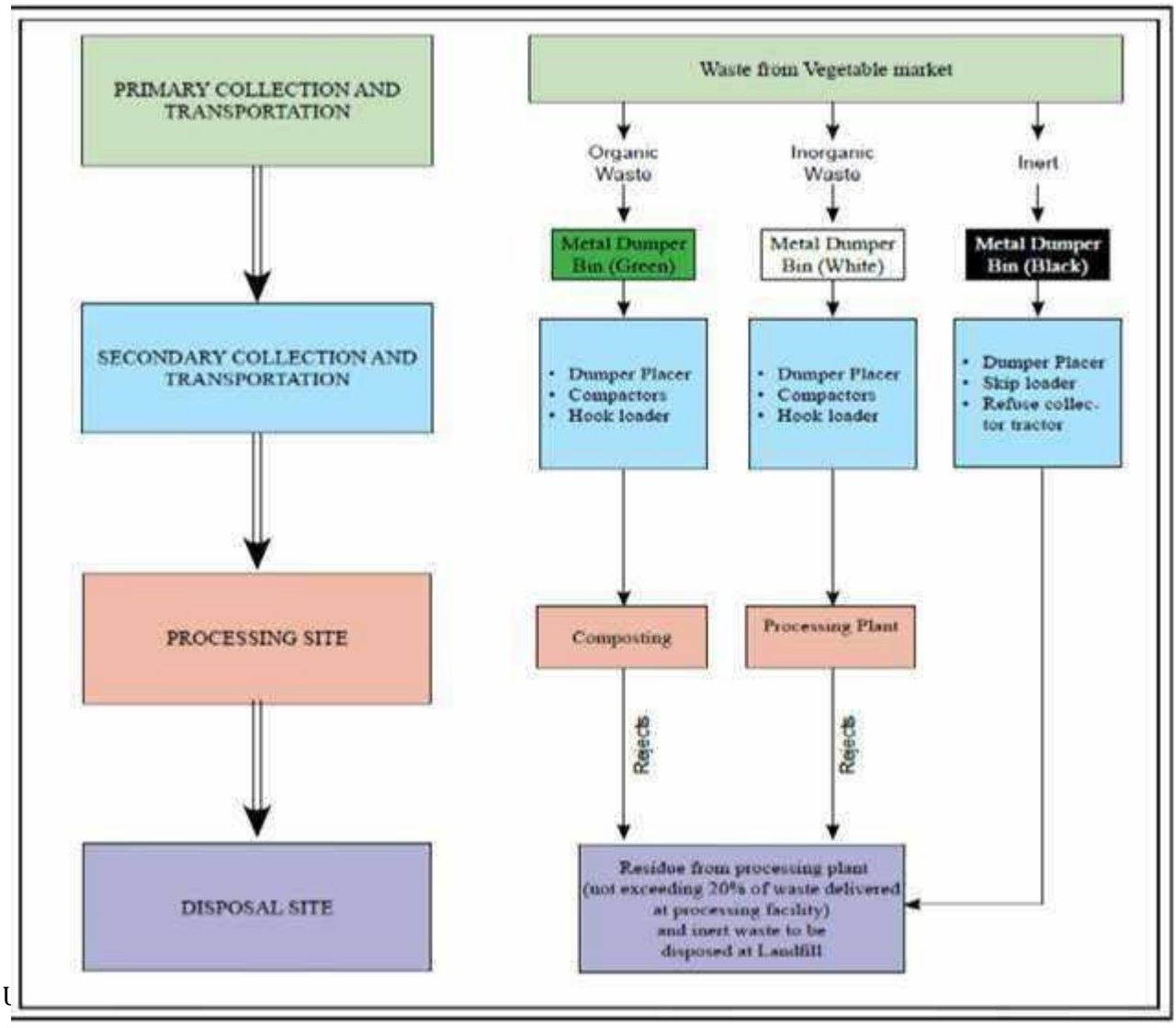
FIGURE 2.8: DESIGNER DUSTBINS TO BE INSTALL ALONG MAIN ROAD IN THE CITY AND MAIN MARKET AREA

9	S9	Ward 6 Near district hospital Cemented dust bin

Collection & Transportation system

Collection of segregated municipal waste is an essential step in solid waste management. Inefficient waste collection service has an impact on public health and aesthetics of towns and cities. Collection of wet and dry waste separately enhances the potential of cost-effective treatment of such wastes cost effectively and ensure optimum advantage from the recyclable material fed into the system. Waste collection services are divided into primary and secondary collection. Primary collection refers to the process of collecting waste from households, markets, institutions and other commercial establishments and taking the waste to a storage depot/ transfer station or directly to the disposal site, depending on the size of the city and the waste management system prevalent in the city.

FIGURE-2.9 FLOW CHART FOR COLLECTION, TRANSPORTATION & DISPOSAL OF RESIDENTIAL & VEGETABLE MARKET WASTE



- Segregated waste must be stored on-site in separate containers for further collection and should be kept separate during all steps of waste collection, transportation and processing.
- Further, the transport vehicles should be compatible with the equipment design at the waste storage depot and should be able to transport segregated waste. They should also be easy to maintain.
- Five no. of recycling centre is also recommended with separate bin for electronic waste at main tourist spots and at strategic commercial locations. It will increase awareness among people and will also cater to the huge foreign tourist who are used to this kind of system overseas.
- One such centre can be set up near Nagar Palika's office, remaining one can be set up after having due discussions with all the stakeholders.
- The Entire mangan is planned to be covered by door to door system of primary collection system. Though the city terrain is mostly hilly but it has moderate density of population. Huge manpower will be required if we go for tricycle/ pushcart-based system.
- The wards are recommended to cover the entire door to door collection by Auto tippers and pickup vehicles.
- After assessing the existing infrastructure following vehicles are recommended for primary collection.
- Wheel barrow with colour coded dustbins also suggested for narrow inaccessible lanes.
- Auto tippers are under operation and two not in good conditions.
- Addition to above one Auto tipper and Hydrallic vehicles recommended for covering all the households, commercial and institutional places (one for each 1000 families) plus tipper truck due to high trip time as the newly proposed processing disposal site.
- Street sweeping & drain cleaning (Dirt & silt) are carried by additional wheel barrows & by additional tractors, this will be good to accommodate future increase in waste.
- One Sewer suction machine also proposed for drain cleaning.
- One animal pick up van also suggested for picking up any stray animals and transport them to nearest Gau sadan.

FIGURE 2.10 DECENTRALIZED RECYCLING CENTRES WITH STRICT MONITORING PROCEDURES

Auto tipper – residential areas

Pick up vehicle for commercial & institutions

Tractor trolley

Suction pump loaded truck- drain cleaning

Recycling Station

The Primary collection (vehicles with separate compartment for organic & inorganic waste) should bedone in 2 shifts:

- Morning 7AM to 12 PM (also avoids traffic) &

- 2 PM to 5.30 PM.
- No. of trips to be undertaken by each vehicle is taken as 3.
- The timing and scheduling of collection system is planned by the SI.
- The pickup can also be kept to collect specially to collect from big restaurants and for marriage halls and another for "Sabji Mandi".
- The Nagar Palika currently has Wheel barrows, almost half needs replacement and need further to cover the whole town for daily sweeping of streets.
- Small & medium size drains shall be attended by the sweeping crew.
- Pre-monsoon clearing of drains shall also be carried out.

Selection of Waste Management Technologies

The proposed processing cum disposal site is chosen to be in the Mandakhan village land area allottedis of 2.0 Hectare.

Considering the features of the site, the design approach for the development of waste processing andtreatment facility for Mangan will comprise of following components:

- Developing a waste processing facility for organic waste in the site.
- Processing facility for the recyclable materials from the dry waste.
- Sanitary Landfill for rejects from processing & inert.
- Development of infrastructure facilities for optimum operations.
- Complete facilities to prevent any type of contamination due to operations.
- All the ICT (Information and communications technology) related infrastructure for smooth functioning of the site.
- All facilities for proper work place for workers and officers.
- This project was developed after considering the following design criteria for a concession periodof 20 years
- Compliance with Solid Waste Management Rules, 2016.
- Compulsory segregation at the source.
- Provision of segregation infrastructure at all stages of collection and transportation.
- Waste to be covered at all stages of handling.
- Reduction of manual handling of waste by providing of proper PPEs to the workers.
- Maximum recovery of resources by segregation of recyclables and biodegradable waste.
- Advocate 4R's i.e. reduce, recycle, reuse, and recover materials in MSW management.
- Promote information, education and communication across the stakeholders to ensure system efficiency and sustainability.
- Ensure economic sustainability of the proposed system by introducing public private partnership in MSW management and have robust complaint-handling system in place.

- Adequate health and safety provisions for workers at all stages of waste handling.

The municipal waste received will be processed at the waste management facility by segregating the waste into recyclables and compostable material. After separation of recyclables, the compostable material will be diverted to a Biomethanation plant. The plant will be designed to process 16.0 TPD municipal solid wastes (MSW) and will be able to process different kind of waste types. The MSW processing unitwould comprise of the following plants: Composting Facility and Sanitary Landfill.

2.6 PROCESS DESCRIPTION MSW PLANT

Municipal solid waste (MSW) primarily consists of organic, inorganic, and inert fractions. Under natural conditions, the organic fraction of waste continually decomposes, accompanied by a strong foul odour and production of gases, which are predominantly methane or CO2 depending on the aerobic condition of the decomposing mass. Vector infestation during the natural decomposition is a common phenomenon. Out of all the available technologies composting, vermicomposting, anaerobic digestion or any other appropriate processing for bio stabilisation of biodegradable wastes; Biomethanation is most recommended for processing based on the quantity and composition of waste and the available area.

Pre-treatment:

The mixed waste shall be fed to segregation unit followed by Pulverizer/ Homogenizer where the material shall get homogenized and sieved /shreddedfor size reduction < 10 mm material. After aeration time of few hours in the Pulverizer/ Homogenizer, the waste is fed into the AD unit.

Digestion:

The AD unit is provided with recirculation. During the anaerobic digestion process, the material passes through the AD unit. The digested residue is extracted from the AD unit from the bottom. The biogas generated is collected at the top.

BIOGAS:

The bio-gas generated through Biomethanation process can be used in bio gas engines to generate electricity.

Power Generation from Bio-Gas:

The gas stored in the gas holders is fed to Biogas engines to generate electricity. Necessary utilities, basic safety requirements and instrumentation are considered for proper operation, monitoring and control of the plant performance. The captive power will be utilized from the Gross generated power.

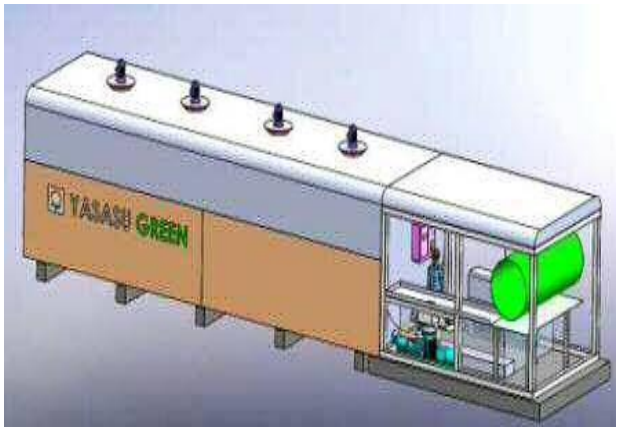
Slurry Dewatering:

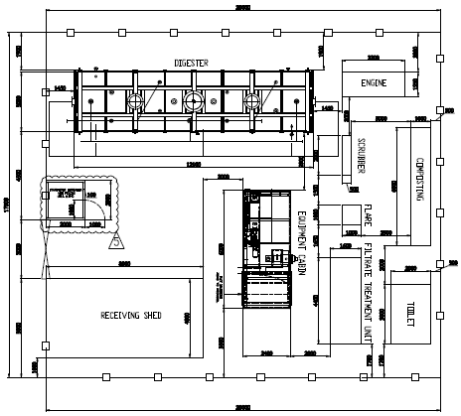
The residue left after the anaerobic digestion will be dewatered and dried. The dried solid can further be sold as organic compost.

A) Wet Waste Treatment Technology – Biomethanation Plant for Mangan:

Urban Development & Housing Department (UD&HD), Govt. of Sikkim

From the above the quantity of Wet waste generated is 15.51. For these wet waste generation from Mangan and NHPC, the Biomethanation plant capacity is of 16 TPD.





BASIC CONSIDERATIONS

Following points are considered for basic designing and proposal preparation:

- Raw material /Garbage - 16 Ton/day mixed solid waste (Accordingly further details provided) and to be made available on regular basis at our plant till commissioning and handing over.
- Input material consideration : Organic content in mixed waste - 53%, Total solids in segregated waste - 30 %, Organic content in TS - 70%
- Plot area is rectangular with flat ground /No undulations / Slopes.
- The approach to the plot is by all weather motorable roads.
- The plot is marked and identified without any hindrances/ encroachments/ over and underground diversions or obstruction of any kind.
- Any variation in the TS & VS value will reflect in power generation accordingly.
- The above outputs are based on the Organic Waste characterization assumed on the general thumb rule basis considering that the waste to be processed is delivered at the site as per above assumptions. Actual Biogasyields and power generation may vary as per waste characterization

Plant and Other Specifications: (values are for the final design year)

A. Capacity of Project: Feed to the System: 16 MT/Day mixed solid waste.

B. Biogas generation per day: approximately 600 Nm^3/ Day biogas will be generated based on average feed to plant. (Based on input material as per design consideration output potential may vary).

C. Power generation per day: approximately 900 Kwh/Day power will be generated based on average feed to plant. (Based on input material as per design consideration output potential may vary.)

D. Net Power Generation per day: (Net Power Generation = Gross Power Generation – Captive consumption) approximately 500 Kwh/Day power will

be generated after captive consumption based on average feed to Plant.(Based on input material as per design consideration output potential mayvary.)

E. Calorific value of Bio gas: approximately 4500 Kcal/m^3 (Based on input material as per design consideration output potential may vary).

Note: Any change in waste characteristics mainly TS, VS, and BVS will change output. Therefore care to be taken to provide municipal garbage only.

SCOPE OF SUPPLY

Supply, Erection & commissioning of Containerized Biogas plant having following Items:

Sr. No.	Equipment	Qty
1.	Segregation Unit	1 LOT AS REQUIRED
2.	Pre treatment Unit	
3.	Pump	
4.	Container with inbuilt Digester tank	
5.	Dewatering Unit	
6.	Gas balloon	
7.	Scrubber	
8.	Engine	
9.	Flare	
10.	Safety devices like PRV, Flame arrestor	
11.	Piping & Valves	
12.	Electrical and Instrumentation	

Battery Limits: Battery limits to our plant will be as per following:

- ✓ Inlet: Plant Premises.
- ✓ Rejects: Plant Premises
- ✓ Output Power Supply: 415 V AC, 3 Phase, 50 Hz at our electrical panel.
- ✓ Input Power Supply: 415 V AC, 3 Phase, 50 Hz at incomer of our main electrical panel.
- ✓ Service water: 1 meter flange connection from plant boundary.

B) Waste Disposal Options

As per the MSW Rules, the organic fraction of waste generated from Biomethanation will be sold as manure and the rejects from the plant and the inertmatter will then be disposed in a landfill site, fully complied with the requirements of MSW Rules 2016.

Design Criteria

The landfill is designed with 20 years perspective. The design requirements for sanitary landfill development are primarily guided by the characteristics of the proposed site and the guidelines framed by the Ministry of Environment and Forests, Government of India. Part II, Section 3, Sub-Section (ii), Rule 6 (1), 6 (3)

and 7 (2) of these guidelines indicate that the sanitary landfill shall comply withthe following:

- The minimum bottom liner specifications shall be a composite barrier having 1.5 mm High Density Polyethylene (HDPE) geo-membrane overlying 90 cm of soil (clay/amended soil) having permeability coefficientnot greater than 1 x 10^{-7} cm/sec. The highest level of water table shall be 2m below the clay/amended soil layer.
- In order to prevent the pollution problems storm water diversion drains, leachate collection and treatment system and preventive measures for runoff from landfill area entering any stream, lake, river or pond shall be provided.

C) Regional Landfill Site Selection & Planning

Landfill Site Identification& Selection

The same is to be provided free from encumbrance by UDHD.

Landfill Design Criteria

The design requirements for sanitary landfill development are primarily guided by the characteristics of the proposed site and the guidelines framed by the Ministry of Environment and Forests, Government of India. Part II, Section 3, Sub- Section (ii), Rule 6 (1), 6 (3) and 7 (2) of these guidelines indicate that the sanitary landfill shall comply with the following:

(i) The minimum bottom liner specifications shall be a composite barrier having 1.5 mm High Density Polyethylene (HDPE) geomembrane overlying 90 cm of soil (clay/amended soil) having permeability coefficient not greaterthan 1 x 10^{-7} cm/sec. The highest level of water table shall be 2 m below theclay/amended soil layer;

(ii) Waste shall be compacted adequately and provided with daily cover of minimum 10 cm of soil inert debris;

(iii) Prior to commencement of monsoon intermediate cover of thickness 45 cmhas to be provided with proper compaction and grading to prevent infiltration during monsoon. Proper drainage berms shall be provided to divert runoff from the active cell of the landfill;

(iv) The final cover shall have a barrier layer comprising of 60 cm of clay/amended soil with permeability coefficient not greater than 1 x 10^{-7} cm/sec., on the top of the barrier soil layer there shall be a drainage layer of15 cm and on the top of drainage layer there shall be a vegetative layer of 45 cm thick; This is not included in the cost of this bid offer and should be taken up by the Department during 2041.

(v) The post closure care of landfill site shall be conducted for at least fifteen years and long-term monitoring plan shall be prepared by the Department.

(vi) In order to prevent the pollution problems storm water diversion drains,

leachate collection and treatment system and preventive measures for runoff from landfill area entering any stream, lake, river or pond shall be provided;

(vii) Buffer zone around the landfill site and a vegetative cover over the completed site shall be provided; and

(viii) The sanitary landfill shall be provided with fence, security gate, approach and internal roads, waste inspection facility, weigh bridge, equipment and machinery, infrastructure like water supply, lighting, etc., and health inspection facilities;

Considering the above features of the site, the design approach for the development of waste processing and disposal facility comprise the following components.

- Remediation (re-engineering) the already dumped solid waste with final closure;
- Developing a sanitary landfill facility for the future waste disposal;
- Prevention of ground water contamination, with adequate containment measures.

D) Design of Landfill at Ringdang

Basic Data:

Location	:	Ringdang, Mangan, North Sikkim
Waste Generation	:	19.54 Tonnes per Day (2021) Design
Life	:	Active Period = 20 years
		Closure & Post Closure Period = 20 years
Topography	:	Sloping ground NE to SW
Sub soil	:	Sandy soil
Water Table	:	20 m below ground surface
Average total Precipitation	:	2478 mm per year
Compacted Density	:	0.8 T/cum
Volume of Liner system	:	is considered below the datum of Landfill Base
Rejects from Bio methanation Plant	:	0%

❖ Waste Generation (2021)	=	19.54 TPD
❖ Estimated Waste Generation after 20 years	=	29.26 TPD
❖ Total Waste quantity in 20 years	=	0.5 (19.54 +29.26) x 365 x 20
	=	178120 Tonnes
❖ Only 10% goes to landfill	=	17812 Tonnes
❖ Total Waste Volume (assumed density of 0.8 tonnes/cum)	=	17812/0.8
	=	22265 cum
❖ Volume of Daily Cover	=	10%

= 0.1 x 22265 cum

= 2226.5 cum

- Settlement = 10 %

= 0.1 x 22265 cum

= 2226.5 cum

- First Estimate of Landfill Volume Ci = (22265+2226.5-2226.5)

= 22265 cum

- Type of Landfill – Above ground Landfill with in RCC Retaining Wall containment

Height of Landfill

It is proposed to construct vertical walls on three sides to contain the waste. Since the general terrain of the site is sloping, the height of retaining wall would rangefrom a minimum height of 10 meters to maximum of 15 meters.

Formation of Retaining Wall

RCC Retaining Wall: The Structural Design of the walls shall be submitted for prior approval before execution at site.

Life of Landfill

In case of proper utilization of this landfill the life of the landfill may be upto 20 years. This shall ensure without dumping any mixed waste and also to produce compost from the wet waste. Based on above consideration the life of landfill is detailed below;

E) Design of Various works proposed for Landfill at Ringdang

Up-gradation of the surface for new landfill

Up gradating the present uneven ground, bushes is proposed for the existing site at Ringdang.

Design of Liner System

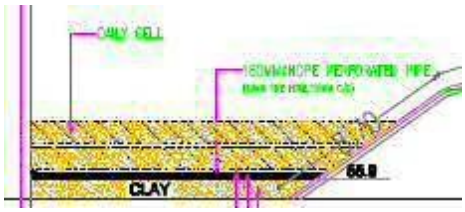
According to the Solid Waste Management Rules, 2016 of MoEF, the base oflandfill facility, to avoid contamination of ground water resources should be at least 2.0 m above the shallowest ground water table. The landfill is a sloping terrain and exposed surfaces with open ditches with various depths and ground water is not observed. Liner system within a landfill involves prevention of percolation of leachate from waste in landfill to the sub-soil by a suitable protective system (liner system). The liner system proposed comprises a combination of barrier material such as natural clay and amended soil and a flexible geo-membrane (1.5 mm thick HDPE sheet). The liner system will be of low permeability and will be robust, durable and to resist the chemical attack, puncture, rupture, etc.

Bottom Liner for Landfill :

A 90 cm thick of clay liner is constructed using wet clay or soil amended with

bentonite or other agents, having coefficient of permeability not greater than 1 x 10-7 cm/sec, laid in layers of 150 mm thickness, tamped and the top surface smooth finished, The liner system is designed in compliance with Solid Waste Management Rules 2016 and, will comprise, a 90 cm thick compacted clay or amended soil (Bentonite amended soil) of permeability not greater than $1x10^{-7}$, a

HDPE geo-membrane liner of thickness 1.5mm and a drainage layer of 30 cm thick granular material of permeability not greater than $1x10^{-2}$ cm/sec. After the preparation of the amended soil liner, the liner should be constructed in series of lifts each of 25cm compacted to about 15cm by four to five passes of sheep foot roller. The finished thickness of the liner should be 90 cm and the final permeability of the amended soil should also be checked for the desired permeability of $1x10^{-7}$. The cross section of proposed landfill site is presented in the drawing below.



Geo-Membrane Liner

Geo-membrane is relatively a thin sheet of flexible thermoplastic orthermopolymeric material. Because of their inherent impermeability, geo-membranes are proposed as barrier layer in landfill site. Even though geo- membranes are highly impermeable, their safety against manufacturing, installation, handling and other defects is essential criteria in design of linersystem.

The thickness of geo-membrane against puncture is determined as below, with various factors being considered, as indicated in the following tables.

Design Parameters for Geo-Membrane Liner

Item	Details
Factor of Safety Against Puncture	2.50
Unit Weight of Solid Waste	8.33 KN / m^3
Depth of Fill	8 m
Height of protrusion above drainage layer	25 mm
Modification Factor for Protrusion Shape	1.00
Modification Factor for Packing Density	1.00
Modification Factor for Arching in Solids	1.00
Reduction Factor for Long-Term Creep	1.00
Reduction Factor for Long-Term Chemical/Biological Degradation	1.30

The effectiveness of barrier layer basically depends on the hydraulic conductivityof the clay/amended soil liner and density of the geo-membrane. The clay/amended soil liner is effective only if it is compacted properly and geo- membrane liner is effective only if it has the density or mass per unit area is sufficient enough against punctures. The mass per unit area is calculated based onthe following factors.

Factor of Safety (F) = (P_{al} / P_{ac})

P_{al} = Allowable Pressure for different Types of Geo-Membrane;

P_{ac} = Actual Pressure due to landfill = W x D;

$P_{al} = [50 + 0.00045(M/H^2)]$ X $[1/(MF_s \times MF_p \times MF_a)]$ x $[1/(RF_{cr} \times RF_{cbd})]$;

M = Geomembrane Mass per Unit Area;

H = Height of protrusion above drainage layer;W

= Unit Weight of Solid Waste;

D = Depth of Fill;

MF_s = Modification Factor for Protrusion Shape;

MF_p = Modification Factor for Packing Density; MF_a

= Modification Factor for Arching in Solids; RF_{cr} =

Reduction Factor for Long-Term Creep; and

RF_{cbd} = Reduction Factor for Long-Term Chemical/Biological Degradation.

Modification and Reeducation Factors for Geo-Membrane

MF_s		**MF_p**		**MF_a**	
Angular	1.00	Isolated	1.00	Hydrostatic	1.00
Subrounded	0.50	Dense, 38mm	0.83	Geostatic, Shallow	0.75
Rounded	0.25	Dense, 25mm	0.67	Geostatic, Moderate	0.50
		Dense, 12mm	0.50	Geostatic, Deep	0.25

Reduction Factor for Long-Term Creep

Mass/Unit Area (g/m^2)	**Protrusion (mm)**		
	38	*25*	*12*
270	NR	NR	> 1.5
550	NR	1.5	1.3
1,100	1.3	1.2	1.1
>1,100	1.2	1.1	1.0

Reduction Factor for Long-Term Chemical/Biological Degradation

Rate of Leachate Generation	**Reduction Factor**
Mild Leachate	1.1
Moderate Leachate	1.3
Harsh Leachate	1.5

Based on the parameters / factors presented in tables 77 to 80, the required density of geo-membrane is calculated as 1.01 gm/cc, and thickness as 1.5 mm.

Typical Values for Geo-Membrane Measure in Performance Tests

Property	**Typical Value**

1. Thickness	1.5 mm
2. Density	0.94 gm/cc
Property	**Typical Value**
3. Roll Width x Length	6.5 m x 150 m
4. Tensile Strength	
a. Tensile Strength at Yield	24 kN/m
b. Tensile Strength at Break	42 kN/m
c. Elongation at Yield	15 %
d. Elongation at Break	700 %
e. Secant Modulus (1%)	500 MPa
5. Toughness	
a. Tear Resistance (initiation)	200 N
b. Puncture Resistance	480 N
c. Low Temperature Brittleness	-94 □F
6. Durability	
a. Carbon Black	□2 %
b. Carbon Black Dispersion	A - 1
c. Accelerated Heat Ageing	Negligible Strength Changes after 1 month at 110 □C
7. Chemical Resistance	
a. Resistance to Chemical Waste Mixture	10 % Strength Change Over 120 days
b. Resistance to Chemical Reagents	10 % Strength Change Over 7 days
8. Environmental Stress Crack Resistance	1500 hrs
9. Dimensional Stability	2 %
10. Seam Strength	80 % or more (of Tensile Strength)

Source: Page 386, CPHEEO Manual.

Side Lining with Geo-synthetic Clay Liner (GCL)

As per MSW Rules 2016, the sides of the landfill are to be impervious. In the present

context since Retaining wall is a vertical structure it is difficult to provide clay lining facility. Also the steep sloping sides are not possible for 90 m thick clay liner. Therefore Geo-synthetic Clay Liner (GCL) of equivalent permeability

requirement was proposed for the sides of landfill.

F) Leachate Collection & Removal System (LCRS)

Leachate refers to the liquid that has passed through or emerged from solid waste and contains dissolved and suspended materials from solid waste. Leachate is generated due to exposure of uncovered waste to the precipitation and should be collected and treated to prevent contamination of ground water.

Assessment of Leachate Quantity

The leachate generation is a function of precipitation and is directly proportional to rainfall intensity and surface area.

Post Closure Leachate Leakage.

After construction of final cover, only that water, which can infiltrate through final cover percolates through the waste and generates leachate. The major quantity of precipitation will be converted to surface runoff. Therefore the leachate generation rate after closure of landfill is always less than the pre closureperiod (active life).

Leachate Collection Network System

Leachate collection system to collect above calculated quantity comprises a network of pipes known as feeder pipes and header pipes. The primary function of leachate collection system is to collect and convey the leachate out of the landfill unit and control the depth of the leachate above the liner. As per USEPA Manual the leachate collection system should be designed to maintain a leachate depth or head of 30cm above the liner. The design leachate head is very important as flow of leachate through imperfections in the liner system increaseswith an increase in leachate head above liner. The main components of leachate collection system are feeder mains and header main and leachate collection sump. The design of above collection network has considered the following factors:

- The required flow using known percolation impingement rates and pipe spacing;
- Pipe size using required flow and maximum slope; and
- Structural strength of the pipes.

Sizing of feeder and header pipes

This is calculated by using hydraulic principle and the following equation is derived:

Diameter of Pipe, D = $\sqrt{(A \times Q) / (\prod \times N \times V)}$

A = Area of Segment Considered for Design;Q

= Leachate Flow Rate;

N = Number of Pipes in each Segment; and

V = Velocity of Flow (allowable hydraulic velocity).

In view of the small size of the landfill, the design calculations for leachatecollection network yields a smaller diameter pipes which generally not feasible. Therefore a minimum size of 110 mm HDPE pipes is recommended for feeder pipe. The leachate from feeder pipes flow into header pipe with ultimately transferred to leachate collection sump. Similarly the header pipes are designed to take the flow from feeder pipe and accordingly a minimum size of 150 mm is recommended.

*The spacing of leachate pipe*s is worked out by the Mound Model. The maximum height of fluid between two parallel drainage pipes is calculated based on the following formula:

$$h_{max} = \{[(L \times C^{0.5}) / 2] \times [(\tan^2 a) / c]\} + 1 - \{[(\tan a / c)] \times [(\tan^2 a + c)^{0.5}]\}$$

Where, c = q/k

h_{max} = Maximum Hydraulic Depth (30 cm)

L = Distance between the Pipesk

= Permeability, 8.64 m/day

q = Inflow Rate, 0.00994 m^3/m^2/day

a = Slope, 2%

Accordingly and considering the sensitivity of the site, the design features etc. the spacing between feeder pipes are spaced at 15 m and same is recommended in the design.

Feeder and Header Pipe Material

Perforated drainage pipes provide long-term performance and these pipes transmit fluids rapidly and maintain good service lives. Considering the above, HDPE perforated pipes of the above design size are considered in the design. It will be ensured that the depth of the drainage layer is deeper than the diameter of the pipe. The pipes will be placed in trenches to provide the extra depth. In addition, the trench serves as a sump (low point) for leachate collection.

Feeder Pipe – 110 mm dia
Header Pipe – 160 mm dia

Drainage Layer

A 200 mm thick graded pebble and 100 mm thick sand layer is provisioned as drainage layer to facilitate the removal of leachate.

Leachate Collection Sump/ Well

The purpose of leachate collection sump is to collect leachate from header pipes, active landfill area and compost plant. The leachate will be collected through header pipe and discharged in the leachate collection sump / well, provided at the leachate treatment plant.

Leachate Treatment Plant

It is estimated that the landfill generates about 25 m^3 of leachate, the quality of

leachate is a function of waste characteristics and climatic conditions, especially precipitation. The leachate is generally expected to be high in TDS, BOD and Heavy metals. Treatment of the same involves a combination of technologies. The characteristics of leachate vary with time and town and also based on the type of waste disposed off in the landfill. However, for the design purposes the following characteristics are considered for leachate.

Design Base

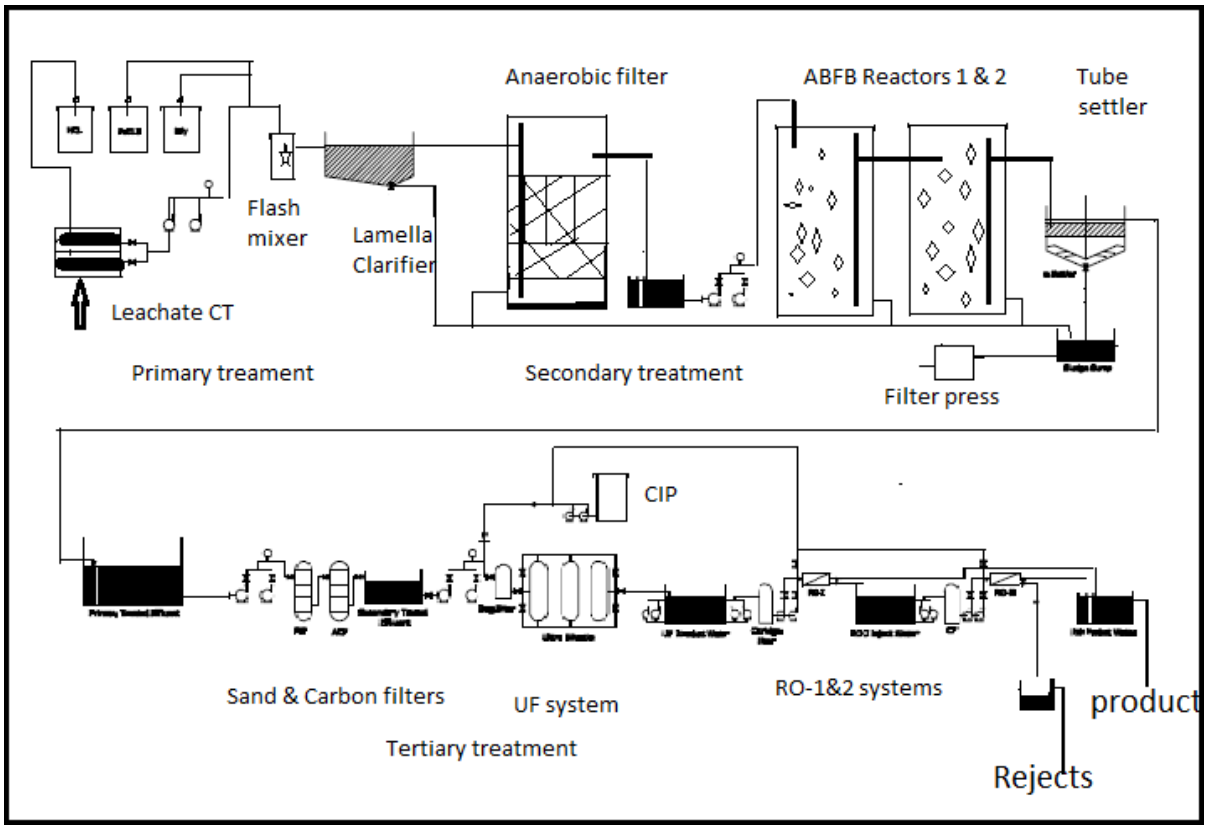
The leachate treatment Plant is designed based on the following parameters

S.No.	Parameter	Raw Leachate	Treated Leachate Inland disposal Standards (MSW rules2000 and SPCB)
1	pH	5.0- 9.0	7.5- 8.5
2	TDS	<30,000 mg/lt.	<2100 mg/lt.
3	BOD	5000 mg/lt.	<30 mg/lt.
4	COD	<15,000 mg/lt.	<250 mg/lt.
5	Oil and Grease	<50 mg/lt.	<10 mg/lt.
6	TSS	<3500mg/lt.	<100 mg/lt.
7	NH4	<500 mg/lt.	<50mg/lt.

In order to meet the above leachate effluent standards, the combination of primary, secondary and tertiary treatment followed by Reverse Osmosis is proposed. The schematic of the treatment process is given below;

PROCESS FLOW

LEACHATE → GRIT CHAMBER → OIL& GREASE TRAPS→LEACHATE COLLECTION TANK→FEED PUMPS→FLASH MIXER CUM LAMELLA CLARIFIER→ANAEROBIC REACTOR → ABFB REACTOR-1→ → ABFB REACTOR -2→ TUBE SETTLER→ INTERMITTENT COLLECTION TANK→ ONLINE HYPO DOSING →DECHLORINATION →MGF →ACF→ULTRAFILTERATION system→RO FEEDTANK→RO SYSTEM→PERMEATE COLLECTION TANK→Disposal/Gardening



PRIMARY TREATMENT

The Primary Treatment is aimed for Total Suspended Solids (TSS) removal efficiency: 70-80% and BOD/COD removal efficiency: 30%). The salient features include,

- Collection cum Equalization tank: To maintain homogeneous conditions of Leachate.
- Chemical Precipitation for Ammonia Stripping
- Flash mixer for addition and mixing of coagulants.
- Lamella clarifier for removal of the suspended solids in the leachate by using inclined plate separation process.

TECHNICAL DETAILS FOR LTP UNITS

1. COLLECTION TANK

No. of tanks	: ONE
Size (m)	: 5 x3 X2.5 SWD (with one partion)
MOC	: MSEP
Free board	: 0.5 m
Volume	: 37.5 M3
HDT	: 36 hours

2. LAMELLA CLARIFIER WITH FLASH MIXER

Size	: 1 X2 X1.8 m
MOC	: MSEP
Volume	: 3.5 M3
No. of Plates	: 10
MOC of Plates	: FRP
Max. Operating Flow	: 1.25cum. /hr.
Internal Protection	: Epoxy
Flash mixer tank	: 500 liters.
Agitator	: 0.5 HP/200rpm
Make	: PBGL/equivalent

SECONDARY TREATMENT

ANAEROBIC FILTER

The Anaerobic Filter is a fixed film anaerobic filter and equipped with PVC

corrugated media of specific block dimensions and arranged one on top of other.

The BOD/COD reduction can be achieved by virtue of anaerobic microbial activities. The efficiency of the anaerobic filter is 40%.

3. ANAEROBIC FILTER

No. of tanks	: One
Size (m)	: 3.5 dia and 5.0 H
MOC	: MSEP
Free board	: 0.5 m
Volume	: 48 M3
HDT	: 46 hours
Expected COD removal efficiency	: 40%

AEROBIC BIOLOGICAL FLUIDIZED REACTOR (ABFBR)

It is a combination of suspended and attached growth system. It is filled up with small carrier elements. The elements are made up of PVC material and biomass stick on the surface of the spiral media. Here the BOD/COD reduction can be achieved by virtue of aerobic microbial activities. The Oxygen will be supplied through fine air bubble diffusers with the help of twin lobe air blowers. The efficiency of the Reactor is 80 -85%

4. AEROBIC BIOLOGICAL FLUIDIZED BED REATORS

No. of tanks	: Two
Size (m)	: 3 x2.5 x 4.5 SWD
MOC	: MSEP
Free board	: 0.5 m
Volume	: 30KL each
HDT	: 57.5 hours
Expected COD removal efficiency	: 60% (each sage)
Proposed blower capacity	: 230 m3/hour at 5.0 m WC, 10 HP for both reactors

TUBE SETTLER (SECONDARY CLARIFIER)

It is a gravity separation for removal of suspended and colloidal materials. It is ainclined settling system like lamella clarifier. This system is works with respect tothe direction of liquid flow relate to the direction of particle settlement. Finally sludge will be settled in the hopper bottom.

5 TUBE SETTLERS	
No. of tanks	: One
Size (m)	: 1.5 x 1.5 x 2.5 SWD
MOC	: MSEP
Free board	: 0.5 m
Volume	: 5.65 M3
HDT	: 4.50 hours

SLUDGE HANDLING SYSTEM - FILTER PRESS (RECESSED TYPE)

It is used for sludge dewatering. It consists of a number of chamber plates with filter cloth mounted vertically on and between two side bars. The plates are closed by using Hydraulic closing power pack. Sludge is fed in to filter press by a suitable pumping system through central inlet. The solid particles deposit on thefilter cloth forming the layer.

6. INTERMEDIATE COLLECTION TANK		7. SLUDGE COLLECTION TANK	
No. of tanks	: One	No. of tanks	: One
Size (m)	: 2 x2 x 2.5	Capacity	: 5kl
MOC	: MSEP	MOC	: HDPE
Free board	: 0.5 m	Stirrer	: one
Volume	: 10.00 M3		
HDT	: 8 hours		

TERTIARY TREATMENT:

Multi grade sand filter and Activated carbon filter. Ultra filtration unit: for 90% recovery.
First stage RO system: 50-55% recovery. Second

Stage RO system: 25-35% recovery.Total System
Recovery: 70%.

TWO STAGE REVERSE OSMOSIS (RO) SYSTEM

The RO membrane has small pore sizes (0.0001) which do not allow ions to pass through. The feed stream is split into two streams one is the permeate (product) which is low TDS and other is the reject containing all the rejected salts. The total system Recovery: 70% RO membranes import from USA.

Mechanical Equipments

MACHINERY AND EQUIPMENT:

1. FEED PUMPS:

No. off	: Two (1W + 1S)
Make	: CNP/Equivalent
Type	: Submersible
Head	: 10 m
Capacity	: 2.5 CUM. /Hr.
MOC	: CI (Non – clogging)
HP	: 1.0

2. BLOWERS FOR COLLECTION/EQ. TANKS

No. off	: Two (1W + 1S)
Make	: Everest/Equivalent
Head	: 40 mm
Air	: 50 cum/hr @ 4.5 m WC
Type	: Twin Lobe
Motor	: Crompton greaves/Kirloskar
HP	: 3

3. BLOWERS FOR AERATION TANKS (FAB Reactor-1&2)

No. off	: Two
Make	: Everest/Equivalent
Head	: 5000 mm
Air	: 230 cum/hr @ 5.0 m WC
Type	: Twin Lobe
Motor	: Crompton greaves/Kirloskar
HP	: 10

Urban Devel

4. FABR sludge recirculation pumps

No. off	: Two (1W + 1S)
Make	: Kirlosker/Johnson /Equivalent
Head	: 10 m
Capacity	: 2.5CUM. /Hr.
MOC	: CI
HP	: 1

5. FILTER PRESS FEED PUMPS:

No. off	: Two (1W+1S)
Make	: KIRLOSKAR/ SYNO/Equivalent
Head	: 20m
MOC	: CI
Flow Rate	: 2,000 liters/hr.
HP	: 2

6. FILTER PRESS

No. off	:	One
Make	:	Yotana/ Sachin
Size (MM)	:	450x450
MOC	:	CS structure and PP plates
No. off plates	:	15
Filter cloth	:	one set
Closing mechanism	:	Hydraulic power pack
Power pack motor	:	2HP
RPM	:	1440

7. FINE BUBBLE DIFFUSERS:

No. off : 20 nos.

Size : 900dia x 1000 mm long.

Make : Southern cogen

8. LIME DOSING TANK with stirrer

No. off : One.

Size : 800 dia, height 1000mm.

Make : FRP

9. ALUM, & PAC DOSING TANKS

No. off : 2 nos.

Size : 200 L.

Make : HDPE

10. Dosing pumps

No. off : 2 nos.

Dosing pumps : E DOSE/Milton roy/Equivalent

Capacity : 10 lit/hr

11. MS PIPES &VALVES : ONE LOT

12. MAGNETIC FLOW METER : RLT/EQUVALENT (40MM)

PARAMETER	#Raw effluent	Primary treatment O/L	Secondary treatment o/l	RO PLANT Permeate
COD, mg/l	6,500	4500	500	<250 mg/l
BOD, mg/l	5,000	3500	280	<30 mg/l
TSS, mg/l	3000	700	100	traces
TDS, mg/l	20000	20000	14000	2000 mg/l

1. Primary treatment TSS removal efficiency up to 70-80%, BOD/COD removal efficiency 30%.
2. Secondary treatment
   a) Anaerobic filter : Overall efficiency: 40%
   b) Aerobic treatment with Fluidized aerobic bio reactor (FAB) technology, COD removal efficiency in each reactor minimum 60% & overall efficiency up to 84.5% and BOD removal efficiency is 92%.
   c) Organic TDS removal efficiency is up to 85 % (we consider TDS-organic is 40% and TDS – Inorganic is 60%)
3. Tertiary treatment
   d) Ultra Filtration unit
      TSS removal efficiency is 95%.
   e) RO PLANT TDS removal efficiency is 90%.

POWER CONSUMTION

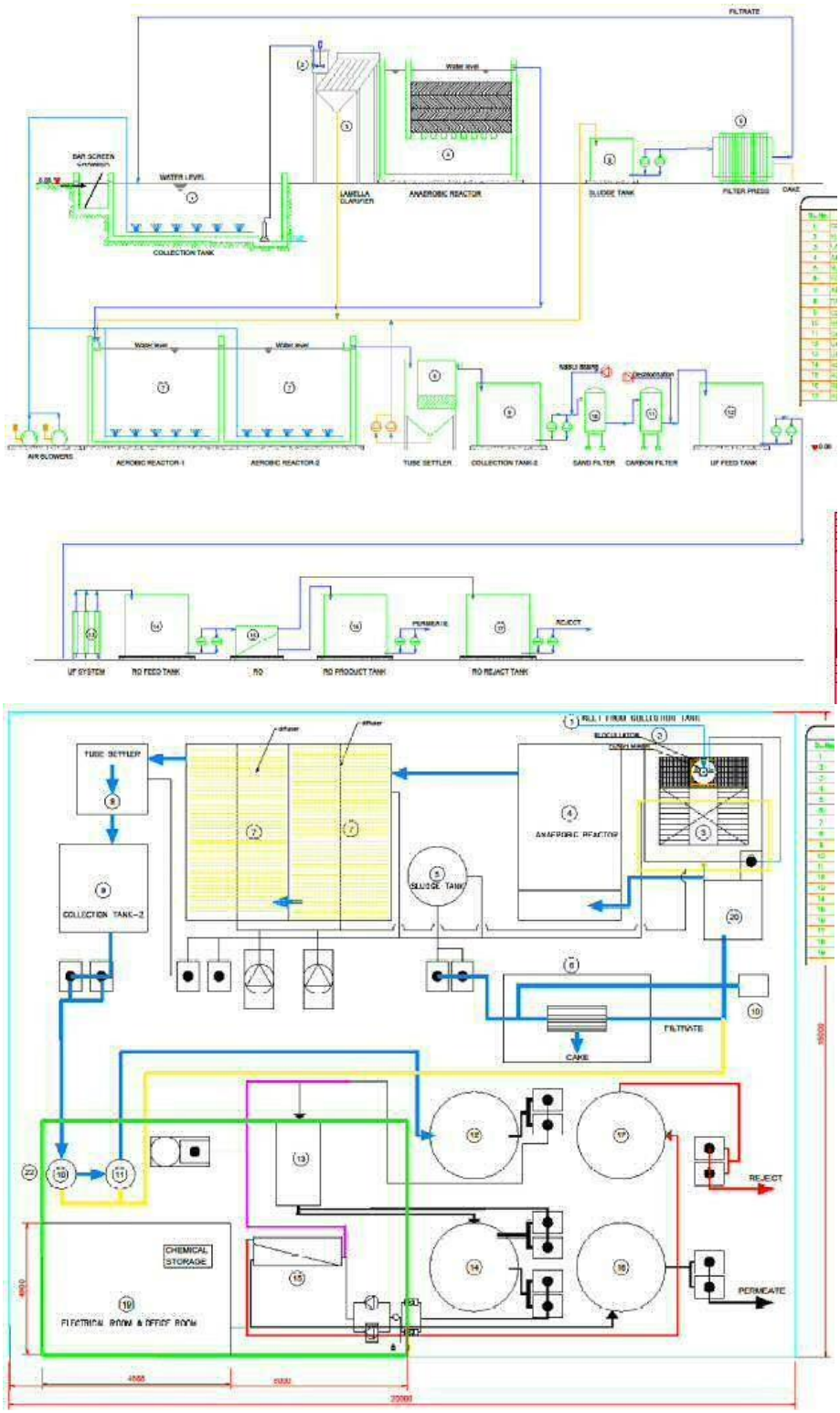
S.no	Description	Working Load HP	Standby HP	Connected Load –HP
1	Feed pumps	1	1	2
2	Air blowers for Collection/EQ. tank	3	3	6
3	Air blowers for FABR-1	10	10	20
6	FAB-2 sludge recirculation pumps	1	1	2
7	Filter press power pack	2	-	2
8	Dosing pumps & stirrers	1.0	--	1.0
9	Filter Press sludge feed pumps	2	2	4
14	Plant lighting	1	-	1
	Total	21	17	38

Influent	Treatment Process		Reduction %	Effluent
5000	Primary Treatment	pH, Coagulation/Floc	30	3500
3500	SecondaryTreatment	Anaerobic Filter -	92	280
		Aerobic - Fluidized Bed Rector		280
280	Tertiary Treatment	Ultra Filtration /Reverse Osmosis	90	28

The leachate shall be treated to the required standards as per the guidelines laidout in MSW Rules 2000.

Sl	Parameter	Standards (Mode of Disposal)		
		Inland surface water	Public sewers	Land disposal
1.	Suspended solids, mg/l, max	100	600	200
2.	Dissolved solids (inorganic) mg/l, max.	2100	2100	2100
3	PH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
4	Ammonical nitrogen (as N), mg/l, max.	50	50	-
5	Total Kjeldahl nitrogen (as N), mg/l, max.	100	-	-
6	Biochemical oxygen demand (3 days at 27^0 C) max. (mg/l)	30	350	100
7	Chemical oxygen demand, mg/l, max.	250	-	-
8	Arsenic (as As), mg/l, max	0.2	0.2	0.2
9	Mercury (as Hg), mg/l, max	0.01	0.01	-
10	Lead (as Pb), mg/l, max	0.1	1.0	-
11	Cadmium (as Cd), mg/l, max	2.0	1.0	-
12	Total Chromium (as Cr), mg/l, max.	2.0	2.0	-
13	Copper (as Cu), mg/l, max.	3.0	3.0	-
14	Zinc (as Zn), mg/l, max.	5.0	15	-
15	Nickel (as Ni), mg/l, max	3.0	3.0	-
16	Cyanide (as CN), mg/l, max.	0.2	2.0	0.2
17	Chloride (as Cl), mg/l, max.	1000	1000	600
18	Fluoride (as F), mg/l, max	2.0	1.5	-
19	Phenolic compounds (as C_6H_5OH) mg/l, max.	1.0	5.0	-

The proposed Leachate Treatment Plant details are given for entire site ispresented below;



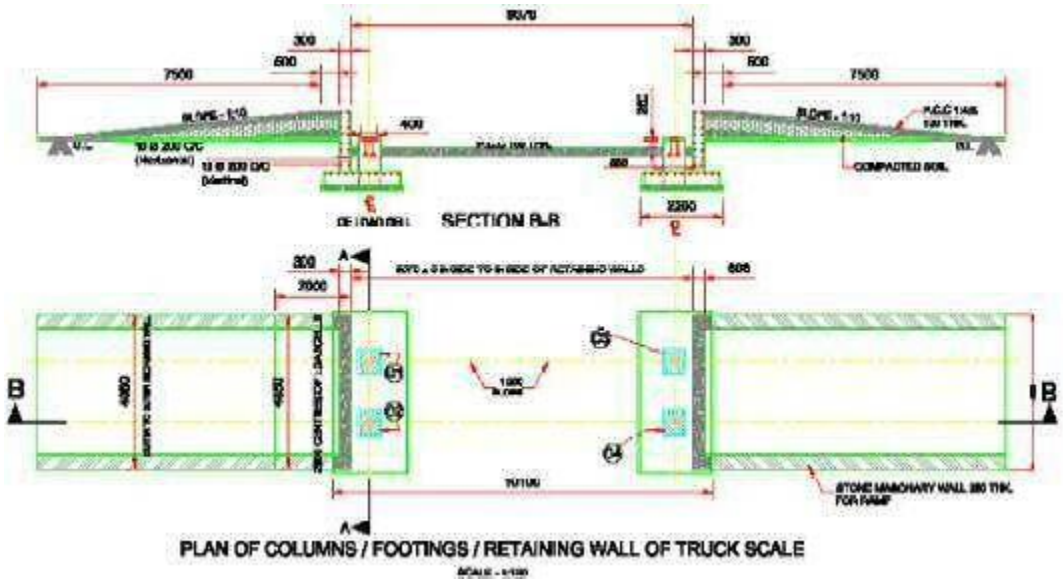
Leachate Treatment Plant

Urban Development & Housing Department (UD&HD), Govt. of Sikkim

LANDFILL ASSOCIATED INFRASTRUCTURE FACILITIES

In continuation to the above scientifically designed sanitary landfill as per the SWM Rules 2016, there is a need for associated infrastructure to be developed to facilitate management of long term landfill operation and maintenance period efficiently. This would involve development of the landfill site with provision of the basic infrastructure of proper road access, fence, weighbridge, toilet facility with bathrooms for staff, green belt/buffer zone, water supply, lighting etc. The same are mentioned below.

- A 30 T capacity Weigh Bridge to record the incoming waste and outgoing compost and other dry recyclables. The Typical Plan showing the construction of Weigh Bridge is presented in **Drawing below**



- Proposed Approach/Access Roads (Internal roads) of 150 m approx is proposed
- Chain link fencing is proposed all around the site for a length of 436 m. The height of the fence is 2.5 m with MS angular poles fabricated out of 2 equal angles of 65x65x6 mm.
- Storm water drainage network all along the access and haul roads are proposed;
- Internal Water supply facilities and PVC storage tank is provisioned with 5000 liters capacity;
- Vegetative cover (with rows of trees) all around the landfill site boundary meters is proposed for Green belt.
- Toilet facilities for Ladies and Gents (140sqm) are made. The proposed plan showing Toilet details is presented below;
- Monitoring well at two locations to cover both upstream and downstream data are provisioned

- Electrical Works for the street lighting and internal lighting is provisioned.
- No handling machineries like front end loader with Backhoe and/orcompactor is provisioned.

FINAL CLOSURE & ENVIRONMENTAL MONITORING PLAN

Operation Phases

Daily Soil Cover: Wastes shall be covered immediately or at the end of each working day with minimum 10 cm of soil, inert debris or construction material tillsuch time waste processing facilities for composting or recycling or energy recovery are set up as per Schedule I of MSW Rules 2000.

Intermediate Cover/ Monsoon Cover:

Prior to the commencement of monsoon season, an intermediate cover of 40-65 cm thickness of soil shall be placed on the landfill with proper compaction and grading to prevent infiltration during monsoon. Proper drainage berms shall be constructed to divert run-off away from the active cell of the landfill.
The waste shall be filled upto RL of 90.00 m forms the first phase of operation. The second phase of landfill operation starts above this RL with every 3 m of height referring to each phases subsequently.

The final cover system shall than be done above RL. 96.00 m and will comprise a 600 mm thick compacted clay barrier layer of permeability $1x10^{-7}$ cm/sec, followed by a drainage layer of 150 mm thick granular material of permeability $1x10^{-2}$ cm/sec and a 300 mm thick vegetative layer.

Availability of Cover Soil:

The Authority shall have to arrange for suitable cover soil from the various tunneling operations etc and suitable directions are required to be issued by District Authorities.

Closure of Landfill site and Post - Care

The post-closure care of landfill site shall be conducted after 20 years and long-term monitoring to assess; (i) Maintaining integrity and effectiveness of final cover and repair required, (ii) Efficiency of leachate collection system, (iii) Ground Water quality and action required to improve, (iv) Maintenance and Operation of gas collection system to meet the standards. The closed landfill may be used for human settlement after 15 years of post-closure care by ensuring gaseous emission and leachate compliance.

Gas venting layer

The Department shall have to take up separately during 2040-41, the final cover system with gas venting layer, gas vent pipe, compacted clay barrier layer of permeability $1x10^{-7}$ cm/sec, and followed by a drainage layer of 150 mm thick granular material of permeability $1x10^{-2}$ cm/sec and a suitable vegetative layer

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CHAPTER-III DESCRIPTION OF THE ENVIRONMENT

CHAPTER-III

DESCRIPTION OF THE ENVIRONMENT

3.1 PREAMBLE

Baseline environmental status in and around the proposed project depicts the existing environmental conditions of air, water, noise, soil, biological and socio-economic environment. With proposed project as the center, a radial distance of 10 km is considered as 'study area' for baseline data collection. Baseline data was collected for various environmental attributes so as to compute the impacts that are likely to arise due to proposed developmental activity.

The main aim of the impact assessment study is to find out the impact of the project on the environment. This study is carried out during the project planning stage itself, so that the proponent can implement the project in a technically, financially and environmentally sustainable.

The success of any impact assessment study depends mainly on two factors. First is estimation of impact from proposed project on the environment and the second is assessment of the environmental condition. Both are key factors to arrive at the post project scenario. The estimated impact due to the proposal can be superimposed over the existing conditions to arrive at the post project scenario. The baseline data generation has been carried out in the summer season (Dec. 2021-Feb. 2022).

3.2 METEOROLOGICAL CONDITIONS

The study of meteorological conditions forms an intrinsic part of the environment impact assessment study. The meteorological conditions of an area and the process are both intertwined and each has a definite influence over the other. Favorable weather conditions and the surroundings help the successful operation of a facility, while the activities influence the weather in both positive as well as negative ways.

Dispersion of different air pollutants released in to the atmosphere has significant impacts on neighborhood air environment. The dispersion/dilution of the released pollutant over a large area will result in considerable reduction of the concentration of a pollutant. The dispersion in turn depends on the weather conditions like the wind speed, direction, temperature, relative humidity, mixing height, cloud cover and also the rainfall in the area. Impacts surrounding the project site are studied in detail.

3.2.1 Analysis of the IMD Data

Regional meteorological scenario helps to understand the climatic factors. It also helps in determining the sampling stations in predicting the post project environmental scenario. Meteorological scenario

exerts a critical influence on Air Quality as the pollution arises from the interaction of atmospheric contaminants with adverse meteorological conditions such as temperature inversions, atmospheric stability and topographical features like hills, canyons and valleys.

The critical weather elements that influence air pollution are wind speed, wind direction, temperature which together determines atmosphere stability. Hence it is indispensable part of any air pollution studies and requires interpretation of baseline information. The Temperature, Humidity, Rainfall and wind speed as per IMD, Gangtok Climatologically Tables shown in **Table 3.1.**

Table 3.1 Meteorological Data from IMD, Climatological (1981-2010)

IMD Station–Gangtok, Distance from proposed site 22 km SE					
Month	**Temperature**		**Relative Humidity**		**Rainfall**
	Min	**Max**	**Min**	**Max**	**Total**
January	1.8	16.4	77	83	27.1
February	2.7	18.0	78	85	72.2
March	5.5	22.7	76	80	126.4
April	8.2	24.0	78	78	296.9
May	11.0	25.0	85	87	496.4
June	14.0	25.2	89	93	609.8
July	15.6	25.0	92	95	626.3
August	15.4	26.0	92	94	565.9
September	13.7	25.3	90	94	438.7
October	9.9	24.0	83	87	173.4
November	6.5	20.6	79	82	37.9
December	3.3	17.4	77	81	19.5

Source: GOI, Ministry of Earth Sciences, IMD, Climatological Tables - 1981-2010

3.2.2 Meteorological Scenario of the Study Area

Wind speed and direction data recorded during the study period is useful in identifying the influence of meteorology on the air quality of the area. The meteorological data recorded at the site for the study period is used for the preparation of the wind rose on sixteen- sector basis (N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW and NNW).

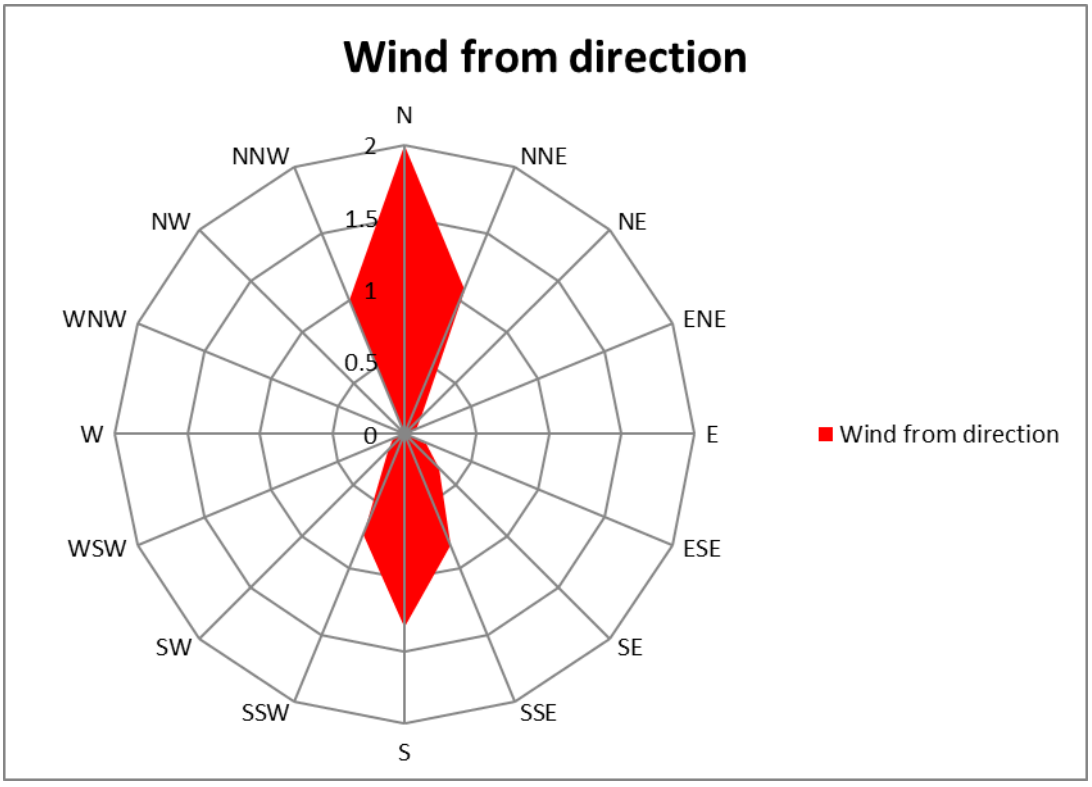
The maximum and minimum temperatures, relative humidity, rainfall recorded, wind speed and predominant wind direction observed are given in **Table 3.2.**

TABLE 3.2 OBSERVED METEOROLOGICAL DATA ONSITE

Period	Temp (°C)		Humidity (%)		Rainfall	Predominant wind direction
	Min	Max	Min	Max	(mm)	
December 2021	17.4	3.3	77	81	19.5	N to S
January 2021	16.4	1.8	77	83	27.1	
February 2022	18.0	2.7	78	85	72.2	

- The predominant wind direction in the Season (Dec. 2021 – Feb. 2021) N with average wind speed of 2 kmph

FIGURE 3.1 WIND ROSE MARCH 2021 TO MAY 2021



3.3 AMBIENT AIR QUALITY

The study area represents mostly rural and urban environment. The baseline status of the ambient air quality has been assessed through a scientifically designed ambient air quality network. The design of monitoring network in the air quality surveillance program has been based on the following considerations.

- Meteorological conditions on a synoptic scale

- Topography of the study area
- Representation of the regional background levels
- Representation of the plant site
- Influence of the existing sources
- Major settlements in the study area

Ambient air quality monitoring stations were set up for 5 different locations with consideration in the above mentioned points. The locations were selected in downwind, cross wind and up wind of the proposed project. The detail monitoring stations is given Table 3.4 and air quality monitoring location on base map is represented in Figure 3.2.The common air pollutants namely Particulate matter (PM10& PM2.5), Sulphur dioxide (SO2), the oxides of nitrogen (NOX), Carbon Monoxide (CO), Ammonia (NH3), Benzene (C6H6), Methane (CH4) Lead (Pb), Nickel (Ni), Ozone (O3), Arsenic (As), Hydrogen Sulfide (H2S) and Benzo (a) Pyrene (BaP) were sampled on 8/24 hourly and results were averaged to 24 hours to meet the requirements of the MoEF&CC and compared with the standards stipulated by CPCB. The detailed ambient air quality levels are given in Table 3.3 – 3.8.

TABLE 3.3 AIR QUALITY MONITORING LOCATIONS

Code	Name of the Location	W.R.T Site			Latitude (N)	Longitude (E)
		Direction	Wind	Distance km		
AAQ1	Project Site	-	-	-	27°30'44.00"N	88°31'49.60"E
AAQ2	Teesta Urja Ltd Office	NE	Up wind	2	27°31'31.30"N	88°32'39.57"E
AAQ3	Salim Pakel	NNE	Up wind	3.8	27°32'20.79"N	88°33'19.55"E
AAQ4	Near Lingdong	SW	Down wind	1.4	27°30'8.53"N	88°31'19.05"E
AAQ5	Unknown	N	Up wind	2.7	27°32'6.27"N	88°32'25.31"E

FIGURE 3.2 AMBIENT AIR QUALITY MONITORING LOCATIONS

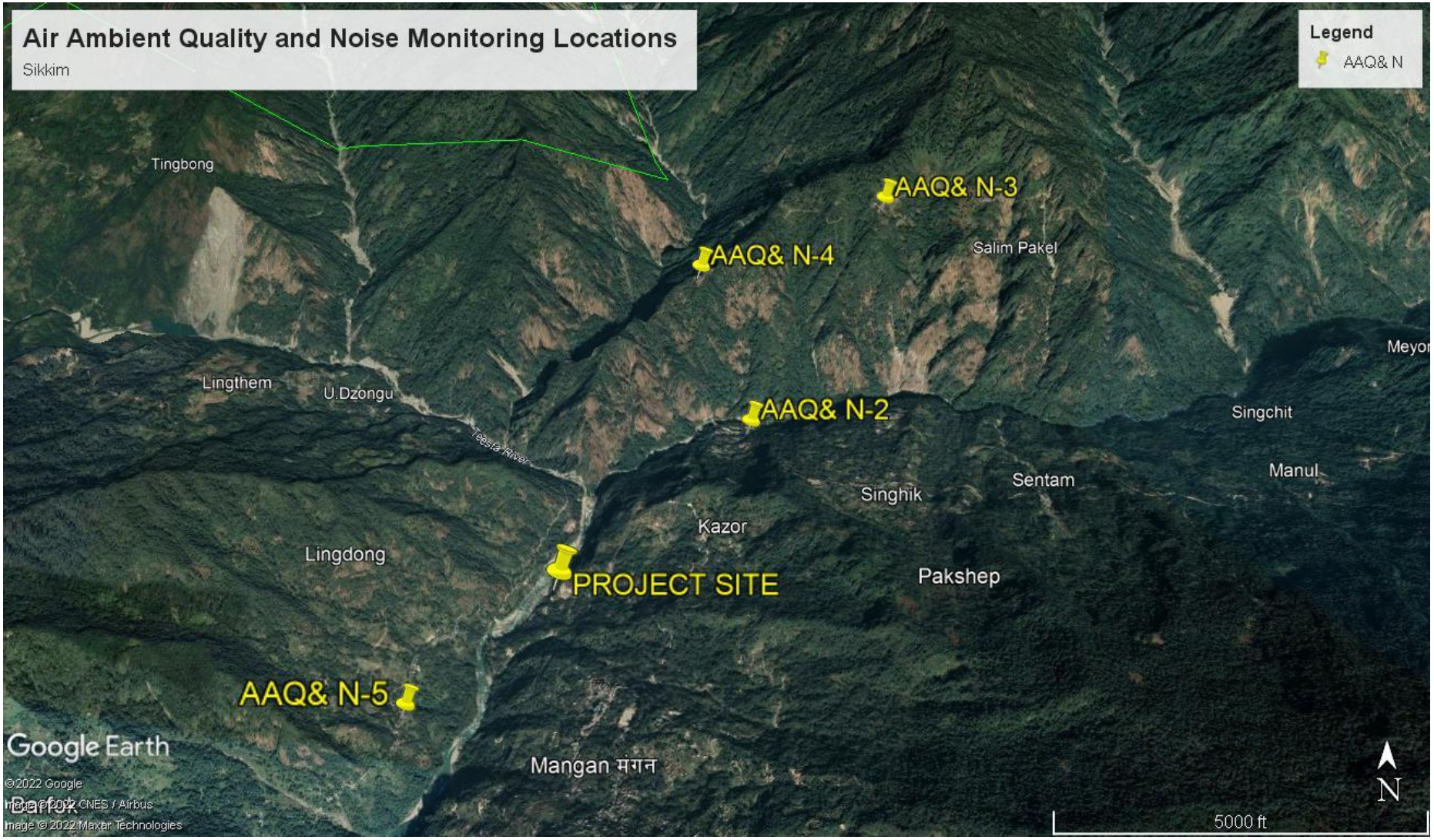


TABLE 3.4 AMBIENT AIR QUALITY LEVELS PM_{10}, $PM_{2.5}$ (µg/m^3)

Code	Name of the Location	PM_{10}			$PM_{2.5}$		
		Min	Max	98th Percentile	Min	Max	98th Percentile
A1	Project Site	43.2	73.4	73.1	16.4	31.3	31.3
A2	Teesta Urja Ltd Office	62.3	83.2	82.8	26.3	37.3	37.3
A3	Salim Pakel	38.5	57.3	57.1	15.5	23.7	23.7
A4	Near Lingdong	38.2	59.5	59.4	16.2	25.5	25.0
A5	Unknown	38.2	55.7	55.5	16.5	24.2	24.2
98th Percentile Range		**55.5 to 82.8**			**23.7 to 37.3**		
NAAQ Standards 2009		**100 (24 hourly)**			**60 (24 hourly)**		

TABLE 3.5 AMBIENT AIR QUALITY LEVELS SO_2, NOX (µg /m^3)

Code	Name of the Location	SO2			NOx		
		Min	Max	98th Percentile	Min	Max	98th Percentile
A1	Project Site	5.3	8.3	8.3	8.5	15.1	15.0
A2	Teesta Urja Ltd Office	5.9	9.1	9.0	8.5	19.6	19.0
A3	Salim Pakel	5.3	6.4	0.36	7.5	12.1	12.1
A4	Near Lingdong	5.2	7.1	0.59	8.2	12.8	12.8
A5	Unknown	5.2	7.4	#REF!	7.5	12.8	12.6
98th Percentile Range		**0.36 to 9.0**			**12.1 to 19.0**		
NAAQ Standards 2009		**80 (24 hourly)**			**80 (24 hourly)**		

TABLE 3.6 AMBIENT AIR QUALITY LEVELS CO

Code	Name of the Location	Carbon Monoxide (CO)		
		Min	Max	98th Percentile
A1	Project Site	0.26	0.55	0.54
A2	Teesta Urja Ltd Office	0.25	0.45	0.45
A3	Salim Pakel	0.22	0.37	0.36
A4	Near Lingdong	0.21	0.39	0.38
A5	Unknown	0.22	0.42	0.40
98th Percentile Range		**0.36 to 0.54**		
NAAQ Standards 2009		**04 (1 hourly)**		

Regional Scenario

Particulate Matter

The 98thpercentile of Particulate Matter <2.5µm recorded with in the study area were in the range of **15.5 to 37.3 µg/m3.** The 98th Percentile of Particulate Matter<10µm recorded with in the studyarea were in the range of 55.5 to 82.8 µg/m3. The 24 hourly average values of Particulate Matter <2.5µm & Particulate Matter <10µm were compared with national ambient air quality standards and found that all sampling locations recorded values within the applicable limits of residential and rural area limits for all locations in the study area.

Sulphur dioxide

The 98th Percentile of SO2 recorded within the study area was in the range of **5.2 to 9.1 µg/m3.** The 98th percentile values of SO2 were compared with the national ambient air quality standards and it was found that all sampling locations recorded values much lower than the applicable limit to 80 µg/m3 for industrial, residential and rural areas.

Oxides of Nitrogen

The 98th Percentile of NOx recorded within the study area was in the range of **7.5 to 9.1 µg/m3.** The 24-hourly average values of NOx were compared with national ambient air quality standards and it was found that all the sampling locations recorded values much lower than the applicable limit of 80µg/m3 for industrial, residential and rural areas.

Carbon Monoxide (CO)

The 98th Percentile of CO recorded within the study area was in the range of **0.21 to 0.55 mg/m3**. The 8 hourly average values of CO were compared with national ambient air quality standards and it was found that all the sampling locations recorded values much lower than the applicable limit of 04 µg/m3 (1 hourly) for industrial, residential and rural areas.

Remaining Parameters (Lead, Nickel, Arsenic and Benzo (a) Pyrene) are all falling below detectable Limits. Ambient Air Quality Standards (NAAQS)/CPCB are given in **Table 3.7**

TABLE 3.7 NAAQ/CPCB STANDARDS FOR AMBIENT AIR QUALITY

S.No	Pollutant	Time weighted Average	Concentration in Ambient Air		Method of Measurement
			Industrial, Residential, Rural and Other Area	**Ecologically sensitive area (notified by Central Govt.)**	
1	Sulphur Dioxide (SO2), µg/m3	Annual*	50	20	➢ Improved West and Geake ➢ Ultraviolet fluorescence
		24 hours**	80	80	
2	Nitrogen Dioxide (NO2), µg/m3	Annual*	40	30	➢ Modified Jacob &Hochheiser (Na-Arsenite) ➢ Chemiluminescence

S.No	Pollutant	Time weighted Average	Concentration in Ambient Air		Method of Measurement
			Industrial, Residential, Rural and Other Area	Ecologically sensitive area (notified by Central Govt.)	
		24 hours**	80	80	
3	Particulate Matter (size less than 10 µm) or PM10µg/m3	Annual*	60	60	➢ Gravimetric ➢ TOEM ➢ Beta attenuation
		24 hours**	100	100	
4	Particulate Matter (size less than 2.5 microns) or PM2.5 µg/m3	Annual*	40	40	➢ Gravimetric ➢ TOEM ➢ Beta attenuation
		24 hours**	60	60	
5	Ozone (O3) µg/m3	8 hours**	100	100	➢ UV photometric ➢ Chemiluminescence ➢ Chemical method
		1 hour**	180	180	
6	Lead (Pb) µg/m3	Annual*	0.5	0.5	➢ ASS / ICP method after sampling on EPM 2000 or equivalent filter paper ➢ ED – XRF using Teflon filter
		24 hours**	1.0	1.0	
7	Carbon Monoxide (CO) mg/m3	8 hours**	2	2	Non Dispersive Infra RED (NDIR) Spectroscopy

S.No	Pollutant	Time weighted Average	Concentration in Ambient Air		Method of Measurement
			Industrial, Residential, Rural and Other Area	**Ecologically sensitive area (notified by Central Govt.)**	
		1 hour**	4	4	
8	Ammonia (NH3) µg/m3	Annual*	100	100	➢ Chemiluminescence ➢ Indophenol blue method
		24 hours**	400	400	
9	Benzene (C6H6) µg/m3	Annual*	5	5	➢ Gas chromatography based continuous analyser ➢ Adsorption and desorption followed by GC analysis
10	Benzo (a) Pyrene (BaP) – particulate phase only ng/m3	Annual*	1	1	Solvent extraction followed by HPLC / GC analysis
11	Arsenic (As) ng/m3	Annual*	6	6	AAS / ICP method after sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni) ng/m3	Annual*	20	20	

**Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.*

***24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.*

3.4 WATER ENVIRONMENT

Ground water samples were collected from different sources within the study area and some important physical and chemical parameters including heavy metals were considered for depicting the baseline status of the study area.

Water Quality Assessment

Groundwater collected from the study area to assess the water quality during the study period. The groundwater samples were drawn from the hand pumps and open wells used by villagers for their daily use. The surface water samples were drawn from rivers. The details of the locations are given in the **Table 3.8** and water sampling locations are represented in **Figure 3.3.** Water sample analysis results have shown in **Table 3.9 and Table 3.10.**

Selected water quality parameters for water resources within 10 km of the study area have been used for describing the water environment and assessing the impacts on it. Studies on water environment aspects of ecosystem play an important role in preparation of environmental impact assessment report and to identify sensitive issues and take appropriate action by maintaining ecological homeostasis. To assess the water quality impacts, water resources in the impact area have been grouped into two classes.

- Surface water resources including streams, tanks, rivers etc.
- Ground water resources in the deeper strata of the ground

Ground water from dug wells, tube wells and hand pumps cater to the drinking water needs of the villages in the region. The quality of ground water was assessed by taking samples and analyzed as per CPCB norms. Reconnaissance survey was undertaken and monitoring locations were selected based on the following consideration.

- Location of the aquifer
- Usage and source

TABLE 3.8 WATER QUALITY MONITORING LOCATIONS

Code	Name of the Location	W.R.T. Site		Latitude (North)	Longitude (East)
		Distance (km)	Direction		
Ground Water					
GW1	Passindang	2.3	NW	27°31'39.10"N	88°30'52.51"E
GW2	Singhik	2.5	NE	27°30'58.04"N	88°33'19.12"E
GW3	Mangan	1.8	SSE	27°29'52.37"N	88°32'21.66"E

Surface Water			
SW1	Teesta river downstream	27°31'6.47"N	88°31'56.16"E
SW2	Teesta river upstream	27°31'31.72"N	88°32'23.20"E
SW3	Naga waterfall	27°30'10.07"N	88°31'49.13"E

TABLE 3.9 GROUND WATER SAMPLES ANALYSIS

S. No	Parameters	Unit	Max Requirement as per (IS-10500-2012), Limit		Passindang	Singhik	Mangan
			Desirable	Permissible			
Physical Parameters							
1	pH value	-	6.5-8.5	No Relaxation	7.46	7.36	7.43
2	Color	Hazen	5	15	<5	<5	<5
3	Turbidity	NTU	1	5	<1	<1	<1
4	Total Dissolved Solids	mg/l	500	2000	148	165	132
5	Total Alkalinity as $CaCO_3$	mg/l	200	600	62	72	54
6	Total Hardness (as $CaCO_3$)	mg/l	200	600	82	94	76
7	Calcium (as Ca)	mg/l	75	200	19	22	18
8	Magnesium (as Mg^{2+})	mg/l	30	100	8.4	9.5	7.6
9	Chlorides (as Cl)	mg/l	250	1000	26	28	24
10	Fluoride (as F)	mg/l	1	1.5	0.3	0.2	0.3
11	Sulphate (as SO_4)	mg/l	200	400	14	16	12
12	Iron (as Fe)	mg/l	1	No Relaxation	0.15	0.11	0.13
13	Nitrate(as NO_3)	mg/l	45	No Relaxation	8.2	9.2	7.8
14	Copper (as Cu)	mg/l	0.05	1.5	<0.05	<0.05	<0.05
15	Boron (as B)	mg/l	0.5	2.4	<0.1	<0.1	<0.1
16	Manganese(as Mn)	mg/l	0.1	0.3	<0.05	<0.05	<0.05
17	Phenolic Compounds (as C_6H_5OH)	mg/l	0.001	0.002	<0.001	<0.001	<0.001
18	Sulphide (as H_2S)	mg/l	0.05	No Relaxation	<0.05	<0.05	<0.05
19	Zinc (as Zn)	mg/l	5	15	0.22	0.28	0.33
20	Cadmium (as Cd)	mg/l	0.003	No Relaxation	<0.003	<0.003	<0.003
21	Cyanide (as CN)	mg/l	0.05	No Relaxation	<0.05	<0.05	<0.05
22	Lead (as Pb)	mg/l	0.01	No Relaxation	<0.01	<0.01	<0.01
23	Mercury (as Hg)	mg/l	0.001	No Relaxation	<0.001	<0.001	<0.001
24	Total Arsenic (as As)	mg/l	0.01	0.05	<0.01	<0.01	<0.01
25	Total Chromium (as Cr)	mg/l	0.05	No Relaxation	<0.05	<0.05	<0.05
26	Total Coliform	per 100ml	Shall not be detectable		Absent	Absent	Absent
27	*E.Coli*	*E.coli*/100ml	Shall not be detectable		Absent	Absent	Absent

Urban Development & Housing Department (UD&HD), Govt. of Sikkim

TABLE 3.10 SURFACE WATER SAMPLES ANALYSIS

Surface Water					
S.No	**Parameters**	**Unit**	**SW-1**	**SW-2**	**SW-3**
1	pH value	-	7.22	7.51	7.45
2	Turbidity	NTU	4	9	12
3	Conductivity	mmhos/cm	310	491	642
4	Total Dissolved Solids	mg/l	205	302	385
5	Total Suspended solids	mg/l	16	24	36
6	Total Hardness (as $CaCO_3$)	mg/l	118	162	196
7	Chlorides (as Cl)	mg/l	48	54	87
8	Total Alkalinity as $CaCO_3$	mg/l	72	134	158
9	Sulphate (as SO_4)	mg/l	18	31	47
10	Nitrate(as NO_3)	mg/l	7.8	10.8	13.2
11	Fluoride (as F)	mg/l	0.3	0.5	0.4
12	Iron (as Fe)	mg/l	0.14	0.13	0.16
13	Zinc (as Zn)	mg/l	0.18	0.32	0.29
14	Calcium (as Ca)	mg/l	33	42	51
15	Magnesium (as Mg^{2+})	mg/l	8.7	13.9	16.7
16	Cadmium (as Cd)	mg/l	<0.01	<0.01	<0.01
17	Copper (as Cu)	mg/l	<0.05	<0.05	<0.05
18	Nickel (as Ni)	mg/l	<0.01	<0.01	<0.01
19	Lead (as Pb)	mg/l	<0.1	<0.1	<0.1
20	Mercury (as Hg)	mg/l	<0.001	<0.001	<0.001
21	Total arsenic (as As)	mg/l	<0.01	<0.01	<0.01
22	Phenolic Compounds (as C_6H_5OH)	mg/l	<0.001	<0.001	<0.001
23	Manganese as Mn	mg/l	<0.01	<0.01	<0.01
24	Cyanide as CN	mg/l	<0.05	<0.05	<0.05
25	Total Chromium (as Cr)	mg/l	<0.05	<0.05	<0.05
26	Aluminum as Al	mg/l	<0.03	<0.03	<0.03
27	Oil & Grease	mg/l	<2	<2	<2
28	Chemical Oxygen Demand	mg/l	8	24	16
29	Bio- Chemical Oxygen Demand as BOD (for 3 Days	mg/l	<2	4.6	3.2

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	27 ˚C)				
30	Dissolved Oxygen	mg/l	7.2	6.6	6.9
31	Total Coliform	MPN/100ml	2.1×10^2	3.9×10^3	3.1×10^3

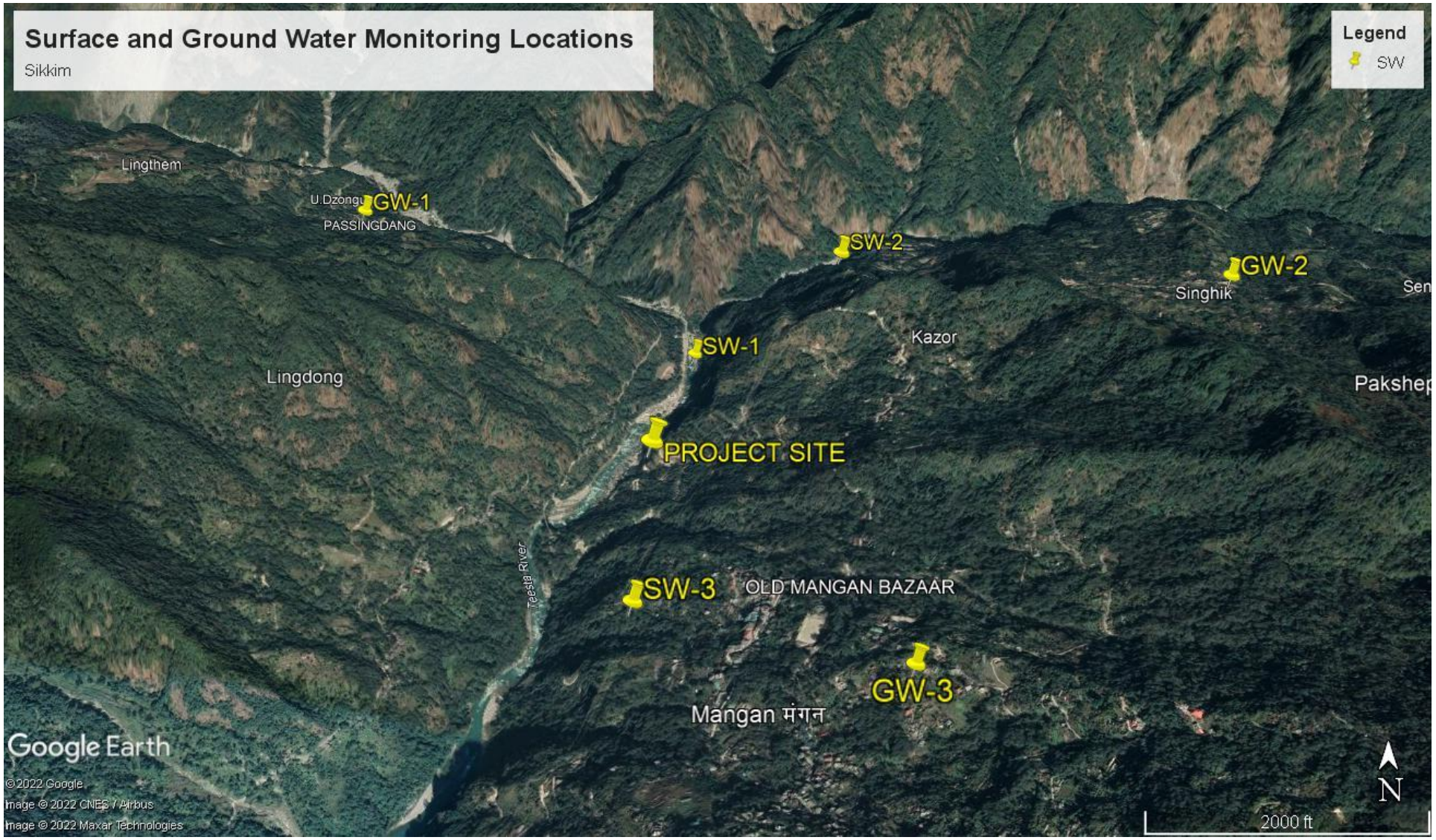

FIGURE 3.3 GROUND WATER & SURFACE WATER QUALITY SAMPLING LOCATIONS

Urban Development & Housing Department (UD&HD), Govt. of Sikkim

Regional Scenario

Ground water

- The pH limit fixed for drinking water samples as per IS 10500-2012 is 6.5 to 8.5 beyond this range the water will affect the mucus membrane and or water supply system. During study period the pH in the ground water samples was varying from 7.36 to 7.46. The pH of all samples was falling within the acceptable limit.
- The acceptable limit for total dissolved solids as per IS 10500:2012 is 500 mg/l, whereas the permissible limit in absence of alternate source is 2000 mg/l, beyond this palatability decreases and may cause gastro intestinal irritation. In water samples collected from the study area, the total dissolved solids in groundwater are varying from 132 to 165 mg/l. All samples are falling within acceptable limit.
- The acceptable limit for chloride is 250 mg/l as per IS10500:2012 whereas the permissible limit of the same is 1000 mg/l beyond this limit taste, corrosion and palatability are affected. The Chloride levels in the ground water samples collected in the study area were ranging from 24 to 28 mg/l. All samples are falling within acceptable limit.
- The acceptable limit as per IS10500:2012 for hardness is 200mg/l whereas the permissible limit for the same is 600mg/l beyond this limit encrustation in water supply structure and adverse effects on domestic use will be observed. In the water samples collected from the study area, the hardness is varying from 76 to 94 mg/l. Three samples are falling above the acceptable limit but within the permissible limits. The general characteristics of all the ground water samples collected in the region shows fairly good quality.

Surface Water

- The pH was varying between 7.22 to 7.51. The pH values for all the samples collected in the study area during study period were meeting the Class 'A' norms as per IS: 2296-1992.
- The total dissolved solids were in the range of 205 mg/l to 385 mg/l. The TDS for all the samples collected in the study area during study period were meeting the Class 'A' norms as per IS:2296-1992.
- The chlorides were in the range of 48 mg/l to 87 mg/l, indicating that all samples were meeting the Class 'A' norms as per IS: 2296-1992.
- The hardness is varying between 118 mg/l to 196 mg/l. n which all samples are meeting the Class 'A' norms as per IS: 2296-1992.

3.5 NOISE ENVIRONMENT

Noise can be defined as unwanted sound or sound in the wrong place at the wrong time. It can also be defined as any sound that is undesirable because it interferes with speech and hearing, is intense enough to damage hearing or is otherwise annoying. The definition noise as unwanted sound implies that it has an adverse effect on human beings and their environment including land, structures, and domestic animals. Noise can also disturb natural wildlife and ecological systems.

Sound can be transmitted through gases, liquids, and solids. Noise impacts can be of concern during the construction and the operational phases of projects. Noise should also be considered in relation to present and future land use zoning and policies.

Construction noise can be a significant source of community noise. Of concern are impacts on people near the construction site, who are totally unrelated to construction activities (e.g. area residents, office workers, school children, staff, etc.) Factors which are important in determining noise levels that will potentially impact such populations include distance from the noise source, natural or man-made barriers between the source and the impacted population, weather conditions which could potentially absorb, reflect or focus sound (such as wind speed, direction, temperature inversions), the scale and intensity of the particular construction phase (excavation, erection, or finishing).

The Environment/health impacts of noise can vary from Noise Induced Hearing Loss (NIHL) to annoyance depending on loudness of noise levels and tolerance levels of individual.

While measuring the day-night equivalent noise levels (Ldn), it is considered that one event at night is equivalent to ten similar events during the day time. Ldn is similar to 24 hours equivalent sound level (LEq) except that, during the daytime 10 dB (A) weighing is added. The Ldn for a given location in a community may be calculated from the hourly (LEq) equivalent sound levels with a 10 dB (A) correction added to the night time value (Ln).

L_{dn}= 10 Log (0.0416 [15 ($10^{Ld/10}$] + 9 ($10^{Ln+10/10}$]) + ...

Where L_d is the Equivalent noise levels at day (6.00 A.M to 10.00 P.M) and

L_n is the Equivalent noise levels at night (10.00 P.M to 6.00 A.M)

Noise Levels in the Study Area

Base noise levels are monitored in 5 different locations within study zone, using a continuous noise measurement device. The day levels of noise have been monitored during 6 AM to 10 PM and the night levels during 10 PM to 6 AM. The noise monitoring locations are given in the Table3.11 and the results obtained are given in Table 3.12, and noise monitoringlocations are represented in Figure 3.4.

FIGURE 3.4 NOISE MONITORING LOCATIONS

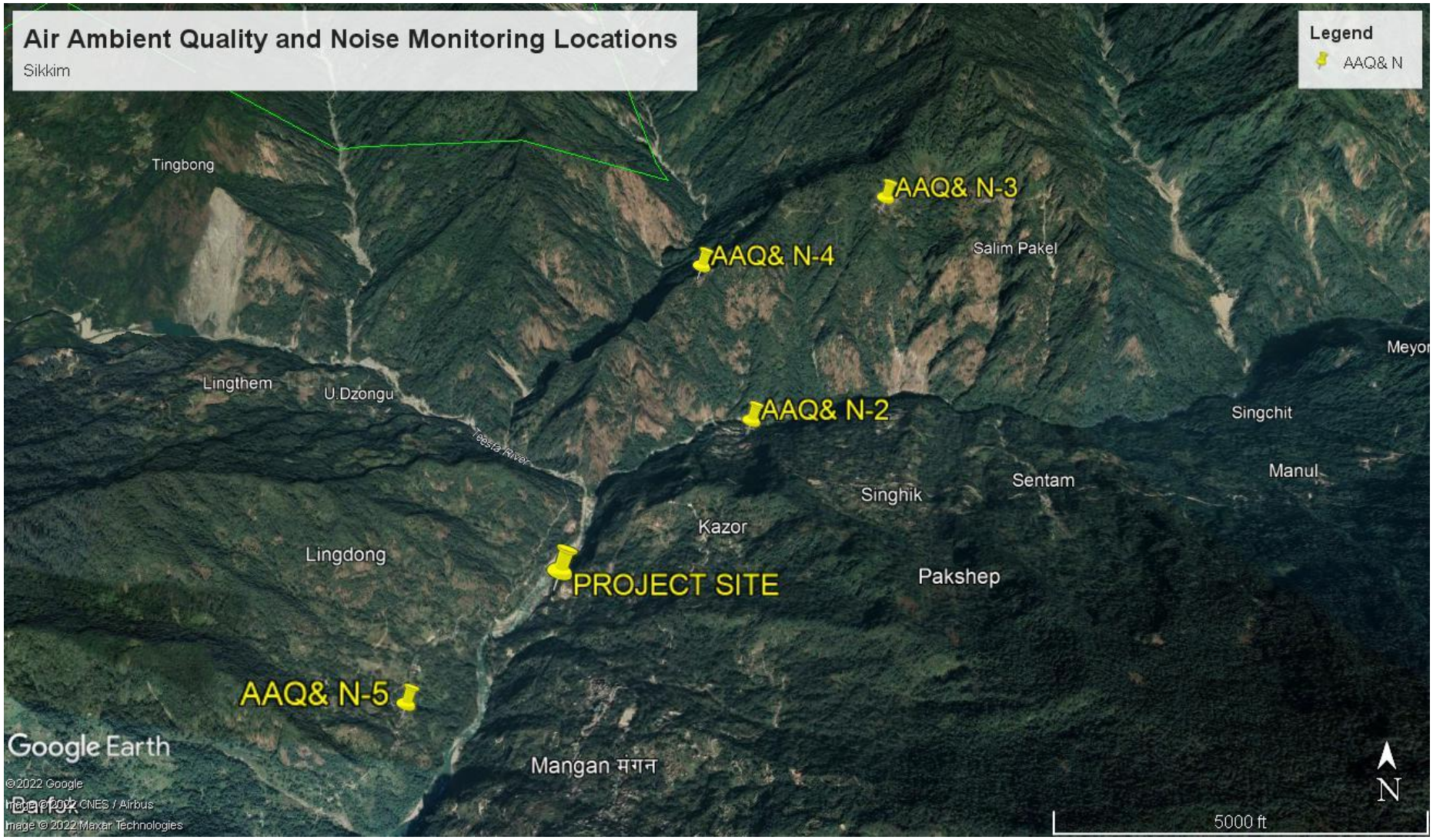

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TABLE 3.11 NOISE MONITORING LOCATIONS

Code	Name of the Location	W.R.T. Site		Latitude (N)	Longitude (E)
		Distance km	Direction		
N1	Project Site	-	-	27°30'44.00"N	88°31'49.60"E
N2	Teesta Urja ltd office	2	NE	27°31'31.30"N	88°32'39.57"E
N3	Salim Pakel	3.8	NNE	27°32'20.79"N	88°33'19.55"E
N4	Near Lingdong	1.4	SW	27°30'8.53"N	88°31'19.05"E
N5	unknown	2.7	N	27°32'6.27"N	88°32'25.31"E

TABLE 3.12 NOISE LEVELS IN THE STUDY AREA – DB (A)

Code	Name of the Location	Average Noise Level in dB(A)	
		Day Time	Night Time
N1	Project Site	58.6	51.2
N2	Teesta Urja ltd office	60.2	53.6
N3	Salim Pakel	56.4	46.8
N4	Near Lingdong	57.3	45.6
N5	unknown	49.2	35.7

Observations

The values of noise observed in some of the rural areas are primarily owing to vehicular traffic and other anthropogenic activities. In rural areas wind blowing and movements of birds would contribute to noise levels especially during the nights. The day equivalents during the study period are range between 49.2 to 60.2 dB (A), whereas the night equivalents were in the range of 35.7 to 53.6 dB (A). From the results it can be seen that the day equivalents and the Night equivalents were within the Ambient Noise standards of residential.

3.6 SOIL QUALITY

The present study on soil quality establishes the baseline characteristics in the study area surrounding the project site. The study has been addressed with the following objectives.

- To determine the baseline characteristic.
- To determine the soil characteristics of the proposed project site.
- To determine the impact of industrialization/urbanization on soil characteristics.
- To determine the impacts on soils from agricultural productivity point of view.

Criteria adopted for selection of sampling locations

For studying soil characteristics, sampling locations were selected to assess the existing soil conditions representing various land use conditions and geological features. The homogenized soil samples collected at 3 different locations were packed in a polyethylene plastic bag and sealed. The sealed samples are sent to laboratory analysis. The important physical, chemical parameter concentrations were determined from all samples. The details of the soil sampling locations are given in Table 3.13. The analytical results of the soil samples are given in Table 3.14. The Soil Sampling locations are given in Figure 3.5.

TABLE 3.13 SOIL SAMPLING LOCATIONS

Code	Name of the Location	W.R.T. Site		Latitude (N)	Longitude (E)
		Distance km	Direction		
S1	Teesta Urja Ltd office(near site)	-	N	27°31'29.93"N	88°32'31.95"E
S2	Kazor	1.0	E	27°30'50.70"N	88°32'29.93"E
S3	Near teesta river	2.0	S	27°31'4.27"N	88°31'51.19"E

FIGURE 3.5 SOIL SAMPLING LOCATIONS

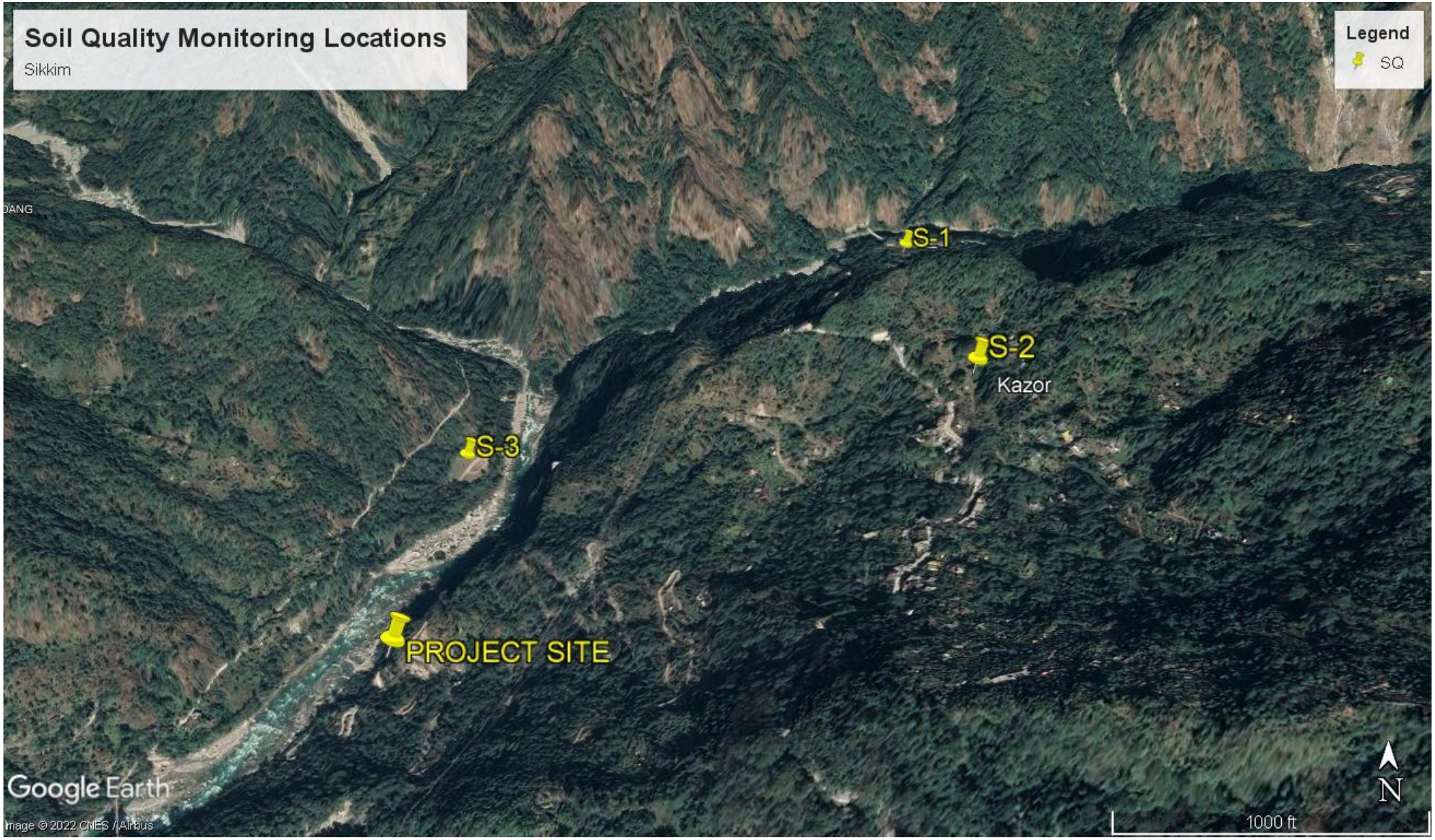


TABLE 3.14 SOIL ANALYSIS REPORT

S.No	Parameter	Unit	Teesta Urja Ltd office(near site)	Kazor	Near Teesta river
1	Texture	-	Silty Clay	Silty Clay	Silty Clay
2	Sand	%	9.6	12.6	11.8
3	Silt	%	47.8	45.6	44.7
4	Clay	%	42.6	41.8	43.5
5	pH (1:2.5 Suspension)	-	7.38	7.45	7.34
6	Electrical Conductivity (1:2)	µmhos/cm	256	224	270
7	Cation exchange capacity	meq/100 gm	8.4	9.5	9.8
9	Exchangeable Sodium	mg/kg	235	283	281
10	Exchangeable Calcium	mg/kg	664	784	840
11	Exchangeable Magnesium	mg/kg	432	456	468
12	Sodium Absorption Ratio	-	1.73	1.98	1.92
13	Water Holding Capacity	%	27.1	31.6	28.9
14	Porosity	%	43.2	47.5	45.5
15	Organic Carbon	%	0.82	0.74	0.64
16	Bulk Density	gm/cc	1.48	1.37	1.45
	Available Nutrients:				
17	Nitrogen as N	kg/ha	285	265	256
18	Phosphorus(Olsen's) as P	kg/ha	12.7	10.8	13.1
19	Potassium as K	kg/ha	203	238	187

Observations

- The pH values in the study area are varying from 7.34 to 7.45 indicating that all soils are falling in normal to saline class.
- The electrical conductivity in the study area is varying from 224 to 270 μs/cm indicating that all samples are falling in normal range.
- The other important parameters for characterization of soil for irrigation are N, P and K are known as primary nutrients and Ca, Mn and S as secondary nutrients. The primary and secondary nutrients are known as major elements. The classification is based on their relative abundance, and not on their relative importance.
- The available potassium in the study area is varying between 187 to 238 Kg/Ha indicating that all samples are falling in medium range.

3.7 ECOLOGICAL ENVIRONMENT

INTRODUCTION

Biodiversity is the biological variety and variability of life on Earth. Biodiversity is a measure of variation at the genetic, species, and ecosystem level.

The biological study was under taken by Ecology & Biodiversity Expert, as a part of the EIA study report to understand the present status of ecosystem prevailing in the study area, to compare it with past condition with the help of available data, to predict changes in the biological environment as a result of present activities and to suggested measures for maintaining its health.

The proposed Municipal Solid Waste Management Facility will be established in an area of 2.0 Hectares for Mangan.

A survey was conducted to study the flora around 10 km radius. Some of the information was gathered from the local habitants. All the collected data were classified to interpret the impact of pollution on the flora and fauna of that region. Survey of the mild plants as well as cultivated crop plants was made and all the available information was recorded.

OBJECTIVES OF ECOLOGICAL AND BIODIVERSITY STUDIES

The local biota and fauna study of the area has been conducted in order to fully appreciate the ecological status of the existing flora and fauna to generate baseline information and correlation with secondary data of the 10 K.M radius.

Activities undertaken during the study :-

- ❖ Flora survey
- ❖ Fauna survey
- ❖ Habitat/microhabitat diversity in the Core site and Buffer areas.

- ❖ Photo Documentation.
- ❖ Methodology Adopted for Generic & Specific Flora Study
- ❖ Assessment of potential damage to Ecology & biodiversity

Flora survey-

- To have an inventory /checklist & details of vegetation found in the 10 km radius area.
- Identification and enumeration of tree, shrub, herb, climber, and grass species.
- Generation of primary data by undertaking systematic ecological studies in the area.
- Analysis of Rare-Endangered-Threatened flora.
- To conduct detail study of Terrestrial and Aquatic avifaunal species in the study area of the proposed project activity.
- To identify Impact of project during construction and operational phases on the biological environment.

Fauna survey

- Documentation of Avian, Reptilian, Insect, Amphibian, Mammal and other faunal diversity.
- Observations by direct and indirect evidence (Direct evidence- Sighting and hearing, indirect evidence- Pug marks, nests and other signs).

Analysis of Scheduled Species

- To suggest management/mitigation/conservation plan for habitat improvement for different faunal Groups.

Photo Documentation

Functional area expert has carried out flora & fauna survey by collecting the information of biological environment of Sikkim, their forests, type of forest and forest cover in Garwal District & the floral species from the website. Further details of type of flora, botanical name, family use & fauna of the area have been studied by collecting the details by forest department. The secondary data so collected were also verified by the field survey.

List of Equipment/Material used in the survey

S. No	Equipment/Material used
1	Digital camera
2	GPS
3	Brunton Compass
4	Magnifying Glass
5	Hammer
6	Binocular
7	Rope
8	Ballpoint pen
9	Field notebook

10	Sampling equipment

Study of flora & fauna in Core & Buffer zone: - The Ecological and biodiversity survey has been conducted during 1st Decemeber 2021 – 28th Feb. 2022 (Winter Season) in the core & buffer zone.

Methodology Adopted for Generic & Specific Flora Study

Flora: The present study on the floral assessment for the proposed project activity is based on extensive field survey of the area. The study has been conducted in winter season. The local flora was identified by their morphological observation, such as its size and shape of the leaf, flowers, fruits and their bark features of stem and also documented their habitat viz. Trees, Shrubs, Herbs, Grasses and Climbers etc. with the help of secondary sources like degree colleges and forest department. The plants which were not identified at field were collected, brought to the laboratory and identified using standard reference books and internet. Photo documentation of some of the key species present the study area was also done. Besides the collection of plant species, information was also collected with vernacular names of plant species made by local inhabitants. In this process the whole study area was divided into different sections to get the maximum diversity of plant species. The sampling sites were selected based on land use pattern, topography and floristic composition of the study area. Data on forest type, legal status and their extent in the study area has been collected from forest department. The other relevant data on biodiversity, economically important plant species and medicinal plant, rare and endangered species in the study area have been collected during site visit and from different secondary sources.

Forest: There are extensive forests in the district North of the Sikkim. These forests are serving, as a base for many industries, local needs of fuel wood, fodder resources and ecological stability. There is a considerable variation in the forest type, which occur in this area. Such variations are based on altitude, climate, rocks, soil etc.

Chir Pine Forests are the most extensively developed type in the Teesta catchments. The main species is Pinus roxburghii which occurs in pure form. The altitudinal variation of this forest is from 900 mts. to 1500 mts. Besides chir pine, the other tree species which may occur Cedrela toonaToon) be, Anoegissous Latifolia, Ehertia laevis. The density of this forest varies from 0.3 to 0.6, the density tends to higher in areas away from human settlements, intensive grazing, on sandy soil etc.

Oak Forests occur at altitude ranging from 800 m. to the highest elevations of area. The main species include Quercus semicarpifolia Banj, Q. incanaBanj), Rhododendron arboreun Burans), Rhus punjabencis, cedrela toona Toon), vitis himalayansis. These forests occur on moist, shady depressions, declivaties on southern aspects. At times they are mixed with chir pine forests, the former occurring on moister sides and cooler aspects. The density of the forest ranges from 0.4 to 0.8. There is a thick layer of undecomposed humus in the soil. By and large it has been seen that this forest type is associated with moisture.

Deodar Forests are confined to areas of higher elevation. It is one of the most beautiful types found in the Himalayan region. Individual trees may attain a height of over 35 mtr and a diameter of over 110 cms. The main species are cederus deodara which occur in pure form. In cooler aspects Deodar is accompanied by blue pine (pinus exelsa), silver fir and spruce. Regeneration is fairly adequate as these forests occur in areas, which are away from habitation.

Vegetation and Flora of Sikkim

The flora of Sikkim Himalaya has partly been studied by the famous Taxonomist Shri J. D. Hooker as early as 1948 as a part of Flora of British India published in 1872 -1897. Since then, the Botanical Survey of India has been exploring the approachable pockets in parts of Sikkim from Botanical point of view (Rolla S. Rao, 1968). However, no comprehensive vegetation type map of the entire Sikkim could be generated due to inaccessibility probably a great constraint for ground survey.

In the present study, six broad vegetation types have been demarcated in Sikkim based on Champion and Seth (1986). They are: 1. Tropical Semi-evergreen Forests 2. Sub-tropical Broad-leaved Hill Forests 3. Himalayan Wet Temperate Forests 4. Sub-alpine Forests 5. Moist Alpine Forests 6. Dry Alpine Forests

A. Tropical Semi-evergreen forest (300m-900m) The Tropical semi-evergreen Forests with Sal as a dominant species along with a few deciduous components, is the climax type of vegetation in the foot hills of the district. These forests have been influenced by physiographic, edaphic and biotic factors of the region.

B. Sub-tropical mixed broad-leaved hill forests (900m-1800m) As altitude increases from 900-1800m, the forests also gradually change from Tropical to Subtropical forests comprising tree species of Macaranga, Schima, Eugenia, Sapium, Castanopsis and these are generally mixed with shrubby species of Baliospermum, Clerodendrum and Emblica. Generally it is not possible to identify these two vegetation types as separate classes in satellite imagery since the

signatures of these mixed composition of species are not distinct, hence classified as Mixed broad leaved hill/Mixed forests.

C. Himalayan wet temperate forests (1800m-2700m) The vegetation gradually changes from sub tropical to sub-temperate in the altitudinal range of 1800-2400m and beyond that the vegetation becomes that of distinct Temperate forest. In the region between 1800 m to 2400 m, the dominant species are Suaga (Hemlock), Acer, Michelia, Juglans, Rhododendron, Ilex associated with Rosa, Rubus, Berberis and Viburnum. The typical temperate forests Quercus (Oak), Acer, Populus, Larix and Abies densa predominate the region between 2400 m and 2700m. The Himalayan wet temperate forests comprise of coniferous species with needle shaped leaves easily differentiable from broad leaved species due to their distinct spectral signatures.

D. Sub-alpine forests (2700m3700m The vegetation from typical temperate type gradually changes to sub-alpine type at higher elevations. The tree species of Rhododendron are found predominantly mixed with a ariety of species like Gaultheria, Euonymus, Vibrunum, Juniperous and Rubus. Under this zone, the extensive Rhododendron patches were delineated but further stratification into different density classes could not be done due to their uniform canopy cover.

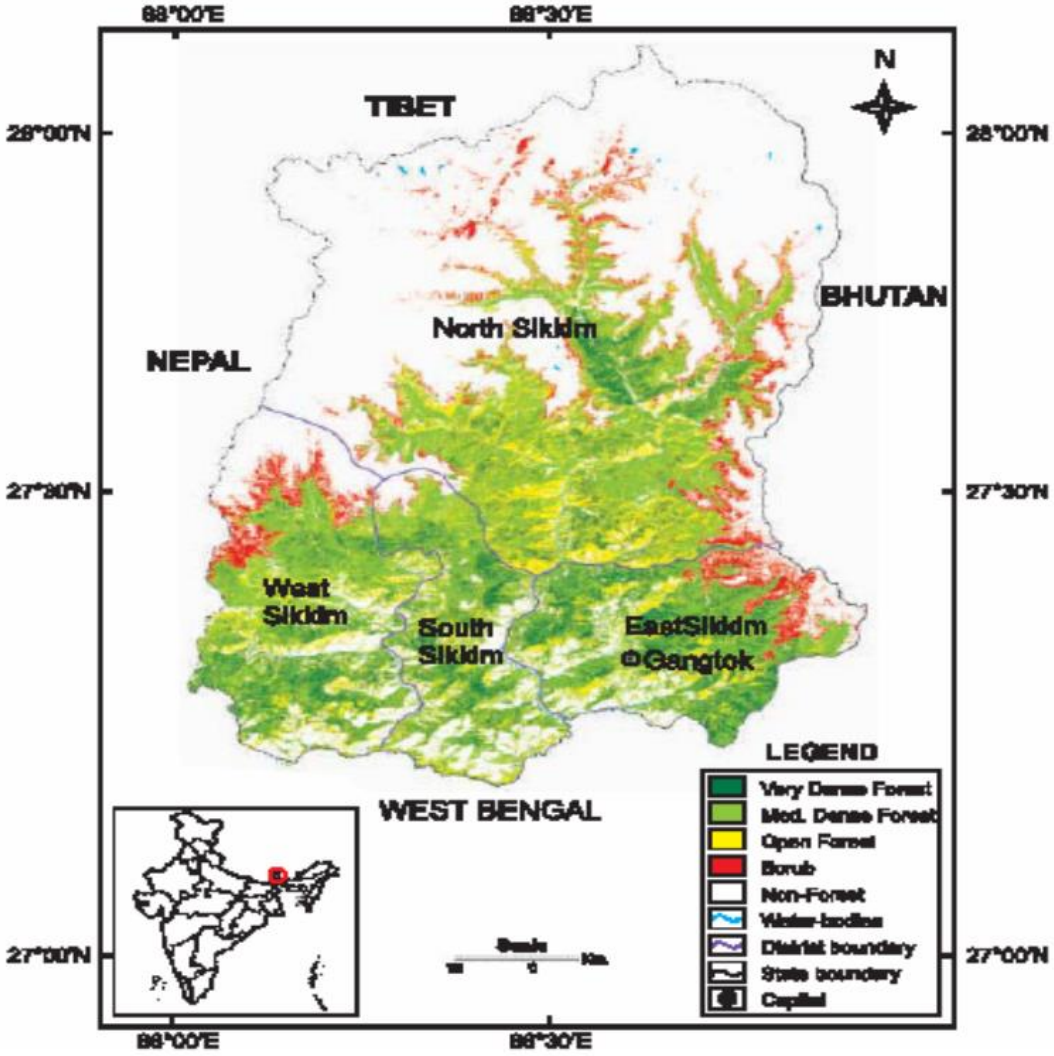
E. Moist Alpine forests (3700m4000m) The vegetation in this zone mainly comprises of typical alpine meadows where tree growth is completely arrested. Quite a few stunted bushy growth species of Rhododendron mixed with tough clumps of Juniperous, Salix, Berberis, Rosa and Lonicera are common.

F. Dry Alpine forests (above 4000 m) The vegetation is practically of scattered scrubs, often barren. Most of the species are of stunted thorny scrubs nature. Some of the common species are Berberis, Juniperous and Salix. In the present investigation, the alpine zone has been delineated into three categories as alpine barren with no vegetative cover, alpine scrub with scattered bushy vegetation and alpine meadows/pastures with predominantly of grasses.

North District- Forest Cover of Sikkim								
North District Forest Cover							(Area in km^2)	
District	Geo-graphical Area	Assessment 2019			Total	Percent of GA	Change	Scrub
		Very Dense Forest	Mod. Dense Forest	Open Forest				
North	4,226	132	755	439	1326	31.38	0	208

Perched at a height of 1,700 m, Khirsu is dotted with dense pine and deodar forests, which make for excellent venues for nature walks and hikes. The hamlet is endowed with lush orchards of apples and wildflowers of every kind.

FIGURE 3.6: MAP SHOWING FOREST TYPES OF SIKKIM



Source: State of Environment, Sikkim

Core and buffer zone (10 K.M radius) varying in vegetation types were studied along an altitudinal range. Maximum tree, shrub, and herb species were recorded 10 km radius of core zone. The herb and climber species were greater on moist site. The distribution and species richness pattern in this elevation range largely depend on the altitude and climatic variables. The opening canopies increase the richness of tree, shrub, herb, and climbers.

FIGURE 3.7: PHOTOGRAPHS SHOWING SITE & FLORA & FAUNA STUDY IN CORE &BUFFER ZONE

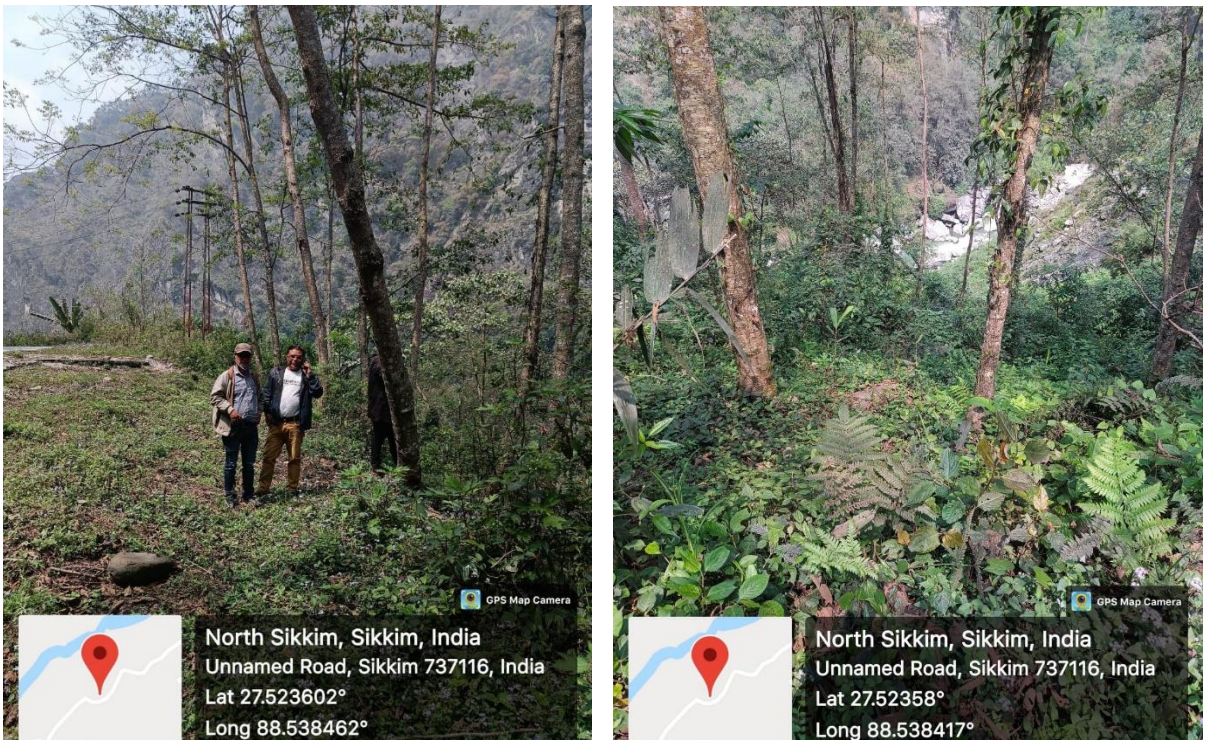
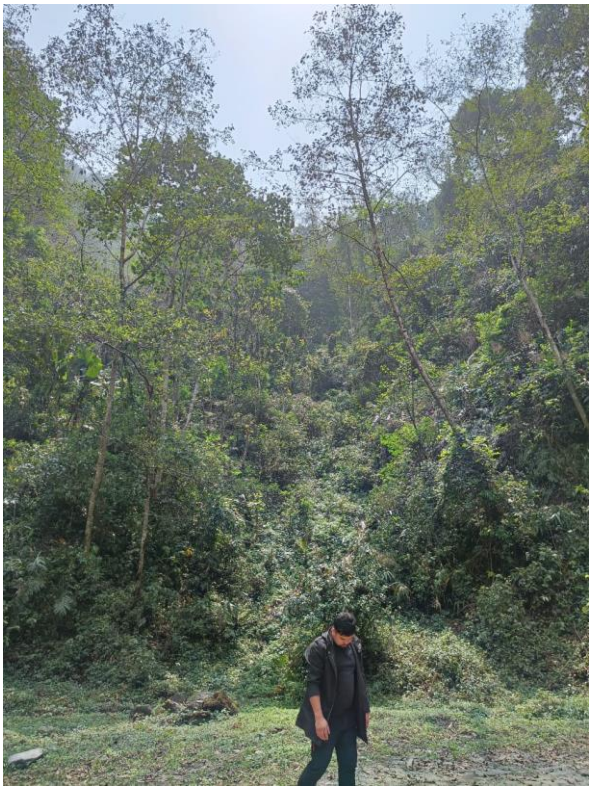


FIGURE 3.8: PICTURES OF SITE SHOWING NATURAL VEGETATION



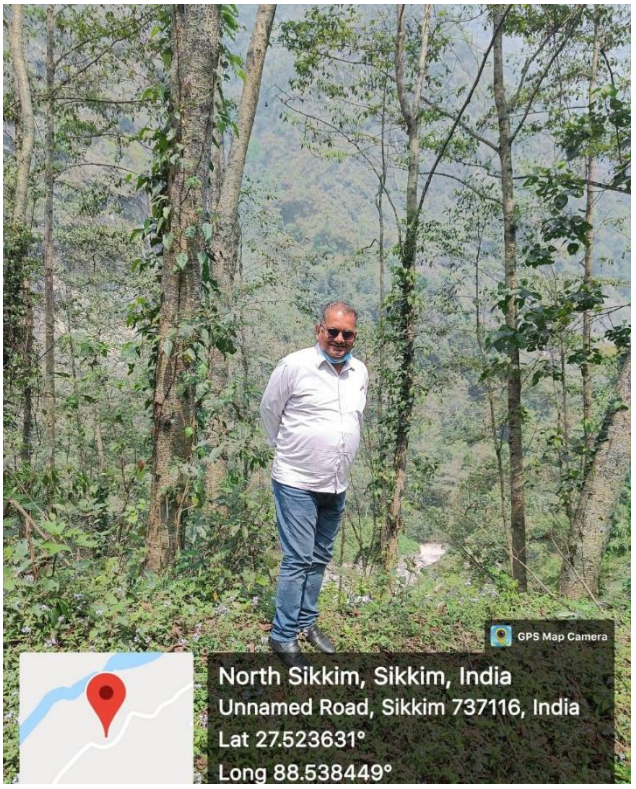


TABLE 3.15: LIST OF FLORA SPECIES OBSERVED IN THE CORE ZONE

S. No	Local Name	Botanical Name	Family
TREE			
1	Chir	Pinus roxburghii,	Pinaceae
2.	Himalayan cedar	Cedrus deodara	Pinaceae
3	Banj oak	Quercus leucotrichophora	Fagaceae
4	Box berry or Kaphal	Myrica esculenta	Myricaceae
SHRUBS			
1	Hisalu	Rubus ellipticus Sm.	Rosaceae
2	Tang	Rhus parviflora Roxb.	Anacardiaceae

3	Ceylon raspberry	Rubus niveus Thunb.	Rosaceae
HERBS & Grass			
1	Crofton weed,	Eupatorium adenophorum Spreng	Asteraceae
2	Gandhabel	Cymbopogon martini (Roxb.) Wat.	Poaceae
3	Doob	Cynodon dactylon (L.) Pers.	Poaceae

TABLE 3.16: LIST OF FLORA SPECIES OBSERVED IN THE BUFFER ZONE

S. No	Local Name	Botanical Name	Family
TREE			
1	Khair	Acacia catechu (L.f.) Willd.	Mimosaceae
2.	Kadam	Adina cordifolia (Roxb.) Hook.f. ex Brandis	Rubiaceae
	Banj oak	Quercus leucotrichophora	Fagaceae
3.	Bel	Aegle marmelos (L.) Corr.	Rutaceae
4.	Chhal	Anogeissus latifolia (Roxb. ex DC.)	Combretaceae
5.	Kurial	Bauhinia variegata L.	Caesalpiniaceae
6.	Semal	Bombax ceiba L.	Bombacaceae
7.	Maindul	Catunaregam spinosa (Thunb.) Tirvengadum	Rubiaceae
8	Shisham	Dalbergia sissoo	Fabaceae
9	Khareek	Celtis australis L.	Ulmaceae
10	Lisora	Cordia dichotoma Forst.	Rutaceae
11	Gulmohar	Delonix regia (Bojer ex Hook. F.) Rafin.	Caesalpiniaceae
12	Phagoora	Ficus auriculata Lour.	Moraceae
13	Anzir	F. palmata Forsk.	Moraceae
14	Khaina	F. semicordata Buch.- Ham. ex J.E. Smith	Moraceae
15	Amaltas	Cassia fistula L.	Caesalpiniaceae
16	Amla	Emblica officinalis Gaert.	Euphorbiaceae
17	Vad	Ficus benghalensis L.	Moraceae
18	Pipal	Ficus religiosa L.	Moraceae
19	Bihul	Grewia opositifolia Buch.- Ham. ex D. Don	Tiliaceae
20	kanju	Holoptelea integrifolia (Roxb.) Planch.	Ulmaceae
21	Gurjon	Lannea coromandelica (Houtt.) Merr.	Anacardiaceae
22	Subabul	Leucaena leucocephala(Lam.) De Wit.	Mimosaceae
23	Kamela	Mallotus philippensis (Lam.) Muell.-Arg.	Euphorbiaceae
24	Aam	Mangifera indica L.	Anacardiaceae
25	Sunara	Moringa oleifera Lam.	Moringaceae
26	Sahtoot	Morus serrata Roxb.	Moraceae
27	Sandar	Ougeinia oojeinensis (Roxb.) Hochreutiner	Fabaceae
28	Aunmla	Phyllanthus emblica L.	Euphorbiaceae
29	Melu	Pyrus pashia Buch.- Ham.ex D.Don	Rosaceae
30	Amara	Spondias pinnata (L.f) Kurz	Anacardiaceae
31	Tooun	Toona ciliata M. Roem.	Meliaceae
32	Chir	Pinus roxburghii,	Pinaceae
33	Buransh	Rhododendron arboreum	Ericaceae
34	Deodar	Cedrus deodara	Pinaceae

35	Silver oak	Grevillea robusta	Proteaceae
36	Utis	Alnus nepalensis	Betulaceae
37	Kaner	Nerium odoratum	Apocynaceae
38	Rambans	Agave americana L.	Agavaceae
39	Kheena	Sapium insigne	Euphorbiaceae
40	Burans	Rhododendron arboreum	Ericaceae
41	Siris	*Albizzia lebbeck*	Leguminosae
42	Pangar	Aesculus indica	Sapindaceae
43	Mehal	*Pyrus pashia*	Rosaceae
44	Kilmora	*Berberis asiatica*	Berberidaceae
SHRUBS			
1	Ratti	Abrus precatorius L.	Fabaceae
2	Basutri	Adhatoda vasica Nees	Acanthaceae
3	Nuriya	Aerva sanguinolenta (L.) Blume	Amaranthaceae
4	Kingore	Berberis asiatica Roxb. ex DC.	Berberidaceae
5	Kingor	B. lycium Royle	Berberidaceae
6	Daiya	Callicarpa macrophylla Vahl	Verbenaceae
7	Karaunda	Carissa opaca Stapf ex Haines	Apocyanaceae
8	Bindu	Colebrookia oppositifolia J.E. Smith	Lamiaceae
9	Kharna	Eupatorium adenophorum Spreng.	Asteraceae
10	Thor	Euphorbia royleana Boiss.	Euphorbiaceae
11	Callicarpa macrophylla Ghaneri	Lantana camara L.	Verbenaceae
12	Agla	Mimosa himalayana Gamble	Mimosaceae
13	Kari Patta	Murraya koenigii (L.) Spreng.	Rutaceae
14	Nagfani	Opuntia elatior Miller	Cactaceae
15	Ghari	Randia tetrasperma (Roxb.) Poir.	Rubiaceae
16	Tang	Rhus parviflora Roxb.	Anacardiaceae
17	Arandi	Ricinus communis L.	Euphorbiaceae
18	Hinsalu	Rubus ellipticus Smith	Rosaceae
19	Kandali	Urtica dioica L.	Urticaceae
20	Dhan	Woodfordia fruticosa (L.) Kurz	Lythraceae
21	Ber	Ziziphus mauritiana Lam.	Rhamnaceae
HERBS & GRASSES			
1	Aghara	Achyranthes aspera L.	Amaranthaceae
2	Mayurshikha	Adiantum incisum Forsk	Adiantaceae
3	Ghandugli	Alternanthera sessilis (L.) DC.	Amaranthaceae
4	Chaulai	Amaranthus creuntus L.	Amaranthaceae
5	Anjiri-ka-patta	Anisochilus carnosus (L.f.) Wall. ex Benth	Lamiaceae
6	Satawari	Asparagus racemosus Willd.	Liliaceae
7	Chaturi	Barleria cristata L.	Acanthaceae
8	Kasmal	Barleria strigosa Willd.	Acanthaceae
9	Kumra	Bidens pilosa L.	Asteraceae
10	Bhang	Cannabis sativa L.	Cannabaceae
11	Andhahuli	Cynoglossum zeylanicum Thunb. ex Lehm.	Boraginaceae
12	Tuntkya	Capsella bursa-pastoris (L.) Medikus	Brassicaceae

13	Gadria	Celosia argentea L.	Amaranthaceae
14	Kandara	Cirsium wallichii DC.	Asteraceae
15	Jakhya	Cleome viscosa L.	Cleomaceae
16	Bhium Kaphal	Duchesnea indica (Andrews) Focke	Rosaceae
17	Visnukrantha	Evolvulus alsinoides L.	Convolvulaceae
18	Jangi gobi	Launaea acaulis (Roxb.) Babcock ex Kerr.	Asteraceae
19	Akra	Solanum verbascifolium auct. Non. L.	Solanaceae
20	Guthari	Borreria articularis (L,f.) F.N Williams	Rubiaceae
21	Bathua	Chenopodium album L.	Chenopodiaceae
22	Akanadi	Cissampelos pareira L.	Menispermaceae
23	Kala bel	Cryptolepis buchananii Roem. and Schult.	Asclepiadaceae
24	Tusara	Debregeasia longifolia (Burm.f.) Wedd.	Urticaceae
25	Dudhi	Euphorbia hirta L.	Euphorbiaceae
26	Bal Raksha	Gnaphalium luteo-album L.	Asteraceae
27	Ban-pindalu	Gonatanthus pumilus (D.Don) Engler & Krause	Araceae
28	Kaladana	Ipomoea nil (L.) Roth	Convolvulaceae
29	Dori	Leptadenia reticulata (Retz.) Wight and Arn.	Asclepiadaceae
30	Poudina	Mentha arvensis L.	Lamiaceae
31	Poudina	M. longifolia (L.) Hudson	Lamiaceae
32	Billilotan	Nepeta hindostana (Roth.) Haines	Lamiaceae
33	Amrul	Oxalis corniculata L.	Oxalidaceae
34	Kali tulasi	Ocimum americanum L.	Lamiaceae
35	Gajar ghas	Parthenium hysterophorus L.	Asteraceae
36	Atrilal	Peristrophe bicalyculata (Retz.) Nees	Acanthaceae
37	Chitrak	Plumbago zeylanica L.	Plumbaginaceae
38	Perilla	Perilla frutescens (L.) Britton	Lamiaceae
39	Basanti	Reinwardtia indica Dumort.	Linaceae
40	Madder	Rubia manjith Roxb. ex Fleming	Rubiaceae
41	Kareta	Sida acuta Burm.f.	Malvaceae
42	Kharenti	Sida cordifolia L.	Malvaceae
43	Makhoi	Solanum nigrum L.	Solanaceae
44	Ghamra	Tridax procumbens L.	Asteraceae
		GRASSES	
1	Phool jhadu	Thysanolaena maxima (Roxb.) O. Kuntze	Poaceae
2	Gandhabel	Cymbopogon martini (Roxb.) Wat.	Poaceae
3	Doob	Cynodon dactylon (L.) Pers.	Poaceae
4	Beard grass	Andropogon munroi C.B Clarke	Poaceae
		CLIMBER	
1	Bhinura	Ampelocissus latifolia (Roxb.) Planchon	Vitaceae
2	Malkauni	Celastrus paniculatus Willd.	Celastraceae
3	Kaduri	Coccinia grandis (L.) Voigt	Cucurbitaceae
4	Genthi	Dioscorea bulbifera L.	Dioscoreaceae
5	Siralu	Pueraria tuberosa (Roxb. ex Willd.) DC.	Fabaceae
6	Machali	Vigna vexillata (L.) A. Richard	Fabaceae

Cropping Pattern of North Sikkim

Rabbi season

Rabbi season generally occurs from November. ~ December to March~April. But at project site, it is observed from Dec.~ Jan. to May~ June. The main crops during the Rabbi season are, wheat, barley, ray, sarson (mustered), pea, gram, and masur. Almost, all the crops are grown in the entire region.

Kharif season

The period of the Kharif season is from May~June. to Sep. ~ Oct., but in high elevation areas lasts from Jun. ~July to Oct.~ Nov. In the hilly terrain, the traditional millets are also grown extensively. It is found that millets crops are grown in the sloppy land and help to reduce the soil erosion. Rice and wheat dominate the agricultural realm from one corner of the region to the other, obviating the culture of the other crops. In the region whatever may be the type of soil or the amount of rainfall the dominance of food grains in the cropping pattern is everywhere obvious. The main agricultural crops grown in the region are rice in the Kharif crop season, wheat, and barley in the Rabi crop season. Food grains such as rice, wheat, and pulses are mostly grown in valley areas and the areas with irrigation facilities.

Agriculture Crops- The crops of North Sikkim include the following:-

TABLE: 3.17 LIST OF AGRICULTURE CROPS IN STUDY AREA

S.No	Common Name	Botanical Name	Family
1	Rice	Oryza sativa	
2	Wheat	Triticum aestivum	Poaceae
3	Barley	Hordeum vulgare	Poaceae
4	Maize	Zea mays	Poaceae
5	Finger Millet	Eleusine coracana Gaertn	Poaceae
6	Urd	Phaseolus mungo Linn	Fabaceae
7	Pea	Pisum sativum L.	Fabaceae
8	Mustard	Brassica spp.	Brassicaceae
9	Sweet potato	Ipomoea batatas Lamb	Convulvulaceae
10	Brocolli	Brassica oleracea var. italic	Brassicaceae
11	Cabbage	Brassica oleraces	Brassicaceae
12	Brinjal	Solaunum melongena	Solanaceae
13	Chilli	Capsicum annuum	Solanaceae
14	Bean	Chaseolus vulgoris	Fabaceae
15	Tomato	Lucopersicum esculentum	Solanaceae
16	Iskus	Sechium edule (Jacq.) Sw.	Cucurbitaceae
17	Cauliflower	Brassica oleracea var. botrytis	Brassicaceae
18	Potato	Solanum tuberosum	Solanaceae
19	Ginger	Zingber officinale	Zingiberaceae
20	Soybean	Glycine max	Fabaceae

TABLE: 3.18 LIST OF FRUITS TREE

S. No	Fruits Tree	Botanical Name	Family
1	Orange	Citrus reticulata	Rutaceae
2	Litchi	Litchi chinensis Sonn	Sapindanceae
3	Passion Fruit	Passiflora edulis	Passifloracerae
4	Jack Fruit	Artocarpus heterophyllus	Moraceae
2	Guava	Psidium guajava	Myrtaceae
6	Banana	Musa paradisiaca	Musaceae
7	Papaya	Carica papaya	Caricaceae

FAUNA (TERRESTRIAL & AQUATIC)

Faunal Assessment: - The study of fauna takes substantial amount of time to understand the specific faunal characteristics of the area. The assessment of fauna was done by extensive field survey of the area. During survey, Line Transect method was used for the study of mammals and Transact & Patch sampling was used for Amphibians, visual encountered methods was used for reptiles, Aerial net was used for butterflies. The presence of wildlife was also confirmed from animal call, foot marks, excreta and from the local inhabitants depending on the animal sightings and the frequency of their visits in the project area which was later confirmed from different government offices like forest department, wildlife department etc.

Study of fauna in core & buffer zone

Identification of fauna (specifically amphibians, birds, mammals and reptiles) based on direct sightings, calls, pug marks, droppings, nests, etc.
Identification and classification of any species recognized as threatened (in accordance with International Union for the Conservation of Nature [IUCN] Red List or according to the schedules of the Wildlife (Preservation) Act 1972 and amendments).
Identification of areas which are important or sensitive for ecological reasons including their breeding, nesting, foraging, resting, over wintering areas including wildlife migratory corridors /avian migratory routes.
Identification and assessment of aquatic ecological resources within the study area.

In addition the following sources were also used during survey-

Sighting during ecological studies

- Animal call
- Foot mark and excreta
- Tree Scars & food leftover

Avifaunal Assessment: -

Avifauna is an important part of the ecosystem playing the various roles as scavengers, Pollinators, predators of insect pest, etc. They are also one of the bio-indicators of different status of environment and affected by urbanization, industrialization and human interference. The areas having good bird diversity signifies healthy ecosystem. They can be used as sensitive indicators of pollution and malfunction of ecosystem. The study area has different type of land cover like grassland, agriculture fields and human settlements.

Observations of birds were made during a walk through in the chosen transect for sighting birds. The number of birds observed in each sampling location was listed. Birds were noted, and identified with the help of 8X40 "Optima Zenith" binocular and standard field identification guides.

Assessment of Rare, Endangered and threatened Flora and Fauna

As per the Wildlife Protection Act, 1972 and their subsequent amendments, schedule category for wild plant and animals also consider for assessing the sensitive species. The scheduled species are given for the assessment of the any available sensitive species. This Act is enacted for protection of plants and animal species. It has six schedules which give varying degrees of protection. Schedule I and part II of Schedule II provide absolute protection - offences under these are prescribed the highest penalties. Species listed in Schedule III and Schedule IV are also protected, but the penalties are much lower. Schedule V includes the animals which may be hunted. The plants in Schedule VI are prohibited from cultivation and planting. The hunting to the enforcement authorities have the power to compound offences under this Schedule (i.e. they impose fines on the offenders).

Assessment of sensitive habitat

The riparian patches, protected areas (wildlife sanctuary & national park) and other specific habitat condition are some those places which are sensitive place for any small changes due to the developmental activity. During the baseline study such habitat fragmentation, ecological sensitivity, if any are taken in to consideration within the study area. Land use pattern of this region was dominated by agriculture land.

TABLE 3.19 LIST OF FAUNA SPECIES OBSERVED IN THE CORE ZONE

S. No	Common Name	Zoological Name	Status as per Wildlife Conservation Act, 1972 and amendments
MAMMALS			
1	Five striped palm squirrel	Felnambulos pennant	-
BIRDS			
1	Common Mynas	Acridotheres tristis	IV
2	Black Drongos	Dicrurus macrocercus	IV
3	Hill crow	Corvus brachyrhynchos	IV
4	Green Pigeon	Treron pompadora	IV
5	Red vented Bulbul	Pycononotus cafer	V

Observations: - The above mammals and birds are observed during the study period but amphibian and reptiles are not observed in the core zone during study period.

TABLE 3.20 LIST OF FAUNA SPECIES OBSERVED IN THE 10 K.M RADIUS

S. No	Common Name	Zoological Name	Status as per Wildlife Conservation Act, 1972 and amendments
MAMMALS			
1	Barking Deer	Muntiacus muntjak	III
2	Rhesus maeaque	Macaca mulatta	II
3	Langur	Presptisen entellus	II
4	Jackal	Canis aureus	II
5	Jungle cat	Felis chaus	II
6	Indian hare	Lepus nigricollis	IV
7	Wild boar	Sus scrofa	
8	Mongoose	Herpest edwardii	IV
9	Common house Rat	Rattus rattus	V
10	Mouse	Mus muculus	V
11	Porcupine	Hystrix Indica	IV
12	Hog deer	Axis porcinus	III
13	Striped hyena	Hyaena hyaena	III
14	Common red fox	Vulpes vulpes	II
15	Five striped palm squirrel	Felnambulos pennant	-
BIRDS			
1	Jungle Babbler	Turdoides striata	IV
2	Common Coots	Fulica atra	IV
3	Common Mynas	Acridotheres tristis	IV
4	Black Drongos	Dicrurus macrocercus	IV
5	Hill crow	Corvus brachyrhynchos	IV
6	Green Pigeon	Treron pompadora	IV
7	Orange minivet	Pericrocotus flammeus	IV
8	Himalayan bulbul	Pycnonotus leucogenys	IV
9	Red vented Bulbul	Pycononotus cafer	V

10	Purple sunbird	Cinnyris asiaticus	-
11	Oriental Turtle doves	Streptopelia orientalis	IV
12	Crested Kingfisher	Megaceryl lugubris	IV
13	Common Kingfisher	Alcedo atthis	IV
14	Oriental magpies robin	Copsychus saularis	IV
15	Yellow Billed blue magpie	Urocissa flavirostris	IV
16	Rose ringed parakeet	Psittacula krameri	IV
17	Night Jar	Caprimulgus europaeus	-
18	Red jungle fowl	Gallus gallus	III
19	Blue Whistling thrush	Myophonus caeruleus	-
20	Little egret	Egretta garzetta	IV
21	Owl	Bubo bubo	IV
22	Asian Koel	Eudybnamys scolopaceus	IV
23	Blue Rock Pigeon	Columba livia	IV
24	Baya Weaver	Ploceus philippinus	-
25	Grey Quail	Coturnix coturnix L	-
26	Black quail	Coturnix corm Andelica Gmelin	-
27	House crow	Corvus spendens	IV
28	Parrot	Psittacula himalayana	IV
29	Pahari bulbul	Pycnonotus jocosus	IV
30	Chakor	Alectoris graeca	IV
31	Laughing Dove	Streptopelia senegalensis	IV
32	Great Cormorant	Phalacrocorax carbo	IV
33	Little Cormorant	Microcarbo niger	IV
34	Eastern Great Egret	Ardea modesta	IV
35	Black Kite	Milvus migrans	IV
36	House Sparrow	Passer domesticus	IV
37	Black Bulbul	Hypsipetes leucocephalus	IV
38	Himalayan Bulbul	Pyconotus leucogenys	IV
39	Titar	Francolinus pondicerlanus	IV
40	Syam kukut / wood cock	Scolopax rusticola	IV
41	Brown-fronted Woodpecker	Dendrocopos auriceps	IV
42	Great barbet	Megalaima virens	IV
43	Rock bunting	Emberiza cia	IV
44	Wild owlet	Glaucidium radiatum Tickell	IV
45	Brown wood owl	Strix leptogrammica	IV

		Hodgson	
46	Grey hornbill	Tockus birostris Scopoli	IV
47	Indian roller	Coracias benghalensis L	IV
48	Large yellow naked wood pecker	P. chlorolophus	IV
49	Black naked wood pecker	Picus canus Baker	IV
50	White throated laughing thrush	Garrulax albogularis	-
51	Kalij pheasant	Lophura leucomelanos	-
52	Grey headed parakeet	Psittacula finschii	-
53	Fire capped tit	Cephalopyrus flammiceps	-
54	Black lored tit	Parus xanthogenys	-
55	Black headed jay	Garrulus lanceolatus	-
56	Himalayan blue tail	Tarsiger rufilatus	-
57	Spot breasyed scimitar babbler	Pomatorhinius erythrocnemis	-
58	Tickells leaf warbler	Phylloscopus affinis	-
59	Wedge tailed green pigeon	Treron sphenurus	-
60	Scaly bellied woodpecker	Picus squamatus	-
61	Plum headed parakeet	Psittacula cyanocephala	-
62	Red rumped swallow	Cecropis daurica	-
63	Ashy drongo	Dicrurus leucophaeus	-
64	Blue capped rock thrush	Monticola cinclorhynchus	-
65	Oriental turtle dove	Streptopelia orientalis	-
66	Ultramarine flycatcher	Ficedula superciliaris	-
67	Gray headed canary	Culicicapa ceylonensis	-
68	Blue capped redstart	Phoenicurus caeruleocephala	-
69	Himalayan woodpecker	Dendrocopos himalayensis	-
70	Wedge tailed green pigeon	Treron sphenurus	-
71	Blue winged minla	Actinodura cyanouroptera	-
72	Speckled peculet	Picumnus innominatus	-
73	Emerald dove	Chalcophaps indica	-
74	Rufous bellied woodpecker	Dendrocopos hyperythrus	-

AMPHIBIAN			
1	Marbled toad	Bufo andersoni	-
2	Indian bull frog	Rana tigrina	IV
REPTILES			
1	Oriental garden lizard	Calotes versicolor	II
2	Indian Cobra	Naja naja	II
3	Russell's Viper	Vipera russelii	II
4	rat-snake	Zamenis longissimus	II
5	Himalayan Rock Agama	Laudakia himalayana	II

There is khangchendzonga national park in approx. 3.5 km in NNW direction of the project site and is in the 10 km periphery of the project area.

AQUATIC ECOLOGY

The sampling was carried out fron Dec. 2021 to Feb. 2022. Biological characteristics that were assessed includezooplankton, phytoplankton, and benthos & fish diversity.

Several methods have been used to analyse the effects of human activities on aquatic environment. They include the use of selected chemical and physical parameters, as well as a variety of biological measurements that range from bacteriological analyses to bioassay studies of fish and other aquatic organisms. Biological species viz. phytoplankton and zooplankton specific for a particular environmental condition are the best indicators of environmental quality. Studies on biological aspects of ecosystem are important in view of the conservation of environmental quality and of natural flora and fauna including human-beings.

Phytoplankton: - For the study of phytoplankton, samples were collected from 10 cm depth below the water surface. Fresh Polythene bottles of 250 ml capacity (Polylab) were used for collection of water samples. After the sampling, the sample was preserved by adding Lugol's solution.

Zooplankton: - For the quantification of zooplankton samples, water was filtered at each site by using standard plankton net made up of fine silk cloth (mesh size 25 µm). After the sampling, the preservation of samples was carried out without delay to avoid damage to animal tissue by bacterial action. The collected filtrate was preserved in the 4% formalin solution (Analytical grade). The density of zooplankton was estimated with the help of APHA (2012). After preservation the zooplankton samples were kept in well-ventilated room at temperature less than 25°C. The samples were kept in the wide mouth bottle. A good quality pre-printed label were used, on which date and time of sampling, fixative and preservative used and other field information were written for ready reference at the time of analysis.

Fish: - Fish samples were collected from different habitats such as Rivers, Dams and Village ponds. For fish collection Cast Net, Mosquito net and locally available fishing pole were used. After sample collection, fish were examined, and released back into the system. For unidentified species, some fish samples were preserved in formalin solution (30%) and transported for species confirmation. Species identification and confirmation were carried out using available literature, books and pictorial guides. At each sampling site, a set of the following environmental variables were recorded: Water source, stream order, altitude, stream width (m) approx. and water depth (cm).

TABLE NO: 3.21 LIST OF SURFACE WATER BODIES FOR AQUATIC ECOLOGY

River	Distance	Direction
Teesta River (Upstream)	1.5	N
Teesta river upstream	2.0	S
Naga waterfall	1 km	S

TABLE NO. 3. 22 PHYTO PLANKTONS ARE OBSERVED IN THE RIVER SIDE.

S.No	Botanical Name	Family
1	Scenedesmus	Scenedesmaceae
2	Microcystis	Chroococcaceae
3	Anabaena	Nostocaceae
4	Spirogyra	Zygnemataceae
5	Chlorella	Oocystaceae
6	Chlamydomonas	Chlamydomonadaceae
7	Volvox	Volvacaceae
8	Chlorella	Oocystaceae
9	Ankistrodesmus	Oocystaceae
10	Coelastrum	Scenedesmaceae
11	Oedogonium	Oedogoniaceae
12	Ulothrix	Ulotrichaceae
13	Cladophora	Cladophoraceae
14	Chlamydomonas	Chlamydomonadaceae
15	Chara	Characeae
16	Microspora	Microsporaceae
17	Chromulina	Ochromonadaceae
18	Desmidium	Desmidiaceae
19	Sphaerozosma	
20	Chlorobotrys	Eustigmatophyceae
21	Botrydiopsis	Pleurochloridaceae
22	Oscillatoria	Oscillatoriaceae

Zooplanktons are observed in the river side.

S.No.	Species Name	Family
1	Euglena	Euglenaceae
2	Phacus	
3	Daphnia	Daphniidae
4	Pteromonas	Phacotaceae
5	Amoeba	Amoebidae
6	Difflugia	Difflugiidae
7	Paramecium	Parameciidae
8	Entamoeba histolytica	Entamoebidae
9	Cyclops	Cyclopidae
10	Rotaria	Philodinidae

Fish is found in almost all the rivers, streams and lakes. River abound in the larger fish. The riparian villages find in it an important supplement to their food. The common species found in the river are given below:

S.No	Scientific Name	Common Name
1	Tor putitora	Golden Mahseer
2	Tor tor	Silver Mahseer
3	Schizothorax richardsonii	Alwan Snow trout
4	Schizothoraichthys progastus	Snow trout
5	Brachidanio rerio	Zebra Fish
6	Puntius conchonius	Rosy barb
7	Puntius sophore	Pool Barb
8	Tor chilinoides	Black mahseer
9	Banillius bendilisis	Baril
10	Glytothorax pecinopterus	River cat
11	Danio devario	Devario danio

Conclusion: -

- We have concluded the ecological study and found that core zone of project belongs to forest land the Dominant species were observed within site area of 2.0 Ha i.e area 1.Chir (Pinus roxburghii), 2. Himalayan cedar, 3. Banj oak (Quercus leucotrichophora), 4.Box berry or Kaphal (Myrica esculenta) in core zone .
- Dominant species in buffer zone observed were Chir (Pinus roxburghii), Himalayan cedar, Banj oak (Quercus leucotrichophora), Box berry or Kaphal (Myrica esculenta), Khair Acacia catechu (L.f.) Willd., Bel, Aegle marmelos (L.) Corr. Etc. in buffer zone as well.
- The floral species which were observed during site visit will be maintained on the respective diversion land as well as on the periphery of project site.
- Due to forest area, few faunal species was observed in the core zone as Five striped palm squirrel etc and in the buffer zone ,we have observed the faunal species as mammals hog deer,

striped hyena, five striped palm squirrel and Avi fauna are Kalij pheasant, Grey headed parakeet, Fire capped tit, Black lored tit, Black headed jay and amphibians are Marbled toad (Bufo andersoni) , Indian bull frog (Rana tigrina)

- The site clearing activities will be done as per Lease agreement terms and condition which creates minor impact on the Ecological and biodiversity of the area 10 km radius. Peripheral green belt development with suitable trees species have been incorporated to mitigate the dustand odour emissions in core zone.
- 33 % green belt area will be developed and maintained in the plant, which will provide more habitats to birds, rodents and small mammals. The landfill cover will also be landscaped with local plants species.

3.8 SOCIOECONOMIC SURVEY

Introduction

The study of socio-economic component of environment incorporates various facets, viz. demographic structure, availability of basic amenities such as housing, education, health and medical services, occupation, water supply, sanitation, communication and power supply, prevailing diseases in the region as well as features such as places of tourist attraction and monuments of archaeological importance. The study of these parameters helps in identifying predicting and evaluating the likely impacts due to project activity in the surrounding region.

The project is for Proposed Solid Waste Treatment Project for Mangan. On the basis of available census data, 2011 different aspects of socio-economic condition of total 45 villages in the study area have been analysed and surveyed.

Methodology used for the Field survey

In order to access and evaluate likely impacts arising out of any development projects on socio economic environment, it is necessary to gauge the apprehensions of the people in the study areas.

Methodology Adopted for the Study

Collection of data

The information analyzed for the project has been collected from various secondary sources, which has been supported by the extensive site visits and field observations.

- **Secondary:** Review of secondary data, such as District Primary Census of North Sikkim 2011 within the study area around the existing project
- **Primary:** A social survey for examination of the respective site and specific region reference to its general character. A questionnaire developed to make it suitable to fulfill the objectives of the

study. Primary data collected by Focus Group discussions in sample villages. Extensive site visits and observations of the socio economic environment.

Sampling method

The studies are conducted and inferences are drawn on the basis of observation and field survey on the basis of non-probability random sampling and convenience sampling with access to the nearest habitation of the project to the extent possible.

Review of Demographic and Socio-Economic Profile – 2011

The sociological aspects of this study include human settlements, demography, social strata such as Scheduled Castes and Scheduled Tribes and literacy levels besides infrastructure facilities available inthe study area. The economic aspects include occupational structure of workers. The information on socio-economic aspects of the study area has been collected from secondary sources, which mainly include District Primary Census 2011 of North Sikkim, Sikkim.

1. Data Collection and Quality Assurance

The available data have been complied to generate the existing socio-economic scenario of the study area. Information on socio-economic profile was collected from the Primary Census Abstract 2011, including the population details of the region and Village Directory, having the details of basic amenities available in the region. In the 10 km radius study area constitute 45 villages from North Sikim district of Sikkim 2011

Table 3.23 CENSUS 2011 DATA OF SOCIO – ECONOMIC REPORT ON SWT PLANT PROJECT FOR MANGAN

			State		District	
Number of Villages		Total	451		55	
		Inhabited	425		52	
		Uninhabited	26		3	
Number of Towns		Statutory	8		1	
		Census	1		-	
		Total	9		1	
Number of Households		Normal	128,115		8,753	
		Institutional	816		110	
		Houseless	75		10	
Population	Total	Persons	610,577		43,709	
		Males	323,070		24,730	
		Females	287,507		18,979	
	Rural	Persons	456,999		39,065	
		Males	242,797		22,274	
		Females	214,202		16,791	
	Urban	Persons	153,578		4,644	
		Males	80,273		2,456	
		Females	73,305		2,188	
Percentage Urban Population			25.15		10.62	
Decadal Population Growth2001-2011			Number	Percentage	Number	Percentage
		Persons	69,726	12.89	2,679	6.53
		Males	34,586	11.99	1,316	5.62

Urban Development & Housing Department (UD&HD), Govt. of Sikkim

	Females	35,140	13.92	1,363	7.74
Area (in sq Km.)		7096		4226.00	
Density of Population (Personsper sq Km.)		86		10	
Sex Ratio	Total	890		767	
(Number of females per 1000 males)	Rural	882		754	
	Urban	913		891	

Important Statistics (District: North District)

State				**District**	
		Number	Percentage	Number	Percentage
Literates	Persons	444,952	81.42	30,450	78.01
	Males	251,269	86.55	18,579	83.30
	Females	193,683	75.61	11,871	70.97
Scheduled Castes	Persons	28,275	4.63	982	2.25
	Males	14,454	4.47	536	2.17
	Females	13,821	4.81	446	2.35
Scheduled Tribes	Persons	206,360	33.8	28,715	65.70
	Males	105,261	32.58	14,741	59.61
	Females	101,099	35.16	13,974	73.63
Workers and Non-Workers Total Workers (Main and	Persons	308,138	50.47	23,359	53.44
Marginal)	Males	194,358	60.16	15,935	64.44
	Females	113,780	39.57	7,424	39.12
(i) Main Workers	Persons	230,397	37.73	17,216	39.39
	Males	160,513	49.68	12,677	51.26
	Females	69,884	24.31	4,539	23.92
(ii) Marginal Workers	Persons	77,741	12.73	6,143	14.05
	Males	33,845	10.48	3,258	13.17
	Females	43,896	15.27	2,885	15.20

Non-Workers	Persons	302,439	49.53	20,350	46.56
	Males	128,712	39.84	8,795	35.56
	Females	173,727	60.43	11,555	60.88
Category of Workers (Main &	**Marginal)**				
(i) Cultivators	Persons	117,401	38.1	7,313	31.31
	Males	63,327	32.58	3,889	24.41
	Females	54,074	47.53	3,424	46.12
(ii)Agricultural Labourers	Persons	25,986	8.43	2,262	9.68
	Males	12,883	6.63	1,308	8.21
	Females	13,103	11.52	954	12.85
(iii)Workers in household	Persons	5,143	1.67	332	1.42
industry	Males	2,947	1.52	152	0.95
	Females	2,196	1.93	180	2.42
(iv) Other Workers	Persons	159,608	51.8	13,452	57.59
	Males	115,201	59.27	10,586	66.43
	Females	44,407	39.03	2,866	38.60

Human Settlement

The study area comprises 55 villages with population of about 43,709 (Male-24,730 & female – 18,979) and number of households are 8753. (According to the Census 2011).

Gender Ratio

The data reveals that male and female percentage in this area is 56.57 % and 43.43 % respectively. The study areas on an average 767 females are per 1000 males which are not good indicators inspect of gender equality. Accordingly, census record the number of females per 1000 males indirectly reveals certain sociological aspects in relation with female births, infant mortality among female children.

Caste Categories: -

As per the classification under our constitution castes are divided into 4 major groups i.e., General, SC, ST and OBC as per their social status.

TABLE 3.24: DISTRIBUTION OF POPULATION BY SOCIAL STRUCTURE

		State		District	
		Number	Percentage	Number	Percentage
Scheduled Castes	Persons	28,275	4.63	982	2.25
	Males	14,454	4.47	536	2.17
	Females	13,821	4.81	446	2.35
Scheduled Tribes	Persons	206,360	33.8	28,715	65.70
	Males	105,261	32.58	14,741	59.61
	Females	101,099	35.16	13,974	73.63

As per 2011 census, the percentage of Schedule caste population is very low i.e. 2.25% and Schedule tribe population is good 65.70%.

Literacy Levels

The study area experiences a considerably average literacy rate of 78.01% (2011). The distribution of literate and literacy rate of study area is in tabulated below –

TABLE 3.25: DISTRIBUTION OF LITERATE AND LITERACY RATES

		State		District	
		Number	Percentage	Number	Percentage
Literates	Persons	444,952	81.42	30,450	78.01
	Males	251,269	86.55	18,579	83.30
	Females	193,683	75.61	11,871	70.97

The male literacy i.e. the percentage of literate males to the total males works out to be 94.01%. The female literacy rate, which is an important indicator for social change, is observed to be 63.20 % as per 2011 census records.

From the above given data, it is revealed that illiterate rate is good in the study area. 78.01 %

Employment Pattern

Economic resource base of any region mainly depends upon its economically active group i.e. the working population involved in productive work. Work may be defined as participation in any economically productive activity. Such participation may be physical or mental in nature. Work not only involves actual work but also effective supervision and direction of work. It also includes unpaid work on farm or in family enterprise.

There are different types of workers that may be classified as - those persons who had worked for at least six months or 183 days are treated to be Main Workers, on the other hand if person categorized as worker has participated in any economic or productive activity for less than six months or 183 days during the last one year is treated as Marginal Worker. Non–workers are those who have not worked any time at all in the year preceding the enumeration.

The workers coming under the main and marginal workers category are those involved in activities such as cultivation, agriculture, livestock, forestry, fishing, hunting, plantations, orchards and allied activities, mining and quarrying, manufacturing, processing, servicing and repairs in household industry, construction, trade and commerce, transport, storage and communication and other services.

		State		District	
		Number	Percentage	Number	Percentage
Workers and Non-Workers Total Workers (Main and Marginal)	Persons	308,138	50.47	23,359	53.44
	Males	194,358	60.16	15,935	64.44

	Females	113,780	39.57	7,424	39.12
(i) Main Workers	Persons	230,397	37.73	17,216	39.39
	Males	160,513	49.68	12,677	51.26
	Females	69,884	24.31	4,539	23.92
(ii) Marginal Workers	Persons	77,741	12.73	6,143	14.05
	Males	33,845	10.48	3,258	13.17
	Females	43,896	15.27	2,885	15.20
Non-Workers	Persons	302,439	49.53	20,350	46.56
	Males	128,712	39.84	8,795	35.56
	Females	173,727	60.43	11,555	60.88

As per 2011 census records altogether the main workers work out to be 39.39% of the total population. The marginal workers and non-workers constitute to 14.05% and 46.56% of the total population respectively. The distribution of workers by occupation indicates that the non-workers are the predominant population.

1. Field Survey and Observations

Field survey and observations is made at each sampling village and the socio-economic status of that region is studied. Visits are made at hospitals, primary health centres and sub-centres to know the health status of the region. Various Governmental organizations such as Statistical Department visited to collect the requisite details of that region.

Salient Observation of the Survey/ Study Area

- **Economy:** The main occupation of the population is agriculture. Besides, army / para-military forces and teaching are a major source of employment for young people. Due to the lack of required infrastructure and the geography of the area, there are no major industries in the hilly part of the district.
- **House pattern:** It is notable that Almost 50% of houses are kutcha house/dilapidated house, 30% of houses are Pucca (brick) rest are Semi- pucca houses in study area. People are using local and Hindi language.
- **Employment:** People here are nice, honest, hardworking and shy! More often they are short and stout. Toughness and difficult life of mountains make them special. A reasonable percentage of sikkim enjoys their share in Armed Forces and many works outside the state/country for better job prospects, for a better earning. Horticulture, Agriculture and Tourism are three major activities after Government Service Sector, which is also a prime engagement. However, Agriculture, Tourism and Horticulture are not fully utilised in the Hills.
- **Fuel:** Most of the villagers use fire woods and LPG for cooking purpose.
- **Agriculture:** Agriculture is not a profitable means of employment in this hilly district due to its uneven geographical conditions, small terraced fields and non-availability of proper irrigation

facilities. The Nayyar (the main river system of the district) catchments are richly endowed with various natural resources viz. Soil, Water, Minerals, Rocks, Forests and a Scenic Landscape. It is still economically under developed. The present form and level of agro economy of the area is considerably poor

- **Main Crops:** crop grown by the farmer of study area are rice, wheat, barley, maize, mandua, and pulses such as urd, moong, masoor, chana, matar, arhar etc.oil containing seeds like sarson, alsi, til, sunflower, soyabean etc.
- **Migration:** During survey it was found that local population were migrating for employment purpose. Male from families are migrated to other cities in search of work leaving females behind at home.
- **Sanitation:** Sanitation facility coverage as found in primary survey may be comparatively better in the urban areas, but in rural areas. Sanitation programme is going on in study area under "Swachh Bharat Mission" and people are well aware about sanitation and its sustainability. Most of households are creating toilets in study area and rest of household's work is going on
- **Drinking Water Facilities:** Spring water is the main source of water providing life to people in the mountain region especially in the study area. Spring is a natural source of groundwater. Unlike wells, which may be owned and controlled privately; springs are generally community-owned and community-managed. Thus, they give a sense of a "common" resource i.e. groundwater shared through a common mechanism, i.e. the spring. Some of respondents have individual taps in their houses for water, whereas most of respondent depends on the natural source of water for their daily requirement.
- **Education Facilities:** Most of the villages had education facilities in the form of Anganwadi and Primary Schools. Higher education facilities were available in the range of 5-10 km. Colleges and other diploma courses were available.
- **Transportation Facility:** For transportation purpose Auto, Public and Private Bus services were available in study areas. Transportation facilities were frequently available in the study area and connecting major cities. Private vehicles like Bicycles & Motor Cycles were mostly used by villagers for transportation purpose.
- **Road Connectivity:** Most of the roads were pucca and connecting to villages. Dambar and cement roads were commonly seen inside the villages.
- **Communication Facilities:** For communication purpose mainly mobile phones, newspaper & post offices were seen in the villages.
- **Medical Facilities:** The availability of medical facilities in the study area is good, there are average numbers of dispensaries, maternity and family welfare centres are available.
- **Electricity:** The power supply connections in Villages are majorly used for domestic purposes, Source/ Govt Power supply.
- **Market Facility:** Study area is predominantly rural. In villages, small shops were available for

daily needs. Wholesale markets were available at Mangan town place.

- **Animal's husbandry:** Normally local villagers are based upon cattle, buffaloes, sheep, goats, pigs and poultry. etc. Villagers are generating daily income from these animals. They are selling Milk to dairy point and get appropriate rates during the year and also supply the milk in their village and nearby Hotels/ road side Dhaba.
- **Savings:** - At study area earnings of families are depend on agriculture crops, daily labour work and some of their small type of business. 55% families has source of income is agriculture. Their yearly income and expenditure is equal so they enable to do saving.
- **Family assets:-**For assessing the family condition as per movable (material) assets information has been taken from the study area. Its show that People have own Television sets, tape, radio, mobile, LPG connections and refrigerator respectively in their houses. Few populations have two wheeler, 4 wheeler, and goods vehicle & own some other assets such as washing machine, telephone, VCD, sewing machine, etc.

Awareness and Opinion about the project

- The respondents from almost of all the villages are not aware about this MSW project.
- The respondents have mixed view about the project. Most of the respondents have fear about the increased solid waste, air, water & soil contamination and emission odour.
- Some respondents from the nearby villages have in the region show favorable opinion about Project and associated activity as it may lead to increase in infrastructural facilities and job opportunities.
- This will improve the living standard of society & will provide safe & hygienic surroundings. It will also eliminate the passage of solid waste/garbage problems in sewer lines.
- This will reduce the chances of spreading of diseases. This project will improve the health condition of the area and society.

Expectation from the project

- Local employment
- Plantation at nearby areas and ensure their survival rate.
- Efficient waste collection & disposal of waste will improve the living & health condition of inhabitants in the area.
- Free Medical facilities for villagers and organize medical camps in nearby villages for seasonable diseases.
- Solid waste Treatment project will ensure timely collection of waste, efficienttreatment & disposal in scientific & environment friendly manner.
- Collection of waste from their villages also.

Impact on Human Settlement

The impact on socio economic of surrounding area will be positive, as Project will directly employ the local workers. Preference to local people residing nearby will be given direct employment for this project. There is no displacement of any habitation or personnel and hence the rehabilitation and resettlement action plan is not required.

Impact on Social Status: The study area is predominantly inhabited by rural population. The proposed project is likely to provide more opportunities in employment to this area. The preference in employment will be provided to the local residents in this area. Thus, population of the study area will be benefited due to the project in terms of direct and indirect employment opportunities.

Impact on Civic Amenities: Cattles & other stray animals are used to roam around the existing open dump site, which creates disturbance to society. Open dumping of waste also creates an unpleasant view and leads to emission of mal odour. It will control the diseases menace which gets spread due to the unattended waste lying at dumping site which attracts flies, rats, and other creatures that in turn spread diseases in society. This leads to unhygienic conditions and thereby causes rise in the health problem. Open dumping of waste also creates an unpleasant view and leads to emission of mal odour. Through this project a scientific technology of waste management shall be developed. Proper Disposal and processing of MSW, processing rejects /inert will create better hygienic conditions within municipal limits of city and nearby villages.

Impact on Public Health: Efficient waste collection & disposal of waste will improve the living & health condition of inhabitants in the area. Littering of waste creates nuisance due to unpleasant view and emission of foul odour. It will eliminate the ground for breeding of mosquitoes & disease-causing pathogens. Solid waste treatment project will ensure timely collection of waste, efficient treatment & disposal in scientific & environment friendly manner. This will reduce the chances of spreading of diseases. This project will improve the health condition of the area and society.

Impact on Health Care Facilities: While MSW activities, sufficient care will be taken in providing health facilities to their employees besides organizing various medical camps for the surrounding villages. The improved health care facilities improve the quality of life in the area.

Impact on Economic Aspects: Project will generate both direct & indirect employment. Local people will be preferred for giving employment. This will improve economic status of the area. Emigration of local people to other parts of state/country due to unavailability of employment will be reduced. The land value of near to the project land will decrease due to this project because of emission of mal odour.

Impact on Archeological and Historical and Places of Religious worship & Tourist Places: The MSW project is unlikely to cause any impact on these places or structures or devotees.

Socio-Economic Development

Based on the requirement of the people in the area, various development activities will be taken by Mangan Nagar Palika Parishad regularly. The basic requirement of the community are strengthened by extending health care, educational facilities developed in the township to the community, providing drinking water to the villages affected, building/strengthening of existing roads in the area etc.; In order to obtain felt needs of the surrounding villagers for effective implantation of desired needs. The proposed project may create opportunities for indirect employment in the field of vehicle hiring, labors, trading of construction material, service sector etc. This will help in improving the socio economic status of the region.

Steps to be taken to Improve Socio-Economic Conditions

The socio-economic conditions in the study area indicate the quality of life of the people. The important indicators which decide the quality of life and required to be improved for better living conditions are literacy levels, occupational structure, infrastructural facilities, transportation, communication linkages, land development and cropping pattern. The project proponents are envisaging undertaking the following socio-economic measures.

- **Health Care:** The adequate funds will be allocated for mobile dispensary, family planning, medical camps and aid to the Govt. hospitals.

- **Educational Facilities:** These include adult education facilities, financial assistance for higher studies, sponsorship to vocational / professional training institution, computer education camps, vocational training for students and aid to existing/proposed Govt. schools and colleges.

- **Civic Amenities**: These include support to community toilets, drinking water facilities like public stand posts, elevated service reservoirs, playgrounds for children and recreation facilities for all age groups. In addition to this participation and support to government efforts.

- **Employment:** Development of project will provide employment opportunity to local skilled, unskilled & semiskilled people during both construction & operation phase. Indirect employment may also generate during construction phase of project. Tea stalls, and food shop may come up around project site for workers. Almost local labour will be engaged for the allied activity like marketing and sale of products like compost may further require more man power engagement.

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CHAPTER-IV ANTICIPATED IMPACT & MITIGATION MEASURE

CHAPTER-IV

ANTICIPATED IMPACTS & MITIGATION MEASURES

4.1 INTRODUCTION

Any development activity in its wake will bring about some impacts associated with its origin, which can be broadly classified as reversible, irreversible, long and short-term impacts, in this chapter, an endeavour has been made to identify various environmental impacts associated with the operation of facility and other activities wherein, there may be chance of pollution.

Based on the possible worst case emission and waste generation from the proposed project and also taking into considering the base line environmental status at the proposed project site, the environmental factors that are likely to be affected (impacts) are identified, quantified and assessed. Both instrumental (positive) and detrimental (negative) impacts are accounted for this purpose.

The environment and social framework is intended to help manage the social and environmental impacts through appropriate measures during the planning, design, construction and operation phases of the project. The management plan will identify the adverse environment and social impacts and provide specific guidance on the policies and procedures to be followed for environmental and social assessment along with roles and responsibilities of the implementing agencies.

Location Impacts

Impacts associated with the planning are mainly due to site selection. Location impacts include on site biophysical array and encroachment/impact either directly or indirectly on adjacent environments.

Mitigation Measures-

The proposed waste treatment plant is proposed & planned to be established at Mangan, North Sikkim, Sikkim. The area of the proposed site is 2.0 Ha. This proposed project site location meets the site criteria's as per CPCB guidelines, CPHEEO guidelines and SWM rules 2016. There is no eco sensitive zone observed in the project site & study area. The details about alternative site analysis & site selection criteria are well furnished in Chapter 5 of this EIA/EMP report.

Design Impacts

Impacts arising from the design of the project, including the technology used, scale of operation/throughput, waste production, discharge specification, pollution sources and ancillary services;

Mitigation Measures-

The design approach for proposed project is planned considering the features of site, advance and best available technology in line with CPCB guidelines, CPHEEO guidelines and SWM rules 2016 to reduce the impact from design point of view.

4.2 IMPACTS DURING CONSTRUCTION AND OPERATIONAL PHASE

Construction phase works include site clearance, site formation, excavation, material handling, building works, infrastructure provision and any other infrastructure activities. The impacts due to construction activities are short term and area limited to the construction phase. The impacts will be mainly on air quality, water quality and soil quality.

4.2.1 Impacts Due To Solid Waste Generated

This category of waste generation in the proposed project is due to different types of raw materials being used during construction stage in general may comprise the following.

- Cement concrete
- Bricks, tiles,
- Cement plaster
- Steel (RCC, door/ window frames, roofing support, railings of staircase etc)
- Rubble, sand, Stone (Marble, granite, sand stone)
- Timber/wood
- Paints/varnishes

Mitigation Measures-

The solid waste generated during this period being predominantly inert in nature. Hence maximum effort would be made to reuse and recycle them. The most of the solid waste material can be used for filing/ levelling of low-laying areas within the site. All attempts should be made to stick to the following measures.

- All construction waste shall be stored within the site itself. A proper screen will be provided so that the waste does not get scattered.
- Attempts will be made to keep the waste segregated into different heaps as far as possible so that their further gradation and reuse is facilitated.
- Materials, which can be reused for purpose of construction, levelling, making roads/ pavement will also be kept in separate heaps from those which are to be sold or land filled.

The use of the construction material basically depends on their separation and conditions of the separated material. A majority of these materials are durable and therefore, have a high potential for reuse. It would, however, be desirable to have quality standards for the recycled materials. Construction waste can be used in the following manner.

- Reuse of bricks, tiles, stone slabs, timber, piping railings etc to the extent possible and depending upon their conditions.
- Sale/ auction of materials which cannot be used at the site due to design constraint.
- Plastics, broken glass, scrap metal etc will be stored and processed within the site premises.
- Rubble/ brick bats can be used for building activity, such as levelling, under coat of lanes where the traffic does not constitute heavy moving loads.
- Larger unusable pieces can be sent for filing up low laying areas.
- The unearthed soil can be used for leveling as well as for lawn development.
- The broken pieces of the flooring material can be used for leveling in the building or can be disposed of.

The screening for environmental impacts is done in all the four phases of the project; viz. planning, design, construction and operation and maintenance.

4.2.2 Impact on Air Quality

The air environment may be described in terms of parameters of ambient air quality such as ground level concentration of particulate matter (PM_{10}) representing suspended particulates which are less than 10-micron size which easily get into our respiratory tracts. Further the particulate matter ($PM_{2.5}$) denotes that fraction of finer particulates which can get deposited in our lungs and cause respiratory diseases and also affect metabolism. The gaseous pollutants namely CO, SO2, and NOx released due to construction vehicular exhausts are noxious in nature.

Construction Phase: All of the developmental activity viz. construction work, operation of diesel driven equipment and machinery, excavations, loading and unloading of materials, haulage of materials, dumping and stacking of construction material and debris cause generation of fugitive dust particulates over the proposed area and in the neighbourhood. Further movement of vehicles cause both emission of exhaust gases and also wheel laden fugitive dust particulates. The fugitive particulate load generated daily depends upon the duration of construction activities which may be said to be temporary lasting for a few months. After the completion of this phase all of the sources stated above cease to exist. The gaseous pollutants namely CO, SO2, and NOX released due to construction vehicular exhausts are noxious in nature. As said earlier, the construction phase is temporary and ceases after a few months. As such the load of gaseous pollutants generated shall be for a limited period of time.

Operational Phase: During this phase, the sources of fugitive dust are due to movement of garbage laden vehicle to and fro the processing site. The unloading of garbage trucks and tractors release suspended particulates. Further; the operation of wheel loader during levelling operations (of the dumped solid waste) creates fugitive particulates. The gaseous pollutants referred to above shall be emitted by the trucks and tractors plying for the transportation of daily garbage. This component of the gaseous pollutants shall be small as compared to the quantum generated during construction phase. Owing to less volume of open landfill site the emissions of methane and ammonia are expected to be very less.

Proposed mitigation measure-

1. The haulage trucks and tractors involved for garbage transportation shall be covered fully with tarpaulins and shall be prevented from spillage of dirt during transit.
2. The trucks and tractors to be deployed for haulage of garbage shall be ensured to be Bharat-IV stage compliant for the exhaust emissions.
3. Periodic maintenance of the machineries and equipment as well as the haul trucks/tractors involved shall be done as per the manual requirement.
4. The operators, semi-skilled workers and drivers of the vehicles and machinery involved shall be trained for the job requirements and their skills shall be updated and monitored regularly for smoother functioning for maintaining clean environment.
5. A dense green belt with fast growing floral species as recommended by CPCB with climatological adaptability shall be developed along the periphery of the landfill site.
6. The development of the green belt shall be such that bushes and shrubs shall be placed inwards towards the site while the taller species shall be placed on the outer area towards the boundary. This shall ensure development of a barrier both for noise and dust particulates. The fully developed green belt shall present an appealing landscape and would be scientific also in purpose.
7. Compaction of haulage road within the landfill site by using water bowser on the haul road both in morning and afternoon hours during winters and one additional trip in the evening in summer season which shall suppress the fine fraction of soil clay on the haul roads.

4.2.3. Impact on Water Quality

Construction phase

Impact on Ground water

- Domestic wastewater/Sewage will be generated from workers during construction activities at the site which can contaminate ground water if not managed or treated.
- Spillage of oil and grease from the heavy vehicles and wastewater stream generated from onsite construction activities such as vehicles washing, workshop etc can percolate and reach till ground water and results in contamination.

- Soil runoff from the site leading to off-site contamination.

Mitigation measure for Ground water

- The proposed toilets will be attached comprising of septic tanks to avoid infiltration of domestic wastewater/sewerage into the ground water system.
- Vehicle/machinery and equipment used during construction will be properly & regularly maintained in way to avoid spillage of fuels and lubricants (as per MoEF&CC and SPCB guidelines)
- Excavation to be avoided during monsoon season.
- Runoff water and equipment washed water from the site will be collected and treated to arrest the suspended solids and treated water (0.8 KLD) will be reused for greenbelt/plantation and for dust suppression (0.5 KLD).

Impacts for Surface Water

- Various construction activities involved in the proposed project like transportation, soil excavation, unloading & loading etc. of materials will generate fugitive dust and also during rain there could be material run off which may increase the suspended solids, oil & grease, etc in nearby surface bodies.

Mitigation measures for Surface Water

- A surface water drainage line which collects and removes all surface runoff from the landfill site is provided.
- Water sprinkling at site is proposed and will be maintained periodically for avoiding generation of fugitive dust.
- The Runoff water should be collected and safely treated and disposed off to prevent accumulation of water and avoid breeding of flies, mosquitoes.

Operation phase

Impact on Ground & Surface water

- Leachate generated from municipal waste may percolate to water table and contaminate ground water if not treated or managed.
- Leachate, discharged from landfill site and biomethanation plant runoff caused by monsoon from the waste may reach and contaminate surface water body.
- Blockage of Leachate in narrow row or gather at a place if proper collection system and drains are not installed.

Mitigation measure for Surface water

- The proposed sanitary landfill will be using a Geosynthetic Clay Liner system to prevent leakage of leachate from the landfill site. A geotextile is a woven or nonwoven sheet of material that is impervious to liquid as compared to geo-membrane and is more resistant to penetration damage.
- The minimum bottom liner specifications shall be a composite barrier having 1.5 mm High Density Polyethylene (HDPE) geo-membrane overlying 90 cm of soil (clay/amended soil) having permeability coefficient not greater than 1 x 10-7 cm/sec. The highest level of water table shall be 2 m below the clay/amended soil layer.
- Proper garland drains equipped with baffles to prevent run off from the site to contaminate surface or ground water resources.
- To prevent surface and ground water contamination by oil/grease, leak proof containers will be used for storage and transportation of oil/grease. The floors of oil/grease handling area will be kept effectively impervious by laying a sheet of plastic over the ground surface.
- The leachate generated from the landfill & Biomethanation area is collected in the leachate holding tank through collection system and will be treated in proposed LTP of capacity 25 KLD. Treated wastewater will be used for greenbelt/horticulture & dust suppression. (2.7KLD)
- Regular checking for functioning of leachate collection, treatment and disposal system.
- Monthly monitoring of ground water at project site shall be carried out to check and monitor for any contamination as per CGWA Guideline 2020 & SPCB.
- An environmental monitoring system is proposed to periodically collect and analyses air, surface water, soil-gas and ground water samples around the Sanitary Landfill site.

4.2.4 Impact on Land Environment and Mitigation Measures

Proposed plan is for setting up of Waste processing/disposal facility with provision of Biomethanation plant for organic waste and landfill. The proposed project shall have direct impacts occurring through direct interaction of an activity with an environmental, social, or economic component.

Seepage of generated leachate containing suspended solids and pathogens from the waste disposal site may lead to contamination of land and soil quality. Due to the pollution potential and on aesthetic considerations, the land values may diminish in the immediate surroundings of the proposed disposal site.

Mitigation Measures:

1. All solid and other wastes from the complex shall be properly collected, stored and disposed. A solid waste management plan shall be developed.
2. Disposal of waste from the project site should be within the capacity of the local environment to absorb without unacceptable degradation of its future waste absorptive capacity or other important services.

3. The entire site area shall be well paved and thus there will be no leaching of any substances in case of spills.

Impact & mitigation measures of Geology & Topography:

The new construction is proposed impact on surround environment land use directly or indirectly. Due to proposed project activities minor impact on account of topography is envisased as the project area has undulating terrain and for establishment partial leveling of the site is required.

Hence, no significant impact is anticipated on the topography and physiographic from project by Urban Development & Housing Department.

Proposed Mitigation Measures –

Since there is little or low significant impact on topography from the project, no detailed mitigation measures are proposed. It is however proposed that apart from the proposed plantation greens, turfing with local species will be carried out extensively. It is further proposed to maintain area as green through plantation of various local and aesthetic species as to improve the vegetation covers of the area.

Post closure of landfill, If is intended to be used for a specific purpose e.g. park or golf course or vehicle parking area or human settlement, then the cover shall be stabilized in such a manner that the end – use is achieved. However, if no specific end –use is envisaged, then long – term vegetative stabilization will be undertaken to return the land to its original and natural vegetative landform.

All topography would be used as in natural topo type with minor scientific & environmental sustainable modifications.

Following is the measures to minimize the impact on land environment.

- The installation activities include excavation of soil from the proposed site.
- The excavated loose soil will be utilized for leveling of low-lying areas inside the plant. Thus, the impact on topography during construction phase is insignificant

Hence there will be no significant impact from changing the land topography; because proper levelling land sculping of the project area by the project proponent.

4.2.5 Impact & Mitigation of Foul Odour

Although the odour emanating from a landfill operation is an inescapable problem, but the problem can be mitigated if proper measures are taken. Foul smelling gases like CH4 and H2S creates major impact if Biomethanation operation is not done properly.

Mitigation measures: -

- The project proposes to cover the wastes with daily and intermediate covers of soil on a regular basis to ensure that odour generation is minimized.
- Spray of herbal sanitizers and inoculums will be done to remove odour. The compost facilities, roads, equipment and the surrounding area shall also be cleaned regularly to remove the odour generating wastes. The processed compost is stored in sheds so as to avoid attraction to birds and runoff due to rain or windblown entrainment of particles.

4.2.6 Impact of Noise / Vibrations & Mitigation Measures

The construction phase involves developmental activities and entails usage and deployment of machinery and equipment which would generate noise substantially. Intermittent source of noise shall be movement of vehicles used in construction activities. This shall be temporary in nature. Continuous source of noise pollution shall be construction activities. This shall account only during day time. The operational phase shall see a lesser usage of machinery and equipment than the construction phase and as such the noise generated by various machineries shall be comparatively lesser than the levels during Construction Phase. RCC wall thought-out the site where ever possible plus fencing is recommended.

Mitigation measures

During construction, the machinery used will be of highest standard of reputed make and will adhere to the CPCB Guidelines & SWM rules 2016. Proper enclosures and noise shields will be used for reduction in noise levels. Also, since the project site is sufficiently away from habitation, there will not be any significant increase in the impact of the noise generated from the site. However, impact due to noise pollution can be minimized by ensuring that no noise generating activity is carried out during night hours. All vehicles entering into the project will be informed to maintain speed limits, and not blow horns unless it is required. In this context, it is to be noted that:

Periodic maintenance of the machineries and equipment as well as the haul trucks/tractors involved shall be done as per the manual requirement.

1. The operators, semiskilled workers and drivers of the vehicles and machinery involved shall be trained for the job requirements and their skills shall be updated and monitored regularly for smoother functioning for maintaining clean environment.
2. A dense green belt with fast growing floral species as recommended by CPCB with climatological adaptability shall be developed along the periphery of the landfill site.
3. The development of the green belt shall be such that bushes and shrubs shall be placed inwards towards the site while the taller species shall be placed on the outer area towards the boundary. This shall ensure development of a barrier both for noise and dust particulates. The fully developed green belt shall present an appealing landscape and would be scientific also in purpose.
4. There are no villages within 100 meters of the project site. Also the natural wall will act as a barrier for noise. As there are no major sources of noise pollution critical impacts to neighbouring communities and wild animals is not envisaged.

4.2.7 Impact on Biological Environment (Flora and Fauna) & Mitigation Measures

- Site clearing activities will be done as per terms and condition whichcreates minor impact on the Ecological and biodiversity of the area 10 km radius.
- During the construction phase removal of trees, shrubs and herbs will reduce the habitat for a few faunal species (mainly birds) and suitable alternatives are available with 1-2 K.M areas.
- Major impacts on terrestrial ecology include air, water and noise pollution caused by site activities, vehicular movement, wastewater and waste handling.
- The present vegetation of site is comprising of trees, shrubs and bushes and does not support any sensitive species of flora and fauna. Hence no Major impact is anticipated due to project.

Mitigation Measures:

- Peripheral green belt development with suitable trees species have been incorporated to mitigate the dust and odour emissions in core zone.
- 33 % green belt area will be developed and maintained in the plant, which will provide more habitats to birds, rodents and small mammals. The landfill cover will also be landscaped with local plants species.
- Local species, fruit trees and healthy seedlings will be selected at intervals of 4 × 4-m in 60× 60 × 60-cm size pits filled with topsoil around the plant as well as on the landfill cover.

- Tree plantation will be done in order to prevent erosion of topsoil of thearea. It will absorb the PM10 and reduce the concentration of SO2, NOx.
- The project operations will be carried out in a systematic manner as to minimize any disturbance of Ecological and biodiversity of the area 10 KM radius.
- Development of a planation with varied variety of trees and shrubs would have a positive impact in the buffer zone.
- PUC certified vehicles will be used for transportation of MSW.
- Emission levels of NOx and SO2 all pollutants will be kept within CPCB permissible levels through various engineering control measures.
- Personnel protective equipment's will be provided to all workers who are engaged at inside plant site.
- Proper and timely maintenance of machines and transport vehicle will help to check and reduce sound nuisance.
- LTP will be provided for effluent treatment and treated water will be reuse in again process.

4.2.8 Impact on Socio Economic Environment & Mitigation Measure

The following are the impacts on Socio environment associated with this project:

1. Quality of life: The proposed Municipal Solid Waste Management Project will help in reducing burden of municipal solid waste in the city. It will help the families to look after themselves, their children's education and future savings because of healthy surrounding's. The Municipal Solid Waste Management project will help a better and decent lifestyle. The additional manpower recommended will also add to employment opportunities for local residents.
2. Increase in revenue & strengthening of ULB: This will bring additional revenue to the ULB by selling of compost and recycle items. Decrease in heath spending due to better hygiene. With time this will have an incremental show of revenue generation with time with more and more people segregating waste and participating in community programmes.
3. There is no displacement of people involve in any stage of the project as the processing site located at least 500 m away from the nearest residential area.

Impact on Social Status

The study area is predominantly inhabited by rural population. The proposed project is likely to provide more opportunities in employment to this area. The preference in employment will be provided to the local residents in this area. Thus, population of the study area will be benefited due to the project in terms of direct and indirect employment opportunities.

Mitigation measure

The socio-economic conditions in the study area indicate the quality of life of the people. The important indicators which decide the quality of life and required to be improved for better living conditions are literacy levels, occupational structure, industrial development, infrastructural facilities, transportation, communication linkages, land development and cropping pattern. The project proponents are envisaging undertaking the following socio-economic measures.

Impact on Human Settlement

There is no displacement of any habitation or personnel and hence the rehabilitation and resettlementaction plan is not required.

Impact on Civic Amenities: Waste processing also creates an unpleasant view and leads to emission of mal odour. It will control the diseases menace which gets spread due to the unattended waste lying, which attracts flies, rats, and other creatures that in turn spread diseases in society. This leads to unhygienic conditions and thereby causes rise in the health problem.

Aesthetics

The landfill will be capped and the topmost layer will be landscaped thereby improving the aesthetics of the area.

Impact on Public Health: Efficient waste collection & disposal of waste will improve the living & health condition of inhabitants in the area. Littering of waste creates nuisance due to unpleasant view and emission of foul odour. It will eliminate the ground for breeding of mosquitoes & disease-causing pathogens. Solid waste treatment project will ensure timely collection of waste, efficient treatment & disposal in scientific & environment friendly manner. This will reduce the chances of spreading of diseases. This project will improve the health condition of the area and society.

Odour Nuisance

Odour is such a parameter that it attains all importance due its unbearable characteristics. Bad and foul smell causes headaches, nausea and vomiting and even giddiness to workers in the landfill area and also to the inhabitants in the neighborhood. Intensity and duration of the odour both are important. Some odour are present all the days while some others are active for smaller duration. It all depends upon the nature of compostable matter in the municipal solid waste. The odour may not be a bigger problem in the construction phase but will be major problem in the operation phase due to the degradation of the organic matter in the Biomethanation plant and in the open dump area.

Mitigation measures:

1. The entire load of municipal solid wastes shall be processed same day upon receiving at the land fillsite.
2. The biodegradable component of the municipal solid wastes shall be separated and taken forcomposting on daily basis.

3. Both the biodegradable and non-biodegradable components of the municipal solid wastes shall be covered with a cover of soil or building material debris to prevent coming in contact with air and also water through rains. Complete covered shed for maturing and curing place is recommended.
4. A dense growth trees with perfume releasing flowers may be grown which shall curb this menace to greater and effective way naturally.
5. Boundary wall of at least 10 m high to mitigate some odour and aesthetic issues.
6. Proper leachate management system with drains and leachate collection tank is recommended.

Impact on Traffic:

The project envisages unidirectional pathways for both incoming and outgoing waste trucks/vehicles to avoid traffic congestion. There will be dedicated corridors of specific pathways for the incoming and outgoing vehicular traffic for meeting the movement of finished product. Therefore, there will not be any significant impacts on traffic in the area and on the site.

Impact on Health Care Facilities: While MSW activities, sufficient care will be taken in providing health facilities to their employees besides organizing various medical camps for the surrounding villages. The improved health care facilities improve the quality of life in the area.

Impact on Economic Aspects: Project will generate both direct & indirect employment. Local people will be preferred for giving employment. This will improve economic status of the area. Emigration of local people to other parts of state/country due to unavailability of employment will be reduced.

Impact on Historical and Worship Places: The MSW project is unlikely to cause any impact on places like Archaeological and Historical and Places of Religious worship & Tourist attraction or structures or devotees.

Economic Benefits to Local Municipality:

Development of the facility will create more jobs in the area and also present the opportunity to provide improved products or services to people in the area. During the operation phase, one of the project activities would comprise of manual segregation of waste. The locals inhabiting or rag pickers, who have been performing the task of informal waste collection, can be employed for this specific activity during the operational phase. There will be fixed source of income on monthly, weekly or daily basis to the rag pickers of the area, who otherwise depend upon the collection of recyclables from various dump sites across the city. Therefore, the positive impacts on rag pickers due to sustenance of livelihood and improvement in living conditions are anticipated.

STEPS TO BE TAKEN TO IMPROVE SOCIO-ECONOMIC CONDITIONS

The socio-economic conditions in the study area indicate the quality of life of the people. The important indicators which decide the quality of life and required to be improved for better living conditions are literacy levels, occupational structure, industrial development, infrastructural facilities,

transportation, communication linkages, land development and cropping pattern. The project proponents are envisaging undertaking the following socio-economic measures.

- **Health Care:** The adequate funds will be allocated for mobile dispensary, family planning, medical camps and aid to the Govt. hospitals.
- **Educational Facilities:** These include adult education facilities, financial assistance for higher studies, sponsorship to vocational / professional training institution, computer education camps, vocational training for students and aid to existing/proposed Govt. schools and colleges.
- **Civic Amenities**: These include support to community toilets, drinking water facilities like public stand posts, elevated service reservoirs, playgrounds for children and recreation facilities for all age groups. In addition to this participation and support to government efforts.
- **Employment:** Development of project will provide employment opportunity to local skilled, unskilled & semiskilled people during both construction & operation phase. Indirect employment may also generate during construction phase of project. Tea stalls, and food shop may come up around project site for workers. Almost local labor will be engaged for the allied activity like marketing and sale of products like compost may further require more man power engagement.

4.2.9 Impact on Occupational Health & Safety

Healthy and safe working conditions are among the first expectations for sustainability, i.e. Occupational injuries and ill-health have huge social and economic implications for individuals, their families and their communities. They also have an adverse impact on the economy of the society as a whole.

- Injury due improper handling, operation and execution
- Occupational hazards like high noise, electric shocks etc.
- Trip and fall, inadequate fall safe arrangements
- Diseases from unhygienic surrounding
- Exposure to hazardous substances etc.
- Workers at times are not accustomed to use of Personal Protection Equipment, their attitude to avoid PPE may result in accident/hazard.

Mitigation measures

- Workers will be provided with required PPEs to be used at site;
- The necessary safety measures will be taken up before and during the construction.
- Good Waste Handling practices will be implemented which will greatly reduce foul smell and reduce impact from odors.

Details of Infrastructural Facilities for Worker-

- Water for drinking & other purpose will be arranged.
- All the safety equipment's such as helmets, safety shoes, goggles, dust masks etc.

- A well-equipped first aid facilities,
- Periodic (Half-Yearly) medical health check-ups
- Rest shelter, washrooms etc. will provided near the working blocks.

4.2.10 Landfill Gas Management

The proposed project is of Solid Waste Treatment project for Mangan, in noryh Sikkim district of Sikkim. The project is proposed to facilated with source segregation of waste and then transporting the same to composting yards for processing, recycling and disposal. The organic waste (Biomethanation Plant) would be converted into manure, recyclables to be pressed and packed for sale while the rejects would go to landfill. The recyclable material would be collected separately and given to the recycling route. The inert material collected at source mainly comprising of soil from road sweeping would come to landfill.

A large part of mixed waste (50%–60%) consists of biodegradable parts which produce methane gas. With a view to reduce GHG emissions and thereby reduce environmental impacts, it is mandatory to install a degassing system for the sanitary landfill.

The gas management strategies should follow one of the followingoptions:

- controlled passive venting; or
- controlled active collection and treatment or reuse.

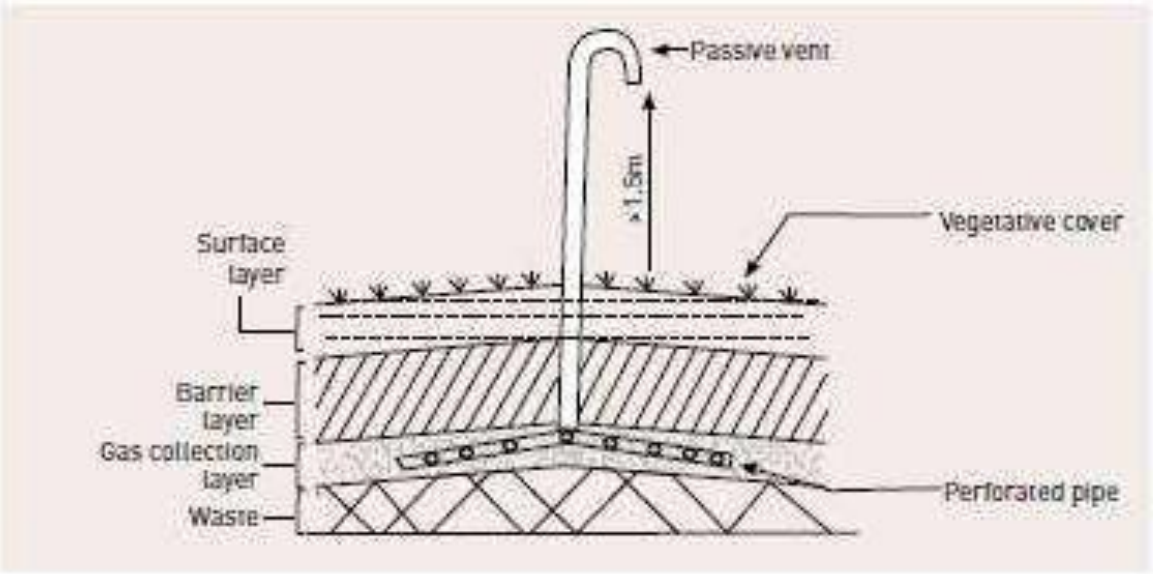
Controlled Passive Venting

The proposed provision of composting is present, only inert material will be deposited in the landfill. For all sanitary landfills, controlled passive degassing systems in the form of gas windows covered by suitable passive gas vents is recommended (Illustrated in below Figure: 4.1). The gas windows are to be installed in the frame of the final covering. It has openings in the cover system which may be filled with compost to avoid the generation of bad odours. Some quantity of rejects of large size organics from the compost plant will also get into the landfill. It is expected that not more than 5% of the waste in the landfill would be biodegradable. As the particle size of organic rejects of compost plant is large, its degradation will be very slow and will continue for a long time in the Dry Tomb Landfill.

Hence it is suggested to have passive gas wells for gas management.

Design Method: The size should be not less than 1 m x 1 m, and the distance between two gas windows should be about 20 m.

FIGURE 4.1 PLACEMENT OF PASSIVE VENTS IN A LANDFILL



Source: CPHEEO Manual

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CHAPTER-V ANALYSIS OF ALTERNATIVE

CHAPTER-V

ANALYSIS OF ALTERNATIVES

5.1 Introduction

This chapter below presents the project site evaluation with respect to siting guidelines prescribed by Ministry of Urban Development, CPHEEO, & SWM rule 2016 and its subsequent amendments for setting up waste management facilities, rationale for sizing of the proposed facility, and selection of the waste treatment technology.

It has been planned to adopt Wet Waste Treatment Technology – Biomethanation Plant technology for treatment of biodegradable organic fraction of the waste. Recyclables will be segregated and sent for further processing while the inert waste will be stored separately. The project has been planned in such a manner that the emphasis shall be laid on maximizing resource efficiency and for promoting 4R's-Reduce, Reuse, Recycle, and Recover. The gas production ranges from 0.29 cubic meter (m^3)/kg of Volatile solids added per day to 0.16 cubic meter (m^3)/kg of Volatile solids added per day in different seasons.

The proposed SWT facility to be developed for mangan, in north Sikkim district, sikkkim will manage 16.0 TPD of municipal waste in an environmentally sustainable manner with an emphasis on maximizing resource use efficiency. The facility will make a significant contribution in diverting the municipal waste reaching the landfill sites and also reducing the load on the existing waste management/processing facilities in the Mangan city. The area of the proposed site is 2.0 Ha. The siteis located adjacent to a road that provides access to the site. There is no high-tension line issue at the site.

5.2 Site Evaluation

While studying the suitability of various alternative sites within Mangan, the UD & HD reviewed land availability in the zone, and identified the site. Mangan as a suitable location for an SWT facility.

Presently there is no treatment of waste and mixed waste is being dumped in the dumping ground at Chandey.

The proposed site based in Mangan Town proves to be the best location considering both the environmental, economic factors and also as per SWM 2016 rules, CPHEEO manual.

Table no. 5.1 below shows the brief of the location analysis of the site.

TABLE-5.1 LOCATION ANALYSIS FOR THE PROPOSED SITE

S.No.	Criteria	CPHEEO Manual Requirement	SWM Rules 2016	Description of the Proposed Site
1	Lake/Pond	200 m away from the Lake/Pond	200 m away from the Lake/Pond	No Lake/Pond within 200 m
2	River/Streams	100 m away from the river/stream	100 m away from the river/stream	No River/Streams within 100 m.
3	Flood Plain	No Landfill shall be constructed within a 100 year flood plain	No Landfill shall be constructed within a 100 year flood plain	Not a 100 year flood plain area
4	Highway	Away from 200 m NHAI/State	Away from 200 m NHAI/State	No NH within 200 m
5	Public Parks	300 m away from public parks	300 m away from public parks	No parks within 0.3 km
6	Wet Lands	No landfill within wet lands	No landfill within wet lands	Not a wet land
7	Habitation	500m away from the notified habitation	200m away from the notified habitation	No habitation within 200 m
8	Critical Habitat Area	No landfill within the Critical habitat area. It is defined as the area in which 1 or more endangered species live	No landfill within the Critical habitat area. It is defined as the area in which 1 or more endangered species live	No critical habitat
9	Airports	No landfill within 20 Km	No landfill within 20 Km	No airport within 20 Km
10	Water Suplly Schemes/Wells	Minimum 500 m Away	Minimum 200 m Away	No Water Supply Schemes/ Wells within 500 m
11	Coastal Regulation Zone (CRZ)	Should not be sited	Should not be sited	Not a Coastal Regulation Zone

5.3 Assessment of Alternative Technologies

Solid Waste Treatment (SWT) proposes a waste management hierarchy with the aim to reduce the amount of waste being disposed, while maximizing resource conservation and resource efficiency. The SWT hierarchy ranks waste management operations according to their environmental, economic and energy impacts.

FIGURE: 5.1 MUNICIPAL SOLID WASTE MANAGEMENT HIERARCHY

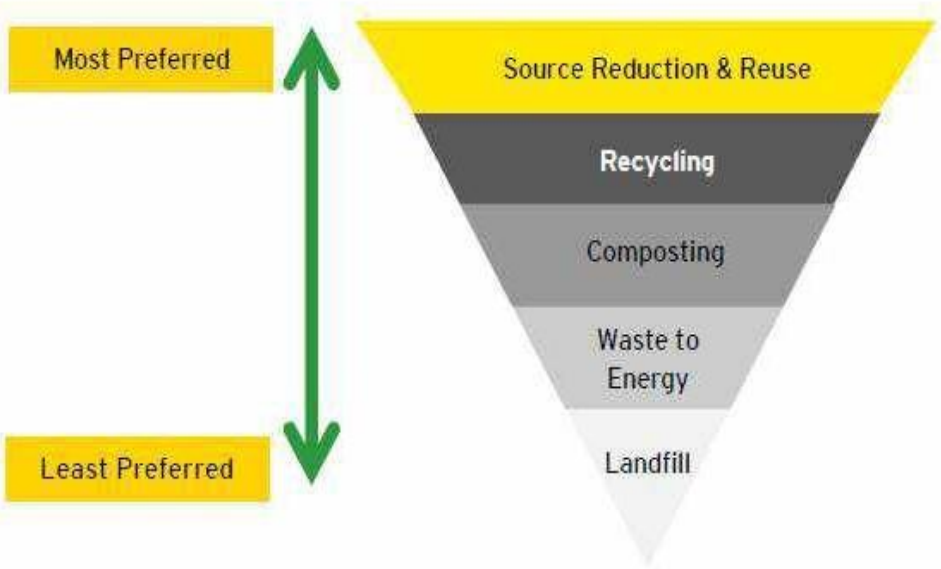
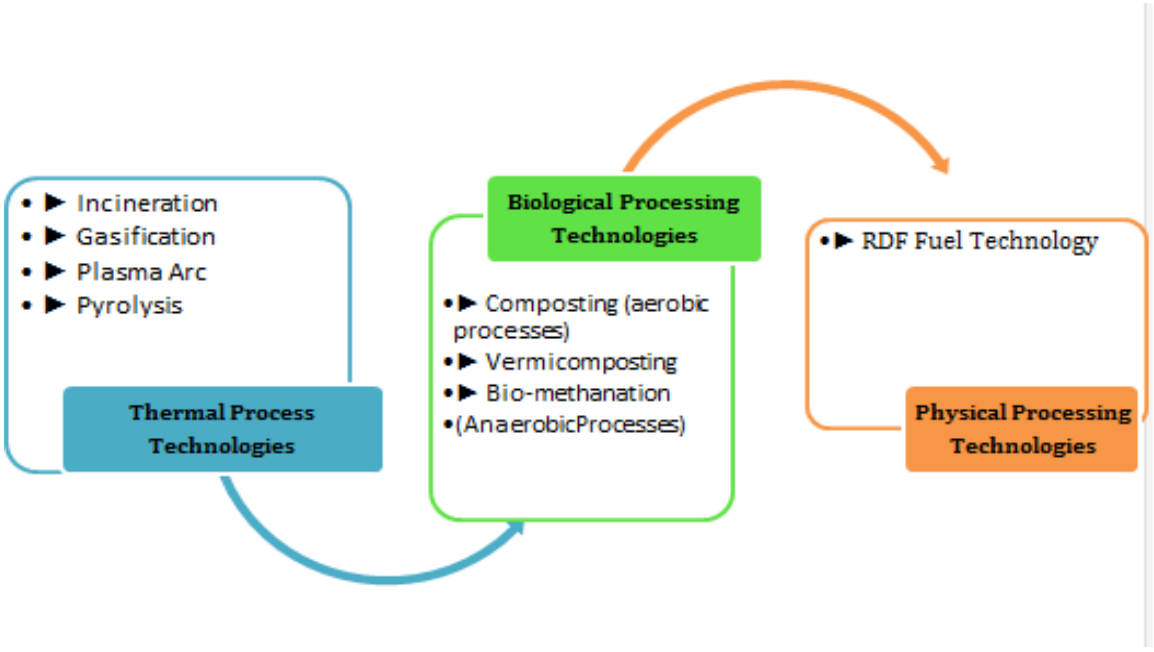


FIGURE: 5.2 MSW TREATMENT TECHNOLOGIES



The detailed evaluation of various waste treatment options as listed below were carried out before selection of treatment technologies for the proposed facility. The various treatment options available were as follows

Summary of MSW processing technologies

Technologies		Pros	Cons
Incineration	Incineration is the process wherein the waste is burned at high temperature. This involves the combustion of processed waste to generate heat which is supplied to a boiler coupled with a steam turbine for electricity generation. The thermal conversion efficiency varies from 80-90% and electricity conversion efficiency is around 14%. Carbon dioxide, water vapour, ash and noncombustible materials will be the end products. However, it is suitable for wastes with high calorific value, low moisture content and is associated with risks such as air pollution.	✓Reduction in volume of waste going to landfill ✓Production of energy which could be used for various purposes ✓Reduction in toxicity of waste and pathogens.	✓Release of harmful emissions in the air. ✓Treatment of the by-products is imperative ✓Skilled operators ✓NIMBY syndrome

Plasma Arc Technology	The system basically uses a Plasma Reactor which houses one or more Plasma Arc Torches which generate, by application of high voltage between two electrodes, a high voltage discharge and consequently an extremely high temperature environment (between 5000-14,000oC) approximating the temperature of the Sun. This hot plasma zone dissociates the molecules in any organic material into the individual elemental atoms while all the inorganic materials are simultaneously melted into a molten lava. The waste material is directly loaded into vacuum in a holding tank, preheated and fed to a furnace where the volatile matter is gasified and fed directly into the plasma arc generator where it is pre-heated electrically and then passed through the plasma arc dissociating it into elemental stages. The gas output after scrubbing comprise mainly of CO and H_2. The liquefied produce is mainly methanol.		
Composting	Aerobic composting is the process of degradation of biodegradable waste matter into simple organic compound by certain micro-organisms in the presence of air. It requires	✓ Relatively cost effective	✓ Discharge of leachate and phenols leading to water contamination ✓ Possible odour ✓ NIMBY syndrome

	adequate supply of air, moisture (50% to 60% optimum), Temperature (50- to 60 degree C, 5 to 7 days for pathogens to get killed), C/N Ratio (between 20–40). Aerobic conversion process is preferable as compared to anaerobic conversion process since it is fast, exothermic and free from odour. Aerobic process also helps to eliminate pathogenic organisms, weed seeds, larva etc. as a result of high temperature developed during the process. The turning of waste is done after approximately 5-7 days to ensure adequate oxygen.		
Vermicomposting	Vermicomposting involves the stabilisation of organic solid waste through earthworm consumption which converts the material into worm castings. It is the result of combined activity of microorganisms and earthworms. The worm species that are commonly considered are Pheretima sp., Eisenia sp.and Perionyx excavatus sp. These worms are known to survive in the moisture range of 20-80% and the temperature range of 20-40oC. The worms do not survive in pure organic substrates containing more that 40% fermentable organic substances.		

	Hence fresh waste is commonly mixed with partially or fully stabilised waste before it is subjected to vermicomposting. The worms are also known to be adversely affected by high concentrations of heavy metals.		

Technology Adopted

As suggested in the pre-feasibility study undertaken by the DPR Consultants, the most feasible technology option recommended for the SWT plant for Mangan based on the quality, quantity and characteristics of waste to be processed, land availability (limited in the area), proximity to residential areas, capital cost and maintenance cost, is Biomethanation for processing of bio-degradable organic waste. Inert wastes will be segregated, stored separately in a designated storage area and final disposed of in proposed sanitary landfill.

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CHAPTER-VI ENVIRONMENTAL MONITORING PROGRAMME

CHAPTER – VI

ENVIRONMENTAL MONITORING PROGRAMME

6.1 Introduction

Environmental monitoring program describes the processes and activities that need to take place to characterize and monitor the quality of the environment. Environmental monitoring is used in the preparation of environmental impact assessments, as well as in many circumstances in which human activities carry a risk of harmful effects on the natural environment.

6.2 Scope of Environmental Monitoring Program

The main objective of environmental monitoring program is aimed such that there is not much of time lack between commencements of damage to environment mitigation measures to various environmental parameters that are being affected.

The Environmental Monitoring Program involves the following.

1. Planning a survey and sampling program for systematic data/information collection
2. Conducting survey and sampling program
3. Analysis of samples and data/information collected, and interpretation of data and information
4. Preparation of reports for submitting to management and statutory authorities
5. Environmental monitoring is carried throughout project operation to detect changes in the key environmental quality parameters, which can be attributed to the project.
6. The results of the monitoring program used to evaluate the following

(a) Extent and severity of the environmental impacts against the predicted impacts;

(b) Performance of the environmental protection measures or compliance with pertinent rules and regulations

(c) Trends in impacts and Overall effectiveness of the project EMP.

Environmental monitoring program has been prepared for the proposed project for assessing the efficiency of implementation of Environment Management Plan and to take corrective measures in case of any degradation in the surrounding environment.

i. Air Environment

For the proposed project, the air emissions are from Biomethanation process, DG sets and vehicular movement. DG set is proposed as standby to use during power failure for emergency needs using diesel as fuel and hence are not expected to contribute emissions to the environment on regular basis. Ambient air quality in and around the project site (nearby villages) will be monitored for important parameters.

ii. Noise Environment

Monitoring of the noise levels and exposures is essential to assess the Environmental Management Plan implemented to reduce noise levels. A good quality integrated sound level meter and noise exposure meter may be procured for the same. Audiometric tests will be conducted half yearly for the employees working close to the noise sources. Noise levels will be monitored within the project site on regular intervals.

iii. Water Environment

Leachate, domestic sewage, water from piezometers, nearby bore wells, nearby surface water will be analyzed regularly for the parameters given below. They are as follows:

- pH & EC
- Suspended Solids
- Dissolved Solids
- Oil and Grease
- Chloride
- Sulphide
- COD and BOD
- Nitrates
- Phosphates

iv. Land Environment

The soil in the neighboring areas will be analyzed for the relevant parameters. The average canopy height of the greenbelt, number and types of plant species will be monitored. Air and noise pollution attenuation achieved by the greenbelt will also be evaluated. It would be ensured that trained and qualified staff supervises the monitoring of ambient air, stack gases, effluents, noise etc. to see that prescribed standards laid down are obtained.

Surveillance and Monitoring Plan

Monitoring of the Municipal Solid Waste operations i.e. the physical environment and the public health in the vicinity of the Solid Waste Treatment Plant is an integral part to design, construction and operation of the facility. The proposed monitoring program for the proposed project has three interrelated objectives.

- To check implementation and management of the various aspects required for impact mitigation.
- To check how effective are the measures for mitigation and control of pollution.
- In case of non - compliance further measures for rectification.

All monitoring strategies and program have reasons and justifications which are often designed to establish the current status of an environment or to establish trends in environmental parameters. In all cases the results of monitoring will be reviewed, analyzed statistically and submitted to concerned authorities. The design of a monitoring program must therefore have regard to the final use of the data before monitoring starts.

The monitoring program will have three phases:

1. Construction phase
2. Monitoring phase
3. Post monitoring phase

Construction Phase

The major construction activities involved in setting up the proposed unit are construction of sheds for treatment units, stores, administrative blocks, etc. major components in the industry are landfill, DG sets, Biomethanation plant and other civil, mechanical and electrical equipment. The construction activities require clearing of vegetation, mobilization of construction material and equipment. The construction activities are expected to last for few months.

During construction phase of landfill at every stage quality of construction will be monitored viz. base preparation, liners quality, drainage layers, leachate collection system, storm water management system, gas vent systems, etc. The generic environmental measures that need to be undertaken during project construction stage are given in the following

TABLE 6.1 ENVIRONMENTAL CONTROL MEASURES DURING CONSTRUCTION SITE

S. No	Potential Impact	Detailed action to be followed as per EMP	Parameters for Monitoring	Frequency of Monitoring
1.	Air Emissions	All equipment's are operated within specified design parameters.	Random checks of equipment logs/ manuals	Periodic
		Vehicle trips to be minimized to the extent possible.	Vehicle Logs	Periodic during site clearance & construction activities
		Any dry, dusty materials stored in sealed containers or prevented from blowing.	Stockpiles or open containers of dusty materials.	Periodic during Construction activities

S. No	Potential Impact	Detailed action to be followed as per EMP	Parameters for Monitoring	Frequency of Monitoring
		Compaction of soil during various construction activities.	Construction logs	
		Maintenance of construction DG set emissions to meet stipulated standards.	Gaseous emissions (SO_2, HC, CO, NO_x)	Periodic emission Monitoring
		Ambient air quality within the premises & adjacent villages of the proposed unit to be monitored.	PM_{10}, $PM_{2.5}$, SO_2, NO_x, and CO	As per CPCB/ SPCB Requirement
2.	Noise	List of all noise generating machinery on-site along with age to be prepared.	Equipment logs, noise reading	Regular during construction activities.
		Night working is to be minimized.	Working hour records	Periodic during Construction activities
		Generation of vehicular noise	Maintenance of records of vehicles	
		Implement good working practices (equipment selection and siting) to minimize noise and also reduce its impacts on human health (ear muffs, safe distances, and enclosures).	Site working practices records, noise reading	
		No machinery running when not required.		
		Acoustic mufflers/enclosures to be provided in large engines	Mufflers/enclosures shall be in place.	Prior to use of equipment.
		Noise to be monitored in ambient air within the plant premises.	Instant Noise recording	As per CPCB/SPCB requirement
		The Noise level will not exceed the permissible limit		

S. No	Potential Impact	Detailed action to be followed as per EMP	Parameters for Monitoring	Frequency of Monitoring
		both during day and night times.		
		All equipments operated within specified design parameters.	Random checks of equipment logs/ manuals	Periodic during construction activities
		Vehicle trips to be minimized to the extent possible	Vehicle logs	
3.	Soil Erosion	Minimize area extent of site clearance, by staying within the defined boundaries	Site boundaries not extended / breached as per plan document.	Periodic during construction activities
		Protect topsoil stockpile	Effective cover in place.	
4.	Wastewater Discharge	No direct discharge of wastewater to be made to surface water, groundwater or soil.	No discharge hoses shall be in vicinity of watercourses.	Periodic during construction activities
		The discharge point would be selected properly and sampling and analysis would be undertaken prior to discharge	Discharge norms for effluents as given in Permits.	Periodic during construction activities
		Take care in disposal of wastewater generated such that soil and groundwater resources are protected.	Discharge norms for effluents as given in permits.	
5.	Drainage and Leachate Management	Ensure drainage system and specific design measures are working effectively. The design to incorporate existing drainage pattern and avoid disturbing the same.	Visual inspection of drainage and records thereof	Periodic during construction activities
6.	Waste Management	Implement waste management plan that	Comprehensive Waste Management Plan	Periodic check during construction

S. No	Potential Impact	Detailed action to be followed as per EMP	Parameters for Monitoring	Frequency of Monitoring
		identifies and characterizes every waste arising associated with proposed activities and which identifies the procedures for collection, handling & disposal of each waste arising.	should be in place and available for inspection onsite. Compliance with SWM Rules, 2016	activities
7.	Non-routine events and accidental releases (Landslide, physical injuries)	Plan will be drawn, considering likely emergencies and steps required to prevent / limit consequences.	Mock drills and records of the same	Periodic during construction activities
8.	Health	Employees and migrant labor health check ups	All relevant parameters including HIV	Regular checkups as per Factories Act

Operations Phase

Monitoring and auditing of the facility should be in conjunction with QA/QC procedures assist the operation of the facility by,

- Providing an early warning of potential liabilities.
- Reducing operational costs.
- Training the staff and defining the responsibilities.
- Facilitate adequate equipment and materials for proper handling of Municipal Solid Waste.
- Providing write up to-date procedures specifying operational methods.
- Maintenance and calibration of the equipment both for operations and monitoring.
- Retention of record.

Regular monitoring of the various components of the physical environment is planned during the operations period of the facility and also during the post-closure period.

TABLE 6.2ENVIRONMENTAL MONITORING DURING OPERATIONAL PHASE

S. No	Project Activities	Receptors	Potential Impact	Action to be Followed	Parameters for Monitoring	Frequency of Monitoring
1.	Waste Collection, transportation, unloading at site Landfill Operations DG Set	Air Environment	Fugitive dust Emissions	AAQ within the project premises. All vehicles to be PUC certificate.	As per CTE conditions / NAAQ Standards Vehicle logs to be Maintained	As per CTE & CTO norms given by PCB or EC norms given by MoEF&CC.
			Gases emission	Gas quality from landfill areas	VOC, H2S, CH4	As per CTE & CTO norms given by PCB or EC norms given by MoEF&CC
				Stack emissions from DG sets	As per CTE conditions PM, SO_2, NOx	
				Meteorological data	Wind speed, direction, temp., relative humidity and rainfall.	
		Flora and Fauna	Fugitive dust & Gases emission	Vegetation, greenbelt / green cover development	No. of plants, species	Once a year
2.	Operation of heavy plant equipments	Noise Environment	Increase in Noise levels	Noise generated from operations to be monitored	Spot Noise Level recording	Periodic during operation phase Once in month by third party
3.	Waste processing & disposal	Water quality	Wastewater/ Leachate generation	Compliance to wastewater treatment	pH, TSS, TDS, BOD, COD & Oil& grease	Daily at regular intervals

S. No	Project Activities	Receptors	Potential Impact	Action to be Followed	Parameters for Monitoring	Frequency of Monitoring
				standards	(Heavy metals if required)	Once in a month by third party
			Degradation of Ground Water Quality	Monitoring ground water quality, through piezometers	as per CPCB & PCB guidelines	Periodically & as per CPCB & PCB norms.
		Land Environment & Soil quality	Contamination of Land Soil runoff	Checking & Maintenance of good soil quality around & at site	Physico-chemical parameters and metals.	Once a year
4.	Plant operation like handling of MSW, equipments handling etc.	Occupational Health of workers	Generation of solid waste	Check compliance to SWM rules	Quality & quantity monitoring	Periodically / CPCB & PCB norms.
			Impact on health of workers	Employees and migrant labour health check ups	All relevant parameters (BP, HIV, chest X-ray, Eye vision, etc.) and HIV for workers	Regular checkups as per factories act, Labour act & MoEFCC.
		Safety of workers	Disaters, accidents like Fire, Land slides, cloud bust, etc.	Emergency preparedness plan will be proposed for its implimentation during the time of	Regular Safety audits to be conducted for plant including the equipments.	Safety Audit as per Fire Safety, factories act, Labour act & MoEFCC.

S. No	Project Activities	Receptors	Potential Impact	Action to be Followed	Parameters for Monitoring	Frequency of Monitoring
				emergency		

Operational Monitoring for processing unit:

Regular risk assessments of the Facility's operations will be under taken and analyzed for improvements for safe and efficient operations. A copy of these will be provided in the progress reports to the authority. In addition to that arrangements will be made for regular site inspections by in house audit team and the independent engineer.

These audits would be quarterly for first 3 years of operation and thereafter semi-annual and audit reports will be submitted from time to time.

The reports will indicate the following:

- Summary of monitoring status including air quality, noise, groundwater, and surface water.
- Accidents, spills and emergencies
- Complaints and their redress
- EHS Issues and their mitigation
- Operation statistics - The amount of waste received, recycled, processed and disposed, efficiencies of operations of equipment and processes;
- Status of compliance with various regulations; and
- Any items requiring the Authority's intervention

Operation monitoring for Landfill

Regular monitoring of the various components of the physical environment is planned during the operational period of the facility. It is proposed to undertake the following monitoring as a part of the normal operations of the facility.

- Leachate quantity and quality.
- Surface water quality both up and down-stream of the facility for important parameters.
- Groundwater quality in surrounding areas of the facility and in nearby village common water supply bores.
- Ambient Air quality within and immediately surrounding areas of the site, and in nearby villages.
- Stability of final cover

Monitoring and auditing of the facility will be in conjunction with QA/QC procedures and helps in

- Providing an early warning of potential liabilities
- Reducing operational costs
- Training the staff and defining the responsibilities.

- Providing written up to-date procedures specifying operational methods.
- Maintenance and calibration of the equipment both for operations and monitoring.
- Retention of record.
- Leachate monitoring & treatment

Post closure Monitoring

Post-closure monitoring of the landfill will be done primarily as a compliance requirement in addition to social responsibility; this also provides an early warning towards possible adverse impacts on human health and the environment. The post-closure program of monitoring for water quality in the ground water and surface waters down gradient of the landfill will be similar to that established for the operational stage of the facility. The frequency of monitoring may be varied from time to time depending on changing circumstances. There is a need for the post-closure monitoring of air quality, noise or visual effects during the post closure period however this need will be reviewed periodically and should any aspects warrant further monitoring they will be included in the program.

TABLE-6.3ENVIRONMENTAL MONITORING DURING POST OPERATION PHASE

S. No	Potential Impact	Action to be Followed	Parameters for Monitoring	Frequency of Monitoring
1.	Air Emissions	Gas quality from landfill areas	VOC, H2S, CH4, NH3	As per CTE conditions given by SPCB or EC conditions given by MoEF&CC and as per CPCB protocol.
		AAQ within the project premises All vehicles to be PUC certificate.	As per CTE conditions / NAAQ Standards Vehicle logs to be maintained	
		Meteorological data	Wind speed, direction, temp., relative humidity and rainfall.	
2.	Leachate generation (if present)	Compliance to CGWB, SPPCB, CPCB & SWM 2016 standards	pH, TSS, TDS, BOD, COD & parameters as per the SWM 2016 rules & CPCB	Once in a month (during initial period more regularly)
3.	Ground Water Quality and Water Levels	Monitoring ground water quality, and water levels within plant site. Compliance to CGWB,	As per SPCB, CPCB & SWM 2016 standards	Periodically and CPCB protocol.

		SPCB, CPCB & SWM 2016 standards		
4.	Flora and Fauna	Vegetation, greenbelt / green cover development	No. of plants, species	Once a year
5.	Occupational Health & Safety	Employees and migrant labor health check ups	All relevant parameters (BP, Sugar, chest X-ray, Eye vision, etc.)	Regular checkups as per factories act & MoEFCC.

TABLE-6.4 ENVIRONMENTAL MONITORING PLAN DURING CONSTRUCTION & OPERATION PHASE WITH INSTITUTIONAL RESPONSIBLITIES

Environmental Component	Project Phases	Monitoring				Institutional Responsibility
Air		Parameters	Standards	Frequency	Duration	
	Pre-Construction Phase	PM10, PM2.5, SO2, NH3, CH4, CO, NOx	As per MSW (M&H) Rules, 2016 and Air (Prevention and Control of Pollution) Rules, 1984	8 hourly samples per day for CO, CH4 and NH3. 24 hrs sampling for PM, and SO2	Once	Contractor through approved monitoring agency
	Construction Phase	PM10, PM2.5, SO2, NOx, NH3, CH4, CO		8 hrs samples per day for CO, CH4, NH3 once in a month. 24 hrs sampling for PM, and SO2	Quarterly till completion of construction phase	Contractor through approved monitoring agency
	Operation Phase	PM10, PM2.5, SO2, NH3, CH4, CO, NOx		5 locations, 8 hour samples per day, and monitoring for three Seasons.	Continuous 8 hour/or for 1 full working day, twice in each season except monsoon.	Contractor through approved monitoring agency
Ground Water	Pre-Construction Phase	pH, Total Dissolved Solids (TDS), heavy metals like As, Cd, Cr, Co, CN, Pb, Hg, Ni, Zn etc., Nitrate, Fe,	As per Municipal Solid Waste (Management & Handling) Rules, 2016 and Water quality standards by	Grab sampling at above selected locations	Twice a year	Contractor through approved monitoring agency

		Chloride, Phenolic Compounds and Sulphate.	CPCB/ IS 10500:1991			
	Construction Phase	pH, Total Dissolved Solids (TDS), heavy metals like As, Cd, Cr, Co, CN, Pb, Hg, Ni, Zn etc., Nitrate, Fe, Chloride, Phenolic Compounds and Sulphate	As per MSW (M & H) Rules, 2016 and Water quality standards by CPCB/ IS 10500:1991	6 Samples in Pre monsoon and 6 samples in post monsoon during operation phase	Twice in every year during operation phase	Contractor through approved monitoring agency
	Operation Phase	Do	As per MSW (M & H) Rules, 2016 and Water quality standards by CPCB/ IS10500:1991			
Noise	Pre-	Noise level on	Noise standards	Hourly monitoring for 24	Once	

	Construction Phase	dB(A) scale	by CPCB	hours at once		
	Construction Phase	Noise level on dB (A) scale	Noise standards by CPCB	Hourly monitoring for 24 hours at once	Twice a year	
	Operation Phase	Noise level on dB(A)scale	Noise standards by CPCB	Hourly monitoring for 24 hours at once	Quarterly	
Soil	Pre-Construction phase	Color, pH, Electrical Conductivity, Moisture Content, Organic Carbon, Bicarbonate, Chloride, P, K, Ca, Mg, Na, SAR, N, Texture	As per Environment (Protection) Act, 1986 and MSW (Management and Handling) Rules, 2016	Representative samples form in and around project site	Once	Contractor through approved monitoring agency
	Operation Phase	Do	As per Environment (Protection) Act, 1986 and Municipal Solid Waste (Management	Representative samples form in and around project site	Twice a year	Contractor through approved monitoring agency

			and Handling) Rules, 2016			
Leachate	Operation Phase	Suspended solid, Dissolved solid, pH, Ammonical Nitrogen, Total Kjeldhal Nitrogen, BOD, COD, As, Hg, Pb, Cd, Cu, Cr, Zn, Ni, CN, Fluoride, Phenolic compound	As per MSW (Management & Handling) Rules, 2016	Before discharging of Leachate for reuse.	Quarterly throughout operation phase of the project	Contractor through approved monitoring agency
Compost quality	Operation Phase	Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Zinc, C/N Ratio, pH	As per Municipal Solid Waste (Management & Handling) Rules, 2016	Before selling the compost	Throughout operation phase of the project	Contractor through approved monitoring agency

Social Factors	Pre-construction phase	Aesthetics, Vectors, Odor, Health of surrounding Habitants and workers, communicable disease and occupational diseases (like skin infection, lung infection, fungal infection, etc	As per Municipal Solid Waste (Management & Handling) Rules, 2016	Once	Once	Contractor through approved monitoring agency
	Construction Phase	Aesthetics, Vectors, Odor, Health of surrounding Habitants, Communicable diseases	As per Municipal Solid Waste (Management & Handling) Rules, 2016	Yearly monitoring of workers health and monitoring of diseases in the surrounding community	During construction phase	Contractor through approved monitoring agency
	Operation Phase	Do	Do	Yearly monitoring of workers health and	During operation phase	Contractor through approved monitoring

				seasonal monitoring of diseases in the surrounding Community. Annual assessment of the ratio of the incident of particular disease related to the project activity.		agency

Public Health Monitoring

The value of Public Health studies in seeking to establish whether or not a site or facility has caused significant adverse health effects is well known. In this situation the results form a public health study may not fulfill the primary objective of such a program, which is to detect health changes before the manifestation of adverse health effects. However, three-stage health-monitoring program is proposed.

- Monitor the health of workers within the project site to identify adverse health effects, and
- Periodically obtain feedback from local doctors regarding any potential indicators of adverse health effects due to environmental cause in the communities surrounding, and particularly down-stream of the landfill.
- By organizing health camps on a regular basis.

6.3 Implementation of Environmental Management Plan

It is understood that the civil works for the SWT Plant will be implemented through tender awarded contractors while UD & HD will be supervising the construction work. UD & HD will also be responsible for operation and maintenance of the facility and closed landfill through a private plant operating agency. The collection and transportation of the mixed municipal solid waste from designated transfer stations to the proposed SWT Plant will also be subcontracted to a private agency.

6.4 Environmental Management ` Cell

For the effective and consistent functioning of the project, an Environmental Management Cell (EMC) is proposed to be established for the project.

The overall management of the project will be undertaken through coordination between UD & HD and project site team. The activities will be managed through Site In- Charge who will be supported by the Site EHS Manager, Social officer and EHS officers. The Site In-Charge will coordinate with UD & HD who are supported by Environment and Health Officer regarding the operations of the project. The Plant Operator will be required to have one Chemical analyst in their team.

6.5 Budgetary Provision for EMP

In order to comply with the environmental protection measures as suggested in the above section, a budgetary provision for Environmental Protection is given in:

TABLE-6.5 BUDGET OF IMPLEMENTATION OF ENVIRONMENTAL MANAGEMENT PLAN

Sr. No.	Particulars	Proposed Capital cost (in lakhs)	Proposed Annual recurring cost (in lakhs per Year)
1	Environmental Pollution control (Air, Water, Soil, Noise etc.)	10.0	0.50
2	Environment Monitoring	-	1.2
3	Occupation Health & Safety & Health Camps	2.0	0.50
4	Green Belt Development	3.0	0.50
5	Education welfare: scholarship for students in nearby govt. school	5.0	0.8
6	Area development: provide assistance to nearby village panchayat for area development.	5.0	0.5
Total		**25.0**	**4.0**

The proposed capital cost for the project is INR 15.99 Crores and total investment on environmental improvement i.e EMP works is envisaged Rs. 25.00 lakhs/- and recurring expenditure during the stage of operation is Rs. 4.0 lakhs/- as recurring investment is earmarks for EMP.

As per the directions given in the MoEF&CC Office Memorandum, F.No. 22 -65/2017-IA-III on 30th September 2020, all the proposed activities will be part of Environmental Management Plan (EMP) instead of CER.

Addition to above the project proponent has proposed to invest amount of 2.55 Lakhs per year on Labours safety, proper sanitation facilities at site, Health checkup facilities, awareness & recreation programs etc. below table is the breakup proposed for budget investment for labours working in this proposed project.

TABLE-6.6 BUDGET BREAK UP FOR LABOUR

S. No.	Activity	Budget (in lakhs/Year)
1.	Safe Drinking Water	0.50

2.	Urinal , Latrine and Bathrooms	1.00
3.	PPE and Safety equipment will be Provided	0.20
4.	First Aid facility	0.20
5.	Regular Health checkup and provision of medicine	0.35
6.	Educational and awareness programme for safety measures & Recreational program	0.30
Total		**2.55**

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CHAPTER-VII ADDITIONAL STUDIES

CHAPTER - VII

ADDITIONAL STUDIES

7.1 RISK ASSESSMENT

7.1.1 Introduction

Risk Assessment policies are essential tools to prevent and mitigate undue harm to people during the development process. When identifying and designing a project, Risk Assessment helps assess the potential physical, environmental and social risks and impacts (Positive and Negative) associated with a development intervention.

A hazard is something that can cause harm, viz., chemicals, electricity, working on height, noise due to machines/ running of plant, work stress etc. However, risk is the chance or the scale say high or low that any hazard will actually cause somebody harm.

7.1.2 Hazard Identification

Hazard can be described as any source of potential damage, harm or adverse health effects on something/ someone. The potential hazards associated with operations of the proposed SWT Plant may be categorizedas below:

- **Physical Hazards**
  - Fire hazard in Biomethanation
  - Heavy equipments and machinery for waste tipping
  - Pre-screening, processing of waste
  - Rough sharp waste items
  - Trip Hazards due to pipes/ hoses
- **Chemical Hazards**
  - Confined spaces
  - Inhalation/ ingestion/ skin contact
  - Chemical reactions within the stored mixed waste
- **Biological Hazards**
  - Allergies from pathogenand airborne dust
  - Pests/ bugs at site
- **Natural Hazards**
  - Heavy Rainfall/ Cloud Burst/ Flood
  - Landsliding
  - Earthquake

TABLE 7.1 DESCRIBES THE ABOVE MENTIONED ALONG WITH THEIR CONTROLS

Sl No.	Hazard Name	Cause & Consequences/ Condition	Control Measures/ Action Required	Control Phase
Physical Hazard				
1	Fire hazard in Biomethanation due to elevated temperatures	Fire hazard may exist with composting process as elevated temperatures and drying may increase the potential for spontaneous combustion.	• Periodic mixing of composting material and maintenance of the proper water content should be done to control temperature and prevent fires. • A well-designed fire suppression system with sufficient water capacity and at sufficient pressures to adequately control a fire within the facility and approved by the local fire authority will be installed • Sufficient internal road network is designed for the proposed project for the movement of fire tenders during accident/hazard.	Design, Operations
2	Heavy equipments and machinery for waste tipping	During soil excavation and compost pile construction, workers may be seriously injured or killed by heavy equipment such as front-end loaders and scrapers.	• When approaching operating equipment, the approach should be made from the front and within view of the operator, preferably making eye contact. • Heavy equipment should be equipped with a backup alarm that alerts workers.	Construction, Operations, Maintenance
3	Accidents during Biomethanation Operation	It require gaseous mixture of Methane & Carbon Dioxide (CH4 & CO2). The mixing equipment may be equipped with a rotary device which lifts and	• All moving or rotating equipment must be guarded to prevent accidental contact. Workers should only operate the system with the machine guards in place.	Construction, Operations, Maintenance

		turns the material.		
4	Accidents during Pre-screening, processing of waste	Pre-screening or sizing equipment, such as grinders, shakers, and screeners, may pose machine guarding hazards with unguarded equipment. Appendages or loose clothing may become entangled in pulleys, drive shafts, and other moving equipment.	• Workers should keep clear of operating equipment and approach only when within view of the operator.	Construction, Operations, Maintenance
5	Rough sharp waste items	Workers may be exposed to puncture and cut hazards to feet and hands from rough or sharp waste material during operations.	Workers should wear safety boots with steel shanks to prevent cuts to the bottom of the foot. Workers should minimize manual handling of waste material, and wear cut-resistant gloves if contact with waste materials is necessary.	Construction, Operations, Maintenance
6	Trip Hazards due to pipes/ hoses	Trip hazards may exist with hoses and piping systems.	Workers should exercise caution when walking over hoses and pipes. In heavily travelled areas, extra lighting may be needed to ensure walkways are adequately illuminated	Design, Maintenance
Chemical Hazards				
1	Confined spaces/ covered compost pads (CO_2, NH_3, CH_4)	Since a closed shed is proposed for the compost plant, it may be considered that the workers entering the facility enter a confined space. Elevated levels of CO_2 may accumulate during composting process. It is	Prior to each entry into the enclosed or tented area, the atmosphere within the tent should be tested to ensure a safe atmosphere. If the testing indicates atmospheric contaminants or oxygen depletion, a confined-space entry program should be developed and implemented.	Design, Operations

		also typical for ammonia gas to be generated during composting. Exposure to ammonia vapors may occur, especially during Biomethanation turning operations. Although aerobic conditions should be maintained in the compost, if anaerobic conditions can develop, methane and hydrogen sulfide may be generated.		
2	Inhalation/ ingestion/ skin contact	Workers may be exposed to contaminants and degradation products of contaminants. Exposure may occur via inhalation/ ingestion/ skin contact routes of exposure during loading, unloading, pre-processing, tilling, turning and other operations where soils are agitated.	An analysis of the work tasks and potential for chemical exposure should be performed to determine the correct personal protective equipment (PPE) and/or respirator cartridge(s), if needed. The analysis should include obtaining specific chemical hazard information to ensure that the PPE specified will be appropriate for the respective chemical hazard. Workers may also use respiratory protection including the use of an air-purifying respirator equipped with HEPA (N100, R100, P100) filters and organic vapor cartridges.	Operations, maintenance
3	Chemical reactions within the stored mixed	Some materials used in composting may be explosive, especially when in contact with other	Workers should minimize contact with acidic or corrosive chemical materials by using mechanical chemical delivery methods. Where	Operations, maintenance

	waste	incompatible materials (e.g. ammonium nitrate and fuels). Others may be hygroscopic, which may result in chemical reactions.	contact is required, workers should wear gloves (e.g. nitrile) and other personal protective equipment that is resistant to the materials handled. All chemical reagents used in composting should be segregated to prevent accidental mixing of reactive chemicals, especially ammonium nitrate fertilizers and fuels.	
Biological Hazard				
1	Allergies from pathogen and airborne dust	During dry and windy periods microbe-entrained dusts may become airborne from soil agitation. Exposure to mold spores, including Aspergillus fumigates and thermophyllic actinomyctes may occur during composting operations. Inhalation of pathogenic microbes may cause allergic reactions or illness.	Periodic application of water to the active area. Personal protective equipment, such as rubber gloves, should be used Respiratory protection (e.g. air-purifying respirator with HEPA (N100, R100, P100) filter/cartridge) may be used during dusty periods	Operations, Maintenance
2	Pests/ bugs at site	Workers may be exposed to a wide array of biological hazards, including snakes, bees, wasps, massive fly hatches, ticks, hornets, and rodents which get attracted to the higher temperatures associated with composting	Workers should be informed of the potential for snakes and other animals around the compost facility, especially during cooler periods. Periodic inspections of the site should be performed to identify stinging insect nests and for the presence of snakes professional exterminating companies should be consulted for their removal.	Operations, Maintenance

		operations and other hideout warm places.		
Natural Hazard				
1	Heavy Rainfall/ Cloud Burst/ Flooding etc.	Flooding situation may arise due to heavy rainfall, sudden cloud burst etc. Also, poor drainage condition (silted/ uncleaned) can worsen the flooding situation.	• Close co-ordination with Indian Meteorological Department, & State Disaster Management Authority, Sikkim well before arriving ofmonsoon. • To train the staff to climb up the roof/ elevated place nearby when the site is flooded. • Keep an emergency kit ready. In all the different types of emergency, it is better to be prepared than to get ready, to get information so as to get organized, to wait rather that act too hastily. • Beware of water contamination, wait until the water is declared safe before drinking or boil the water before drinking. • Clean and disinfect the room that is flooded. • During storms and hurricanes do not go out in a car or a boat once the storm has been announced. • Do not use the telephone, except to call for help, so as to leave telephone lines free for the organization of response. • Listen to the messages broadcast by radio and the various media so as to be informed of development.	Design, Operation and District Administration
2	Landsliding/	It may destruct the plant	• To ensure that no loose debries/	Design,

	Sheet erosion etc.	set-up/ transportation route etc.	rocks stay hanging over the plant area in uphill side and on transportation route. • Restricted speed limit in such area. • No overloading of vehicles. • To make aware district authorities for instant help.	Operation and Dist. Administration
3	Earthquake	It may destruct the plant set-up/ transportation route etc. and it is a severe threat to the lives.	• A strong and earth-quake resistance builing and plant design may be adopted. • To trains staff to crouch under some heavy furniture or stand under the doorframe for self cover. • Carry out the official instructions given over the radio or by loudspeaker. • Close co-ordination with State Disaster Management Authority, Sikkim well before arriving of monsoon.	Design, Operation and Dist. Administration

7.1.3 Health and Safety

The site will be managed by the concern contractor who will be responsible and accountable for all activities on site. He will delegate authority for the day to day running as deemed appropriate but liaise with those with delegated authority daily to discuss and close out health and safety issues that have been identified.

Staffs shall be trained and will be responsible for their own safety, for their actions that may affect the safety of those they are working with or persons who may be working nearby. In this respect and they have the obligation to report unsafe actions and situations to the client/ Site Manager. It is everyone's duty to prevent unsafe situations and actions. The health and safety of all those who worksat the plant shall be ensured, as far as is reasonably practicable by:

- Assessing the risk of all work activities, recording the significant findings and developing method statements as appropriate.

- Providing and maintaining safe plant and systems of work, together with appropriate personal protective equipment.
- Minimising risks associated with hazardous substances including waste to be processed, materials used and the by-products of wastetreatment processes.
- Minimising risks associated with other occupational health risks including noise, vibration and manual handling.
- Maintaining the plant in safe condition including as regards workplace transport and fire risks.
- Providing appropriate information, instruction, training and supervision to those working at the Plant or visiting the Plant, including information and training about the emergency procedures.
- Implementing effective systems for active and reactive monitoring of compliance, including by inspections, audits and incident/ near miss investigation
- Ensure the safety end absence of risk to health in connection with the use, handling, storage and transport of articles and substances.
- Make regular risk assessment available to employees
- Take appropriate preventive/protective measures staff must follow plant's in-house rules and regulations as described further in this HSE plan. In addition, the following rules & regulations if any, are also imposed to each staff:
- The client's worksite safety rules and regulations
- The general safety rules imposed by Indies Government legislation
- If hazard arises, or suspected to be present, they shall be reported immediately and, if necessary, all work stopped, and persons withdrawn from the area.

Safety during Construction

Safety during construction is will be maintained through the site management organisation put into place. Before opening a construction site, concern contractor prepares a set of documents ruling the entire construction process. Part of this document is called safety file which contains local safety regulations to be observed and project safety instruction.

Safety duringoperation

Plant safety as regards normal and disturbed operation will be is being developed during the conceptual and details design phases of the plant e.g. fire protection concept, emergency evacuation concept, safety interlocks of control system etc. for each piece of equipment the relevant safety standards are observed. The operating and maintenance manual handed over to the customer before commissioning contains all information for a safe operation and maintenance of the plant. A special section "safety" provides hints

and warnings as to potential hazards or risks arising during normal operation, start-up, shut- down and maintenance. The training program of future staff will also focus on safety aspects.

7.2 Handling and Management of Municipal Solid Waste

7.2.1 SWT Plant

- Utmost care and safety regulations should be followed.
- SWT Plant shall be fenced or hedged and provided with proper gate to monitor incoming vehiclesor other modes of transportation.
- The SWT Plant shall be well protected to prevent entry of unauthorized persons and stray animals. Further, SWT Plant should be clear of unnecessary obstruction to avoid danger to these persons,
- Approach and other internal roads for free movement of vehicles and other machinery shall exist at the SWT Plant.
- Utilities such as drinking water, bathing facilities, toilets for workers and lighting arrangements for operations at SWT Plant when carried out in night hours shall be provided.
- Regular health inspections of workers at SWT Plant shall be periodically made
- Safety of all persons entitled to be on the Site, by ensuring the use of protective gears amongst sanitary workers, vehicle drivers, guard, gateman, while working and handling waste at SWT Plant should be looked out. Hand gloves, high boots made of tough leather, goggles and masks to all workers for handling municipal solid waste should be provided.

7.2.2 Engagement of Staff and Labour

Arrangements for the engagement of all staff and labour, local or otherwise, and for their payment and extending other facility in compliance to the applicable law should be done. Encouragement, to the extent practicable and reasonable, to employ staff and labour with appropriate qualifications and experience from places not limited to but near to geography should be there.

Rates of Wages and Conditionsof Labour

- Appropriate amount should be paid according to the rates of wages and conditions which are not lower than the minimum wage as notified by GoH should be observed time to time.
- Personnel should be informed about their liability to pay personal income taxes in respect of such of their salaries, wages, allowances, and any benefits as are subject to taxes under the Laws of the Country for the time being in force.

Labour Laws

Compliance with all the relevant labour laws applicable to the Contractor's Personnel, including Laws relating to their employment, health, safety, welfare, immigration and emigration, should be done and their legal rights must be allowed.

- Employees should obey all applicable Laws, including those concerning safety at work and shall do needful
- Following and implementation of all statutory provisions on labour (including not employing or using children as labour and equal pay for equal work), health, safety, welfare, sanitation and working conditions. The employment should be on the basis of equal opportunity and fair treatment, and shall not be on discrimination with respect to aspects of the employment relationship, including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment or retirement, and discipline. Equal wages and benefits should be given to men and women for the work of equal value or type.

Working Hours

The workers shall not be made to work outside the normal working hours stated in the employment terms & condition (appointment letter), unless:

- Otherwise stated;
- The PMU gives consent, or
- The work is unavoidable, or necessary for the protection of life or property or for the safety of the Works, in that case the PMU should be immediately informed and further permissions to taken by them.

Facilities for Staff and Labour

- Welfare facilities for the Personnel should be provided but permission for any of the temporary or permanent living quarters within the SWT Plant should not be given by the authority.
- Medical and Accidental Facilities
- Precautions to maintain the health and safety of the employed personnel should be taken and medical staff facility should be provided at site.
- Safety office should be appointed at site that will be responsible for maintaining safety and protection against accidents. This person shall be qualified for this responsibility and shall have the authority to issue instructions and take protective measures to prevent accidents. Throughout the contract period, whatever is required by this person to exercise this responsibility and authority should be provided.

- Details of any accident should be sent to PMU as soon as practicable after its occurrence. Records and reports should be maintained concerning health, safety and welfare of persons, and damage to property, as PMU may reasonably require.
- If malaria or other insect-borne diseases be prevalent in the SWT Plant, the staff and labour should be provided the suitable prophylactics, equip living accommodation with screens and bed- nets, and carry out spraying with approved insecticides, as appropriate and to the PMU's satisfaction.
- SPCB shall be responsible for the safety of the on-duty labour employed by him and shall be liablefor payment of necessary compensation in the case of accidents as per Workers Compensation Act.
- SPPCB shall provide and maintain upon the Works and the Site sufficient, proper and efficient life-saving appliances and first-aid equipment to the approval of the IE and in accordance with the requirements. HIV-AIDS Prevention
- HIV-AIDS awareness program should be conducted via an approved service provider
- Information, Education and Consultation Communication (IEC) campaigns should be conducted, at least every alternative month, concerning the risks, dangers and impact, and appropriate avoidance behaviour with respect to Sexually Transmitted Diseases (STD)— or Sexually Transmitted Infections (STI) in general and HIV/AIDS in particular
- Provide male or female condoms for all Site staff and labour as appropriate
- Provide for STI and HIV/AIDS screening, diagnosis, counselling and referral to a dedicated national STI and HIV/AIDS program to all Site staff and labour.

Moving/ rotating parts of machines

Hazards caused by moving or rotating parts of machines are covered with providing an electrical/ pneumatic lockout procedure.

Supply of Drinking Water and Sanitation

Adequate supply of drinking water should be provided for the use of Contractor's staff and work people, together with sanitary facilities (portable toilets or latrines), to the satisfaction of the IE.

Measures against Insect and Pest Nuisance

The necessary precautions should be taken to protect the Personnel employed on the Site from insect and pest nuisance, and to reduce their danger to health.

Festivals and Religious Customs

Country's recognized festivals, days of rest and religious or other customs should be respected.

Prohibition of Harmful Child Labour

Employment should not be done of any child to perform work that is economically exploitative, or is likely to be hazardous to, or to interfere with, the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. "Child" means a child below the statutory minimum age specified under applicable National, provincial or local law.

Permits/ authorization

Permits will be issued at the work site when required for the works. Prior to start the operations, it is necessary to be informed about the work permits that are applicable for the site. When permits to work are in force, they are always required before commencement of work, in written and properly authorized.

Plant's personnel should carefully read, understand, sign and explicitly comply with all conditions required by the permit. The permit holder must be on the work spot for the duration of the works being carried out under the permit, if he is to leave the work spot whilst work is on-going, he must transfer the permit through the correct permit transfer system

In commissioning or testing of equipment, the person responsible for the equipment must be present so that all necessary checks are made prior to the commencement of work.

TABLE 7.2: LIST OF PERMITS REQUIRED FOR WORK ON SITE/PLANT

Type of Permit	When Required
Work Permit	A general permit for all activities
T&C Permit	For testing and commissioning
Hot Work	For works involving naked flame , source of ignition of sparks
Confined space	For work carrying out inside a confined space such as underground manholes, tanks, inlet channel, area where possible of asphyxiated from lack of oxygen, the risk of fire/ explosion and the presence of dangerous airborne substances
Work at height	For work activities carried out at a workplace exceeding the height of 2m
Excavation	For any excavating (including drilling) in earth, roads, parking lots, slabs, and slab floo
Lifting & Hoidting	For any lifting and hoisting activities involving lifting machines or lifting appliances

Working on height

Not all work at height can be reasonably removed by the design process. Therefore, the hierarchy of managing and selecting work equipment for work at height shall be followed as set out by the Work at Height Regulations. Working at height will be covered as part of the risk assessment for all work where there is a risk a person could be injured by falling.

Hot work

Some systems or equipment have a hot surface and consequently a thermal hazard. Where reasonably practicable insulation of the system or equipment is provided in design. Other thermal hazards occur in e.g. blower fan, fire fighting pump station. General arrangements for controlling are in most cases implementation of the Lockout/ isolation procedure combined withproviding personal protection means. No hot works canbe carried out in the following areas:

- Fully closed storage tanks, vessels or drum of any nature
- Pipes and vessels under internal pressures whether of steam, feed water, air or gases
- Pipes, tanks and spaces which have contained fuel and other flammable substances Nakes flames, hot works or element that produces sparks (including electric devices) must not be near vicinity of fuel storage areas, oil paint and bottled gas stores and locations where activities such as painting works are in progress.

Chemical hazards

All chemicals must be accompanied by a Material Safety Data Sheet (MSDS) to enable the user to prepare for the arrival, storage and use of the specific substance and to ensure that all safety and environmental implications can be taken into account before the work is started. Plant's personnel should carefully read the MSDS and should handle all chemicals in accordance with the instructions as stated. It should not be mistaken by appearance of chemicals (e.g. some chemicals look like water). Legal requirements and instructions for labelling, handling and care of waste must be followed. The removal of used products, which are contaminated after a spill, shall be carried out in line with the site waste procedure.

Employment Records of Workers

Complete and accurate records of the employment of labour at the site should be maintained. The records shall include the names, ages, genders, hours worked and wages paid to all workers. These records shall be summarized monthly and shall be available for inspection by the Engineer during normal working hours.

Disposal of excavated earth/rock during construction

- During the site clearance and disposal of debris, the public or private properties should not be damaged /affected and the also traffic is not interrupted.
- The dispose of debris is only to the identified places or with prior permission of the Independent Engineer.
- Disposal of the debris for the improvements for public utilities after the proper consent of villagers/community and approval of the Engineer.
- In the event of any spoil or debris from the sites being deposited on any adjacent land, immediate removal of all such spoils debris should be done and the affected area should be restored to its original state to the satisfaction of the Engineer.
- Effective water sprays during the delivery and handling of materials to be done when dust is likely to be created and to dampen stored materials during dry and windy weather.
- Materials having the potential to produce dust will not be loaded to a level higher than the side and tail boards and will be covered with a tarpaulin in good condition.
- During earth removal and disposal of debris proper warning signs will be installed to the satisfaction of the PMU.
- Any diversion required for traffic during disposal of debris shall be provided with traffic control officer.
- During the debris disposal, surrounding features should be taken care and any damage should be avoided
- The disposal of debris will not impact any endangered/rare flora and fauna.
- The horticultural and construction or demolition or debris shall be separately collected and disposed of in accordance with the Bye laws and not to be mixed with municipal solid waste.

Sanitation and housekeeping at the labour/Construction camps

For labours from outside Mangan or migrant labours will be engaged for construction of SWT Plant, temporary camping arrangements shall be made including basic daily facilities ensuring the social safety, security and health condition of labour including women and children (if any). The number of temporary camps/tents and related facilities would depend upon the number of labours engaged during construction period.

Site Selection

- The temparory camps must be located such that the drainage from and through the camps will not endanger any domestic or public water supply.
- All sites must be graded, ditched and rendered free from depressions such that water may get stagnant and become a nuisance.

Water Supply

- An adequate and convenient water supply, approved by the appropriate health authority, must be provided in each camp for drinking, cooking, bathing and laundry purposes.
- At all construction camps and other workplace, good and sufficient water supply will be maintained to eliminate chances of waterborne/water-related/water-based diseases to ensure the health and hygiene of the workers.

Toilet Facilities and Hygiene

- Adequate supply of water, close to latrines and urinals.
- Within the precincts of every workplace, latrines and urinals will be provided in an accessible place, and the accommodation, separately for each of these, as per standards set by the Building and other Construction Workers (regulation of Employment and Conditions of Service) Act, 1996. Except in workplaces provided with water-flushed latrines connected with dry earth system (receptacles) which will be cleaned daily during working hours and kept in a strict sanitary condition.
- Toilet facilities adequate for the capacity of the camp must be provided. Each toilet room must be located so as to be accessible, without any individual passing through any sleeping room.
- Where the toilet rooms are shared, such as in multifamily shelters and in barracks type. Facilities; separated toilet room must be provided for each gender. These be distinctly marked “for men” and “for women” or marked with easily understood pictures or symbols.

Disposal arrangements for the waste generated at construction camp

Waste bins must be provided in the camps and regularly emptied, and the waste disposed off in a hygienic manner to the satisfaction of relevant norms.

Alternatively, excreta may be disposed off by putting a layer of night soils at the bottom of permanent tank prepared for the purpose and covering it with 15 cam layer of waste or refuse and then covering it with a layer of earth for a fortnight (by then it will turn into manure).

On completion of the works, all such temporary structures will be cleared away, all rubbish excreta tank and other disposal pits or trenches filled in and effectively sealed off and the outline site left clean and tidy, at the Contractor’s expense, to the entire satisfaction of the IE.

Electrical

- Only authorised persons are allowed to carry out work to the site/ plant's electrical installation. Unauthorized personnel should not be permitted to enter any switch room.
- No equipment or extension cord should be used if the grounding prong has been removed. No two-wire extension cords are permitted.
- All electrically powered hand tools shall be inspected before use.

After work or in the case of power failure, all portable electrical tools should be switched off. Any equipment that is locked or tagged out into the switch receptacle should not be activated. Conductor should not be handled with bare hands, but with rubber gloves or insulated appliances designed for the voltage applied. Rubber boots shouldalso be provided against the risk of electrical shocks, if necessary. All electrical appliances and conductors have to be clearly marked to indicate their purpose and voltage.
The nominal voltage of the extra low voltage supply is 24V AC 50 Hz single phase. This voltage is safe in conditions where simultaneously accessible parts (such as exposed electric cable) may be touched by a person whose skin is dry or moist, but not wet. It should not be used in locations where a person is immersed in water or working in the rain or working in a confined conductive location such as inside tanks or boiler furnace, etc.

Community participation program

Community participation can be defined as the involvement of people in a community in projects to solve the problems. An efficient waste management program, regardless of the strategy, requires significant cooperation from waste generators and activity community participation. Community participation can take place during any of the following phases.

- Need assessment
- Planning
- Mobilizing
- Training
- Implementing
- Monitoring and evaluation
- Community participation is important to:
- Achieve the principles of reducing, reusing, and recycling waste.
- Discouraging littering of waste on streets and into drains, open spaces, water bodies. Promotes storage of waste at source, segregated as biodegradable and nonbio- degradable (so that hazardous waste and infected waste are kept separate).
- Achieve increased level of awareness about the efficient methods of waste management among the public

7.3 Disaster Management Plan

The proposed facility will have appropriate storage for MSW. To mitigate potential fire problems, adequate measures such as water hydrants with adequate pressure or dry powder type will be provided. Prolonged periods of storage of MSW in its wet form can also lead to spontaneous fires due to biological decomposition and production of methane. To mitigate the situation, provisions have been made in the processing plant not to store raw MSW for more than 72 hours so that the fire hazard possibility is eliminated.

The main occupational hazard likely to occur can be fire, gaseous discharges and noise. Fire protection systems will be provided as per LPA (loss prevention association) norms. Adequate numbers of hydrants shall be provided in the plant. The fire protection system will be provided with main electricity driven pump, one standby diesel engine operated pump with requisite pressure and head, and one jockey pump. The plant and the equipment will be designed and specified with a view to minimize noise pollution to levels of 75 dBA at a distance of 1 m from the equipment. Employees will be provided with ear protection devices. In addition, the proper mechanical/ electrical shutdown procedures will be adopted by ensuring a permit card system (to be placed and issued from the Control Room). Positive isolation of drives from the circuit breaker will be ensured during electrical shutdown and earthing of outgoing will also be done as and when necessary. Proper ventilation system shall be required for preprocessing section to make the working environment conducive for workers.

Workers will be trained to adapt to environmentally benign practices. “No Smoking” and hazard/ danger warning stickers will be put up at appropriate places. Emergency numbers will also be put up at appropriate places. Empty fuel drums/ tanks and other inflammable material will be removed from the premises as soon as possible. Storage yard for chemicals and fuel lubricants will also be provided with fire extinguishers and sand bucket racks. The general safety features adopted will have a provision of fire extinguishers, over pressure relief devices, safe storage of all chemical and fuels, grounding of all electric equipment, safe location of electric gear, proper building and equipment layout, instrumentation alarms, guard railings, security personnel. Silencers will be provided for safety valves and vents of the plant to ensure noise control in the plant. Safety measures will be taken for handling the chemicals in the water treatment plant.

Disaster is a major emergency in plant, which has the potential to cause serious injury or loss of life. It may be due to malfunction of the normal operating procedure or an intervention of outside force such as a cyclone, earthquake and flood. Disaster management has assumed significant role with an aim of taking precautionary step to control the hazard propagation and avert disaster and also to take such actions after the disaster, which limits the damage to the minimum.

Types of Disaster at the plant

Following are the disasters which may occur at plants:

Man-Made Diasasters	Fire
	Explosion
	Oil Spilage
	Acid Spliage
	Electrocution
	Hazardous waste
Natural Disasters	Heavy Rainfall/ Flood/ Cloud Burst
	Land Slide
	Earthquake

- Fire
- Explosion
- Oil spillage
- Acid Spillage
- Electrocution
- Hazardous waste

In any plant there are various activities or area which pose substantial threat to the workers and hence hazardous in nature. The potentially hazardous areas and the likely accidents with the concerned area have been enlisted below.

TABLE 7.3: HAZARDOUS AREA WITH CONCERNED ACCIDENT

S.No.	Hazardous Area	Likely Accident
2.	Oil Tanks	Fir and Spillage
4.	Electrical Rooms	Fire and Electrocution
5.	Transformer Area	Fire and Electrocution
6.	Cable Tunnel	Fire and Electrocution
7.	Storage Facilities	Fir/Spillage

Accident Level

If there is any disaster in any part of plant/work place due to any reason, the classification of areas which may be affected and nature of accidents canbe made as follows:

TABLE 7.4: ACCIDENT LEVELS

S.No.	Accident Levels	
1.	Level I	Operator level
2.	Level II	Local community level
3.	Level III	Regional/national level
4.	Level IV	International level

Out of the above, only level-I and level-II class of accidents can be considered applicable to the plant as they occur at operator, local community level.

Level-I Accidents

Under this level, disaster may happen due to electrocution, fire, explosion, oil spillage and spontaneous ignition of combustible material. This level has probability of occurrence affecting persons inside the plant. Various hazardous areas which have been mentioned above in Table 7.2 as potential hazard areas will be affected during this level of accidents.

Level-II Accidents

Disaster of this level can occur in case of sabotage and complete failure of all automatic control/warning systems, and also if the fuel oil stored in tank and covered by tank bunds leaks out. However, probability of occurrence of this is very low due to adequate security, training and education of persons of plant responsible for operating such systems.

Disaster preventive measure

To prevent disaster due to fire, explosion, oil spillage, electrocution and other accidents following preventive measures shall be adopted.

- Design, manufacture and construction of all plant and machineries building will be as per national and international codes as applicable in specific cases and laid down by statutory authorities.
- Provision of adequate access way for movement of equipment and personnel shall be kept.
- Minimum two no. of gates for escape during disaster shall be provided.
- System of fire hydrants comprising electrical motor division and diesel engine drivers fire pumps with electrical motor driver jokey pump for keeping the fire hydrant system properly pressurized and automatic water sprinkling system for all important transformers.
- Fire hydrants with fire hoses in all areas where fire can break.

Site emergency control room

In order to control the disaster more effectively, a Site Emergency Control Room (SECR) will be established at the plant site. The facilities proposed to be provided are given in following sections:

- Plant Layout
- Plant Layout with inventories and locations of fuel oil/furnace oil storage tanks, etc.
- Hazard identification chart, maximum number of people working, assembly points etc.
- Population around factory
- Internal telephone connections
- External telephone connections
- Hotline connection to district collector, police control room, fire brigade, hospital etc.
- Public address system
- Torch-lights
- List of dispensaries and registered medical practitioners around factory
- Area map of surrounding village
- Nominal roll of employees
- Notepad and ball pen to record message received and instructions to be passed
- The blown-up copy of Layoutplan showing areas where accident has occurred.

Safety Department

Safety department will be manned by experienced engineers and other supporting staff who shall bring safety consciousness amongst the workforce of plant. The safety department will conduct regular safety awareness courses by organizing seminars and training of personnel among the various working levels.

Contingencyplanfor management of emergency

The emergency organisation will be headed by emergency leader called Site Main Controller (SMC) who will be plant manager. In his absence, senior most people available at plant shall be emergency leader till arrival of plant manager.

Besides the top officials described above, rest of the employees will be divided into three action teams namely A, B, C, and a Non-action Group D. Action team 'A' will consist of staff of section in which accident has occurred. Action team 'B', will consist of staff of non-affected sections and maintenance department. Action team 'C' will consist of supporting staff i.e. Security supervisor, Ware house Supervisor, Shift Supervisor etc. Group 'D' will consist of people not included in those teams like contractor, labour, security men etc.

Team 'A' comprising staff of affected section will be taking up the action in case of an emergency. Team 'B' will help team 'A' by remaining in their respective sections ready to comply with specific instructions of SMC. Team 'C' consisting of supporting staff will help team 'A' as required and directed by Team 'B'. Group 'D' will be evacuated to safe region under supervision of Team 'C'. A multi-channel communication network shall connect SECR to control rooms of plant, various shops, and other departments of plant, fire station and neighbouring industrial units.

Outside organizations involved in controlof disaster

In the event of massive spillage of toxic chemicals, fuel oil or occurrence of fire, population inside and outside plant boundaries, vegetation and animal etc. may be affected. State and Local authorities: may also take place. In such an event, help will be taken from outside agencies also.

- The organizations that will be involved District Collector, Revenue Divisional Officer etc
- Factory Inspectorate, Chief Inspector of factories, Joint Chief Inspector of factories, Inspector of factories.
- Environmental agencies: Member Secretary of State Pollution Control Boards, District Environmental Engineer
- Fire Department: District Fire Officer
- Police Department: District Superintendent of Police, SHOS of nearby Police Stations Public Health Department:
- District Medical Officer –
- Residential medical officers of PHCs around plant site Local CommunityResources
- Regional Transport Officer
- Divisional Engineer Telephones

The outside organisations will directly interact with district magistrate who in consultation with SMC will direct to interact with plant authorities to control the emergencies.

Hazard emergencycontrolprocedure

The onset of emergency will in all probability, commence with a major fire or explosion the following activities will immediately take place to interpret and take control of emergency.

- Staff member on duty will go to nearest fire alarm call point and trigger off the fire alarm.
- On site fire crew led by fire man will arrive at the site of incident with fire foam tenders and necessary equipment.

- Site Main Controller will arrive at SECR, from where he will receive information continuously from incident controller and give decisions and direction to the incident controller, plant control room, and emergency security controllers and to the site medical officerto take care of casualties.

Site Main Controller (SMC) will be directing and deciding a wide range of following desperate issues.
In particular SMC has to decide and direct:

- Whether incident controller requires reinforcement of manpower and facilities
- Whether plant is to be shut down or more importantly kept running.
- Whether staff in different locations is to remain indoors or to be evacuated and assembled at designated collection center.
- Whether missing staff members are to be searched or rescued.
- Whether off-site emergency plan to be activated and a message to that effect is to be sent to district headquarter.

When the incident has eventually been brought under control as declared by the Incident Controller, the SMC shall send two members of his advisory team as inspectors to incident site for:

- An assessment of total damage and prevailing conditions with particular attention to possibility of re-escalation of emergency which might, for the time being, be under control.
- Inspection of other parts of site which might have been affected by impact of incident.
- Inspection of personnel collection and roll call centers to check if all persons on duty have been accounted for.
- Inspection of all control rooms of plant to assess and record the status of respective plants and any residual action deemed necessary.

Post emergency, the inspectors will return to SECR with their observations and report of finding and will submit the same to SMC.

Miscellaneous preventive measures

Alarm System to be followed during Disaster

On receiving the message of disaster from Site Main Controller, fire station control room attendant will sound Siren I, wailing type, for 5 minutes. Incident controller will arrange to broadcast disaster message through public address system.

On receiving the message of "Emergency Over" from Incident Controller the fire station control room attendant will give All "Clear Signal" by sounding alarm straight for two minutes. The features of alarm system will be explained to one and all to avoid panic or misunderstanding during disaster.

- Actions to be taken on hearing the warning signal
- On receiving the disaster message, following actions will be taken:
- All the members of advisory committee, personnel manager, security controller, etc. will reach the SECR.
- The process unit persons will remain ready in their respective units for crash shutdown on the instruction from SECR.
- The persons from other sections will report to their respective officer.
- Resident of township will remain alert.

Safety Devices/Equipment

In order to make the services more effective, the workers and rescue team will be provided with the safety equipment and items like gas mask respirators, fire entry suits, fire blankets, rubber shoes or industrial shoes, rubber glove, ladders, ropes, petromax lamp torches, etc.

Fire Extinguisher

The different type of fire extinguishers have been proposed at strategic locations in the plant and given below table:

TABLE 7.5: DIFFERENT FIRE EXTINGUISHER AT DIFFERENT SITES

Name of Site	Type of Fire Extinguisher
Generator area	CO2 Type, Foam Type, Dry Chemical Powder
Cable galleries	O2 & Foam type, Dry chemical powder
High voltage panel	O2 & Foam type, Dry chemical powder
Control rooms	O2 & Foam type, Dry chemical powder
MCC rooms	O2 & Foam type, Dry chemical powder
Pump Houses	O2 & Foam type, Dry chemical powder
Fuel tank area	CO2, Foam type, Dry chemical powder sand basket
Godown	Foam type
Crusher house	CO2, Dry chemical powder, foam type

Fire Protection and Safety Measures

In order to prevent disaster due to fire, explosion, oil spillage, electrocution and other accidents, following preventive measures will be adopted:

- Design, manufacture and construction of all plant and machineries building will be as per national and international codes as applicable in specific cases and laid down by statutory authorities
- Provision of adequate access way for movement of equipment and personnel shall be kept.
- Minimum two no. of gates for escape during disaster shall be provided.
- System of fire hydrants comprising electrical motor division and diesel engine driver's fire pumps with electrical motor driver jokey pump for keeping the fire hydrant system properly pressurized and automatic water sprinkling system for all important transformers.
- Fire hydrants with fire hoses in all areas where fire can break.

7.4 Geology & Topography Studies

7.4.1 Geology

7.4.1.1 Topography

Researchers have divided the Himalayas into a series of longitudinal tectono-stratigraphic domains that include i) Sub Himalayas, ii) Lesser Himalayas, iii) Higher Himalayas, and iv) Tethys Himalayas (Neogi et al., 1998). These are separated by major tectonic discontinuities.

In the Sikkim region, the different lithounits (Acharyya, 1998) are dispersed in an arcuate regional fold pattern (Neogi et al., 1998). The 'core' of the region is occupied by Lesser Himalayan low-grade metapelites and interbedded metapsammite belonging to the Daling Group (Proterozoic to Mesozoic). The distal parts of the region are characterized by mediumto high-grade crystalline rocks of the Higher Himalayan Belt (Higher Himalayan Crystalline Complex, HHC).

A prominent ductile shear zone, the Main Central Thrust (MCT) separates the two belts. In this region, the MCT is the southernmost occurrence of a number of northward-dipping ductile shear zones within the Higher Himalayan Crystalline Complex.

Gondwana (Carboniferous - Permian) and molasse-type Siwalik (Miocene–Pliocene) sedimentary rocks of the Sub-Himalayan Zone (not shown in the map) occur in the southern part of the region. In the extreme north, a thick pile of Cambrian to Eocene fossiliferous sediments of the Tethyan Zone (Tehtyan Sedimentary sequence, Fig. 1b) overlie the HHC on the hanging wall side of a series of north-dipping normal faults constituting the South Tibetan Detachment System (STDS) (Gansser, 1964).

North district is the largest (4,226 sq. km.) in area but in term of population it is the smallest with (43,709) and (78.01) per cent of literacy rate at the third rank in the district level during this census.

"Kabi Lungchok" historically important place where the treaty of blood relationship between the two distant communities, the Lepcha Chief Te-Kung-Tek and the Bhutia Chief Khey-Bum-Sar was signed ritually. The spot where the ceremony took place is marked by a memorial stone pillar amidst the cover of dense forest on the North Sikkim highway is located in the North district.

"Yumthang valley" one of the most famous spot of tourist interest is in this district. The route to Yumthang from Lachung has a very picturesque landscape and is lined with rhododendron shrubs and trees. The entire valley erupts into a riot of colors during the month of May. A hot spring on the left bank of river Lachung is immensely popular for its curative and healing power located on the way to Yumthang.

Mount Kanchenjunga positions the third highest mountain in the world with an elevation of 28,169 feet (8,586 metres). It is situated in the eastern Himalayas on the border between Sikkim and eastern Nepal. The mountain is part of the Great Himalaya Range. The name Kanchenjunga is derived from four words of Tibetan origin extracted Kang-chen-dzo-nga or Yang-chhen-dzö-nga. The mountain holds an important place in the mythology and religious ritual of the local inhabitants.

Climate

The climate of the State has been roughly divided into the tropical, temperate and alpine zone. For most part of the year, the climate is cold and humid. Most part of the state receives heavy rainfall throughout the year. It is only in the month of October-March that the State remains comparatively drier. The extreme northern parts, adjoining Tibet, however, receive very little rainfall. The mean annual rainfall is minimum at Thangu (82 mm) and maximum at Gangtok (3494 mm). An isohyatal analysis of these data reveals that there are two maximum rainfall areas (i) South-east quadrant including Mangan, Singhik, Dikchu, Gangtok, Rongli, etc. (ii) South-west corner including hilly terrain. In between these two regions, there is a low rainfall area (around Namchi). There is an area in north-west Sikkim which receives less than 4.9 mm of rainfall. Rainfall is heavy and well distributed during the months from May to early October. July is the wettest month in most of the places.

Places with an altitude of 6065 m and above are snowbound and places as low as 3002m come within the snowline in the winter. The temperature in the lower altitudes fluctuates between 4°-35°C and places with moderate height (around 1829 m) such as Gangtok temperature varies between 1°C and 25°C. In the high altitude area (above 3993 m), the temperature never rises above 15°C and slides down to the freezing point in winter.

Agriculture

Agriculture accounts for one third of Sikkim's gross domestic product. More than 64% of the population depends on agriculture for livelihood. Products such as rice, wheat, maize, finger-millet, barley, buckwheat, and pulses like ricebean, rajmah, fieldpea, cowpea and clusterbeans and oil seeds like rapseed, mustard, soyabean and sunflower are grown in the area. Of late there is a thrust on planting medicinal herbs, which abound the natural vegetation. The State is reported to have more than 424 species of the medicinal plants.

Physiography and drainage

The State encompasses parts of Lesser Himalaya, Higher Himalaya, and the Trans Himalaya and hosts some of the highest mountain peaks of the Himalaya. The elevation ranges from 300 to 8586 m with increasing elevation from south to north. In Sikkim-Darjeeling Himalaya, the Lesser Himalaya starts from Kalijhora (in Darjeeling) in south/west and continues up to Singhik (in Sikkim) in north/east. The low grade metamorphic rocks of Lesser Himalaya start at as low as 300 m and continue up to 3050 m (Mount Mainak).

In Sikkim exposures of Higher Himalayan rocks start at about 650 m and continue upto 8586 m (Mount Kangchenjunga). The outcrops of gneisses with granitic intrusions exhibit sharp, rugged, snow bound mountains with steep in accessible scarp faces. Extending in the form of an east-west trending ridge, it forms a barrier between the Trans-Himalayan zone and the Lesser Himalayas with Kanchenjunga as its western limit and Lama Angdang as the eastern limit and a series of high peaks, deep valleys, gorges and numerous glaciers in between. Langbo Chhu, Naku Chhu and Chhombo Chhu form main drainage flow through flat bottomed 'U' shaped valleys and finally meet with Tista River.

The Trans Himalaya starts from 5300 m and continue upto 7000 m. The snow capped jagged ridges in the northern portion of the state are feeders to the glaciers which come down to about 4000 m. The topography of the northern part, where rocks are of sedimentary origin, is characterized by barren, reddish-brown mounds and hillocks, with broad, flat bottomed valleys so typical of Tibetan plateau. These hillocks are seen protruding out as fingers, from the main Himalayan ranges, gently merging with broad plains of Tibetan plateau. The river valleys are open towards the top and attain a steep gorge like character towards the beds of river.

In Sikkim-Darjeeling Himalaya the first hill ranges starting from south are having summit between 1158 m to 732 m and runs east west. In the western part, the height increases very sharply to 2592 m within 20 km crow fly distance towards north. Siwaliks starts at 153 m and ends at 823 m. Dalings continues up to 1220 m and then Darjeeling Gneiss starts. On the eastern side Siwalik ends at 732 m, Dalings at 1376 m. At the central part of the area, i.e. in Tista Dome the height is in general between 1200 to 2500 m though the summit point is on 3233 m. As soon as the Daling rocks are crossed the height increases sharply from average 1800 m to 3000 m in the lower reaches, 3000 m to 4500 m in the middle reaches and 4500 m to 6700 m in the upper reaches of the dome. The rocks north of South Tibetan Detachment System (STDS) are in general occurring above 4200 m to 7300 m.

The Tista Rangit water divide is the main N-S water divide within the Sikkim-Darjeeling Himalaya. This water divide takes an E-W swing after crossing the Daling Dome. The N-S stretch culminates at 3700 m and the E-W trend shows sharp rise in altitude from 3700 to 7300 m. The west bound water divide is having the summit point at famous Kangchenjunga peak. Another N-S water divide is between Lachen Chu and Lachung Chu which starts at about 3000 m and slowly increases up to 6700 m.

The other water divide in general trends E W. The height of the water dividing ridges increases slowly from 1100 m to 1500 m, 2100 m, 3000 m, 3600 m, 6700 m towards north. These ridges are lower in height in central portion and height increases both towards eastern and western side. Sharp increase in height has been observed after crossing the Daling Dome. On the eastern side of Tista valley water divide of Rilli, Rongpo, Rani Chu, and Dickchu are spectacular. The ranges south of Dikchu being the longest one known as Gangtok ridge as the Gangtok city is on this ridge. The most important feature is that these ridges continue crossing the Tista River to the Rangit - Tista water divide. The ridge portions which crosses the Tista River are very steep.

North of Dickchu, steep ridges on the eastern side are there but of smaller extent as the Tista valley are subdivided by the water divide between Lachen Chu and Lachung Chu. On the western part long ridges are

present. These are Talang Chu and Zemu Chu water divide.

Thus, the total relief picture of Sikkim-Darjeeling Himalaya is such that the northern part is always above 3300 m to 7000 m forming a part of Tibetan Plateau. MISC. PUB. NO. 30(XIX) 3 The middle part slowly decreases its height towards south and central part giving rise to an amphitheater type relief feature. The amphitheatre follows the trend of MCT indicating that the Higher Himalaya is uplifted relative to the Lower Himalaya. The important Mountain peaks of Sikkim are: Mt. Kanchenjunga (8559.42 m), Mt. Kabru (7361.36 m), Mt. Talung (7356.8m), Mt. Siniolchu (6870.4 m), Mt. Simovo (6832.7 m), Mt. Pandim (6718.4 m), Mt. Rathong (6718.4 m), Mt. Paunhri (6688m), Mt. Kokthang (6129.2 m), Mt. Lamaongden (5887.26 m) and Mt. Masunyange (5867.2 m).

Salient feature of Tista Drainage Basin:

Tista is the trunk river in Sikkim-Darjeeling Himalaya. Like all other major rivers of Himalaya, Tista is also an antecedent river. It starts from Tso Lamo lake of Trans Himalayan region of north Sikkim. Near its origin it initially flows for some distance in E-W direction, and then takes a sudden N-S trend. Near Chungthang it takes an ENE – WSW trend from Mongan takes a N – S trend. This trend continues for its entire route through Himalaya.

At the upper reaches, before Zemu Chu and Lachen Chu confluence, i.e. in the north of Higher Himalaya the valley wall is 1520 m high. The valley wall rises up to 3344m from Lachen to Dickchu as it enters the Higher Himalaya. After Dickchu, the valley wall slowly decreases to 915 m near Rangpo and further downward in the outer hill ranges the valley wall is 457 m high. Thus the gorge forming tendency is mostly noticed in the Higher Himalayan region. It is a case of rapid incision with higher rate of uplift.

Gradient of longitudinal profile of the Tista River is very low in lesser Himalaya and slowly increases towards north. The change in the gradient is very sharp north of Dickchu, near MCT and highest gradient was observed near Zemu. After Zemu, towards north the gradient is again low. The Longitudinal profile of Tista is concave from lesser to Higher Himalaya but changes to convex in the higher reaches. It has been observed that the longitudinal profiles of the Trans Himalayan Rivers are convexo-concave as they pass from the Tibetan Plateau through the Higher Himalaya to the Lesser Himalaya and Sub-Himalaya.

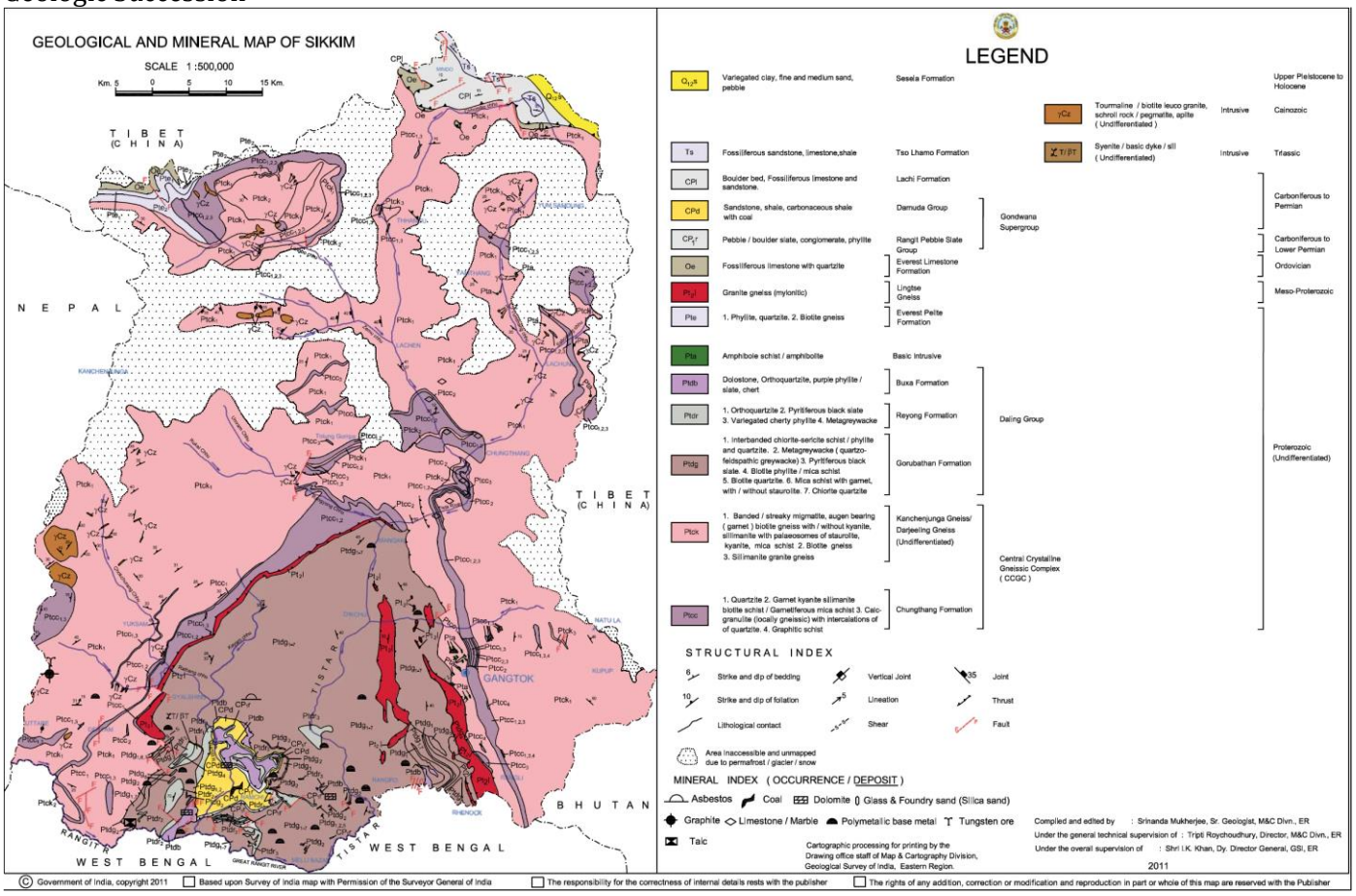
The Tista drainage basin is an asymmetric drainage basin. The western side is wider than the eastern side. compared to the eastern side. The migration of the river towards east may be considered to be a result of tilt of the rocks towards east. A spectacular observation is that the western bounding water divide of the Tista basin is always higher than the eastern bounding water divide across the same latitude. This feature continues all along the east west trend of the bounding water divides.

Rangit sub basin, the biggest sub basin in the Tista valley on its western bank, also shows an asymmetric nature. The southern block is more constricted than the northern block indicating a tilt towards south (Cox 1994). The Talang Chu, another sub basin in the western part of the Tista valley just north of Rangit also shows a southern block constriction indicating a southern tilt. However, the river north of Talang Chu, the Zemu Chu is a symmetric sub basin. The Lachung Chu, the eastern tributary in the similar latitude also shows a more or

less symmetric sub basin. The Tista basin in this latitude is symmetric upto the confluence of Lachen Chu and Zemu. Then the eastern constriction starts. The Tista basin is again symmetric after Tista Rangit confluence. The Rongpo Chu, the biggest eastern tributary is symmetric barring a small part constricted towards north. The other eastern tributaries are symmetric. The lengths of the eastern tributaries are smaller compared to the western tributaries.

The drainage pattern in Tista basin is mostly a mixture of sub dendritic and sub parallel. However, in the northern part directional trellis type drainage pattern is observed. Drainage density is high in the lower reaches but in the higher reaches the drainage density is moderately high.

Geologic Succession



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Stratigraphy of rock succession in Sikkim giving various geological units and their lithological characteristics:

Generalised stratigraphic succession of Sikkim Himalaya
(As per unified legend scheme of GSI)

LITHOLOGY	FORMATION		GROUPAGE
Variegated clay, fine and medium sand, pebble bed	Sesela Formation		Upper Pleistocene Holocene
Tourmaline / biotite leuco granite, schroll rock/ pegmatite, aplite (Undifferentiated)	Intrusive		
Syenite / basic dyke/sill (Undifferentiated)	Intrusive		
Fossiliferous sandstone, limestone, shale	Tso Lhamo Formation		Triassic
Boulder bed, Fossiliferous limestone and sandstone.	Lachi Formation		Carboniferous to Permian
Sandstone, shale, carbonaceous shale with coal Pebble/boulder slate, conglomerate, phyllite	Damuda Group Rangit pebble state Groups	Gondwana Supergroup	
Fossiliferous limestone with quartzite	Everest Limestone Formation		Ordovician
Granite gneiss (mylonite)	Lingtse Granite Gneiss		Meso Proterozoic
Phyllite, quartztte, biotite gneiss	Everest Pelite Formation		Meso Proterozoic
Amphibole schist / amphibolite	Sill		
Dolostone, ortho-quartzite, purple phyllite / slate, chert	Buxa Formation	Daling Group	Proterozoic Undifferenciated
Ortho-quartzite, pyritiferous black slate, variegated cherty phyllite, meta-greywacke	Reyang Formation		
Interbanded chlorite-sericite schist / phyllite and quartzite, meta-greywacke (quartzo feldspathic greywacke), pyritiferous black slate, biotite phyllite / mica schist, biotite quartzite, mica schist with garnet, with / without staurolite, chlorite quartzite	Gorubathan Formation		
Banded / streaky migmatite, augen bearing (garnet) biotite gneiss with/ without kyanite, sillimanlte with palaeosomes of staurolite, kyanite, mica schist, biotite gneiss, sillimanite granite gneiss	Kanchenjunga Gneiss/ Darjeeling Gneiss (Undifferentiated)	Central Crystalline Gneissic Complex (CCGC)	Proterozoic Undifferenciated
1. Quartzite 2. Garnet kyanite sillimanite biotite schist / Garnetiferous mica schist 3. Calc-silicate, carbonaceous schist Chungthang Formation	Chungthang Formation		

7.4.1.3 SEISMICITY AND EARTHQUAKES

The State of Sikkim encompasses parts of Lesser Himalayas, Higher Himalayas and Tibetan plateau. Main boundary thrust (MBT) just passes through the area slightly south of West Bengal-Sikkim boundary; Main Frontal Thrust (MFT) between Siwaliks and Neogene sediments is further south. Main Central Thrust (MCT) passes through the Central part of the State and the normal fault between Central Crystallines and Tethyan Sequence passes through the northern part of the State. A number of smaller thrusts and NW and NE trending oblique faults are also recorded in Sikkim Himalayas, some of which appear to be active faults.

In this area most of the earthquakes are shallow focus (<40 km) and commonly of 4.5 to 5.5 magnitude range. The state along with adjoining regions have been divided into three blocks. The central main Himalayan Block with considerable Seismicity separates the northern Tethyan block and southern fore deep block with subdued seismic activity.

A look at the regional distribution of earthquakes and lineament/fault patterns in Sikkim and adjoining region indicates that a number of high (5.0 to 5.9) and medium magnitude earthquakes are clustered around and related to Tista Lineament along NW-SE direction. One more NW-SE trending lineament, and marked as a fault along Tista River between Lachen and Chungthang (and further south-east) appears to have been the cause of high magnitude earthquakes. There also appears to be yet another NW-SE trending lineament in north-east Sikkim along which the earthquakes have been recorded.

Similarly, a NE-SW alignment of earthquakes is also observed.

The map published by the India Meteorological Department indicates that the state of Sikkim comes under seismic zone IV- a zone of considerable vulnerability. The nearby regions come under zone V and are highly susceptible to earthquakes.

succeeding Figure shows the seismic zones ofIndia & Sikkim.

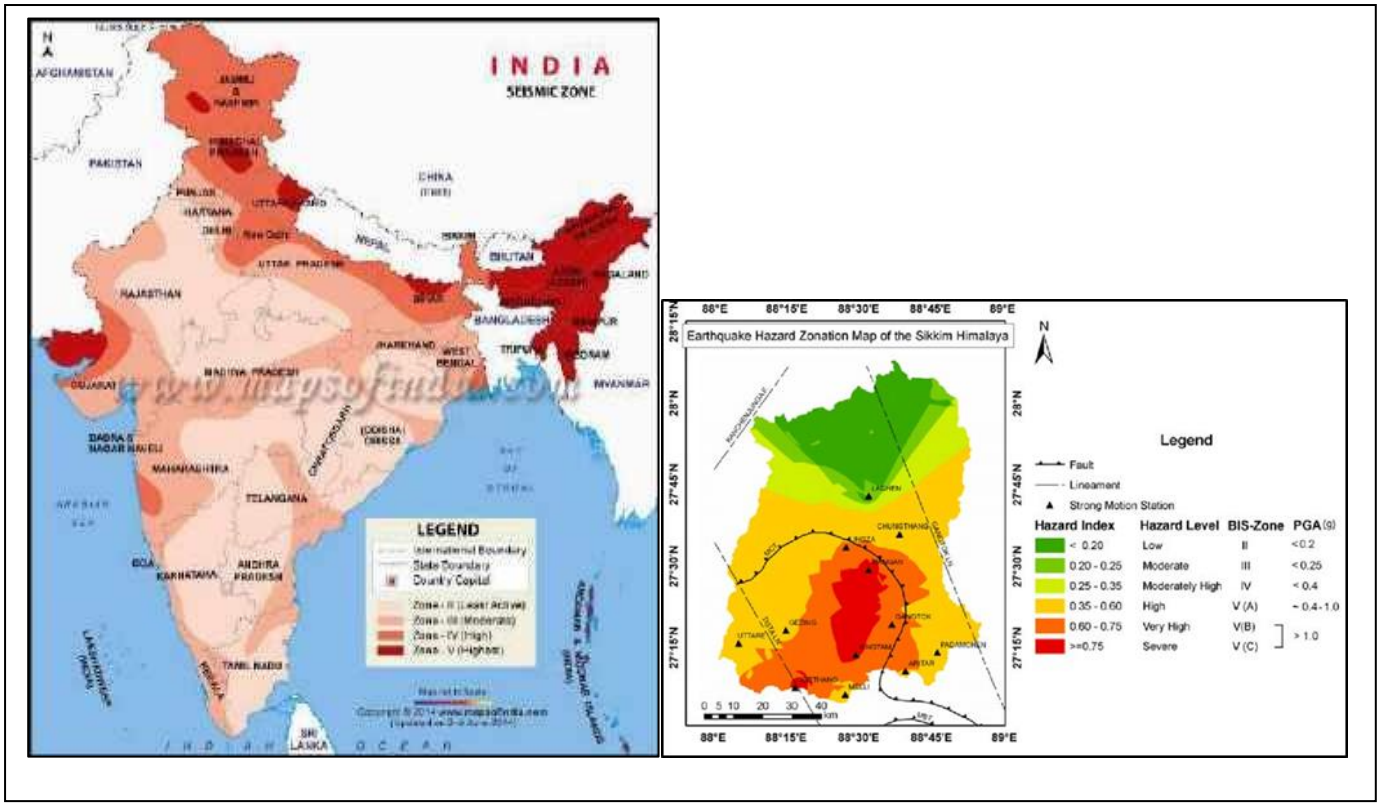

Figure 7.1 seismic zones of India **Fig 7.2 Seismic zones of sikkim**

7.5 Hydrogeology

As increasing industrialization & modernization in lifestyle, issue of water crisis either quality &/or quantity of water is being critical day by day. The main source of such crisis is found to be the activities requiring huge quantity of freshwater and generating huge quantity of waste water. Hence, while studying the probable impacts of industrial project, it is very important to determine the existing status of water quality & quantity. The water resource for such investigations can be groundwater or surface water or both depending upon the water specific planning of the proposed project.

Block Name	Mangan (As per CGWA Classification)
Category of Block	Safe (Non-Notified)
Water Demand	5KLD

Ground Water is occurring in the zone of Secondary Porosity, under unconfined condition. Ground water is the prime source of water supply in the district for drinking purpose. Ground water in the major part of the district occurs in localized, disconnected bodies under favorable geological

conditions. Thus there is no homogenous aquifer system having wide aerial extent. Ground Water occurs along the thrust plains, strike slip fault/ normal fault plains, tensile joints, synclinal folds, tensile fractures and at the contact of two different rock formations etc.

Further it also occurs in solution cavities, channels etc. in the carbonate rocks. In alluvial formation it occurs in the valley fill deposits, terraces, river terraces and glacial valleys, weathered rock cover and in moraines and glacial deposits. On the hill slope ground water mostly occurs in the form of seepages, springs and gadheras under gravity and favorable geological structures intercepting the topography.

The occurrence of springs and seepages is controlled by geological structures and physiography of the area. Most of the springs are originating from higher reaches of the mountains. Two-three springs jointly makes a high discharge gadhera also originating and meeting at higher reaches and flows through contacts of mountains / rocks under gravity. The discharge and temperature of the springs fluctuate throughout the year depending upon its recharge and discharge factor. During the rains the favorable geological structures get recharged and resulting in higher discharge of spring and gadheras after the monsoons. During the post-monsoon period their discharge reduces gradually with time and it is minimum in pre-monsoon period.

The perennial Rivers and streams also recharge the springs located on the valley side and near streambeds. The potential recharge areas in the hilly terrain are flat ridges, hills, saddles, spurs, flood plains developed on terraces of major rivers, fault plains, sheared zones along the riverbed etc. The discharge takes places through springs/ gadheras on the hill slops where the structurally weak and saturated zones intercepts the topography. The ground water budgeting in the hilly terrain is not possible due to hilly, rugged topography and hydrogeological discontinuity.

Hydro-geological studies over the last decades confirm the diminishing water resources and the worsening cries as caused by the following factors which have resulted in the decrease in underground seepages. These have directly contributed the reduction of the water availability in and reduction of discharge in nallas as well as extensive disappearance of spring-the regions primary source of drinking water.

There has been a dimensing regulatory effect of glaciers of the great Himalayan zone. There is a long-tern decreasing trend of stream discharges. The capacities of the lakes have dwindled. Surface runoff on the hillsides has shown high increase. There has been an increase in floodwater and decrease in base flow water in channels and Rivers. Extensive soil erosion and landslips are phenomena in the region.

TABLE NO. 7.6 AVERAGE RAINFALL DATA OF 10 YEAR (2011-2020)

YEAR	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.
2009																								
2010									424.9	21	582.8	8	531.6	10	599.1	30	329.1	6	106.7	-52	111.8	131	11.2	-65
2011	31.8	-48	72.4	-26	79.7	-60	150.3	-37	190.8	-46	393.8	-22	442.8	-10	397.2	-7	261.5	-33	126.8	-52	68.8	58	12.4	-45
2012	96.4	56	39.5	-60	208.3	4	365.3	53	139.7	-61	599.2	19	595.9	22	316.2	-26	785.4	102	302.4	14	0.0	-100	17.5	-22
2013	9.6	-84	62.8	-36	120.8	-39	200.5	-16	615.5	73	313.6	-38	530.2	8	301.8	-30	310.3	-20	226.7	-14	82.4	89	10.4	-54
2014	0	-100	29.8	-70	163	-18	194.4	-18	417	17	651.6	30	605.1	24	629.8	47	297.5	-24	36.7	-86	25.2	-42	13.6	-39
2015	22.0	-64	34.0	-65	180.6	-9	239.4	0	498.4	40	796.4	58	393.6	-20	664.7	55	320.2	-18	102.8	-61	59.0	36	37.5	67
2016	81.8	33	34.9	-65	306.8	54	226.7	-5	383.7	8	548	9	487.3	0	301.6	-30	638.1	64	139.8	-47	0.0	-100	0.0	-100
2017	7.7	-77	9.0	-84	112.3	82	266.1	52	315.7	8	318.3	-31	485.7	-5	400.6	-9	274.5	-26	83.3	-46	6.5	-6.5	0.0	-100
2018	15.2	-75	66.4	-33	216.2	8	221.0	-7	397.3	12	584.2	16	688.2	41	510.8	19	751.9	93	203.5	-23	68.9	58	15.1	-33
2019	25.7	-37	92.7	3	236.2	39	155.3	-25	443.7	52	531.4	29	588.0	41	351.4	-5	559.8	91	88.7	-51	8.5	-75	26.3	21
2020	83.1	104	25.2	-72	155.0	-9	343.7	67	375.0	28	993.7	140	818.9	97	467.2	26	409.7	40	220.9	21	23.5	-32	17.2	-21

Source: HYDROME DIVISION, INDIA METEOROLOGICAL DEPARTMENT, NEW DELHI

Ground water:

It is an important source of water in the study area. There are many bore wells, dug well hand pump in the study area. Water samples collected from near project site and buffer zone area.

Ground Water Resources:

Ground water assessment has not been carried out as the ground water abstraction is done mainly

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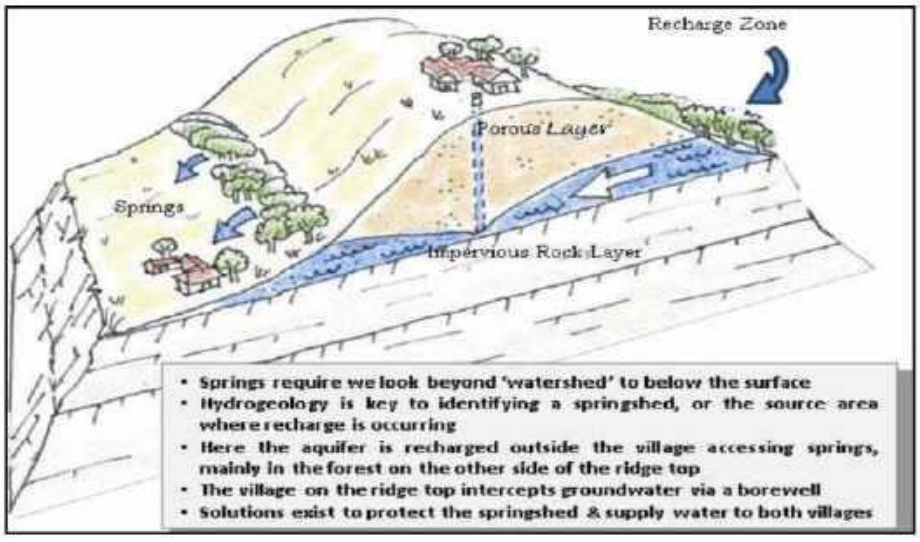
through hand pumps with almost negligible discharges.

Water Conservation and Artificial Recharge

Groundwater, in the area, is mainly developed through hand pumps. The area replenishing the hand pumps should be identified precisely. Suitable groundwater recharge structures like gullying plugs, checking dams, gabion structures etc. can be constructed so that the yield of the hand pump is sustained round the year. Further, ground water is also developed naturally through springs. It oozes out in the under gravity and favorable geological structures intercepting the topography. Basically spring is a localized natural discharge of ground water issuing on the land surface through outlets. The discharge of spring may vary from a trickle to as big as a stream.

Rain water harvesting structures like gully plugs, check dams, gabion structures etc. may be constructed in the nearby vicinity of the springs and nalas having negligible to low discharges.

FIGURE NO. 7.3 CONCEPTUAL LAYOUT OF SPRING RECHARGES AREA



Surface Water Quality:

Surface water quality had been assessed by 3 sample of surface water. The other samples were collected as grab sampling from different ponds within the impact zone. The details of sampling locations and analysis reports are given below:

TABLE 7.7-: SAMPLING STATIONS OF SURFACE WATER QUALITY ANALYSIS:

Surface Water					
S.No	**Parameters**	**Unit**	**SW-1**	**SW-2**	**SW-3**
1	pH value	-	7.22	7.51	7.45
2	Turbidity	NTU	4	9	12
3	Conductivity	mmhos/cm	310	491	642
4	Total Dissolved Solids	mg/l	205	302	385
5	Total Suspended solids	mg/l	16	24	36

6	Total Hardness (as $CaCO_3$)	mg/l	118	162	196
7	Chlorides (as Cl)	mg/l	48	54	87
8	Total Alkalinity as $CaCO_3$	mg/l	72	134	158
9	Sulphate (as SO_4)	mg/l	18	31	47
10	Nitrate(as NO_3)	mg/l	7.8	10.8	13.2
11	Fluoride (as F)	mg/l	0.3	0.5	0.4
12	Iron (as Fe)	mg/l	0.14	0.13	0.16
13	Zinc (as Zn)	mg/l	0.18	0.32	0.29
14	Calcium (as Ca)	mg/l	33	42	51
15	Magnesium (as Mg^{2+})	mg/l	8.7	13.9	16.7
16	Cadmium (as Cd)	mg/l	<0.01	<0.01	<0.01
17	Copper (as Cu)	mg/l	<0.05	<0.05	<0.05
18	Nickel (as Ni)	mg/l	<0.01	<0.01	<0.01
19	Lead (as Pb)	mg/l	<0.1	<0.1	<0.1
20	Mercury (as Hg)	mg/l	<0.001	<0.001	<0.001
21	Total arsenic (as As)	mg/l	<0.01	<0.01	<0.01
22	Phenolic Compounds (as C_6H_5OH)	mg/l	<0.001	<0.001	<0.001
23	Manganese as Mn	mg/l	<0.01	<0.01	<0.01
24	Cyanide as CN	mg/l	<0.05	<0.05	<0.05
25	Total Chromium (as Cr)	mg/l	<0.05	<0.05	<0.05
26	Aluminum as Al	mg/l	<0.03	<0.03	<0.03
27	Oil & Grease	mg/l	<2	<2	<2
28	Chemical Oxygen Demand	mg/l	8	24	16
29	Bio- Chemical Oxygen Demand as BOD (for 3 Days 27 ˚C)	mg/l	<2	4.6	3.2
30	Dissolved Oxygen	mg/l	7.2	6.6	6.9
31	Total Coliform	MPN/100ml	2.1×10^2	3.9×10^3	3.1×10^3

Ground water Quality:

Based on limited records, the water quality of districts Rivers, rivulets and natural water sources is generally good and no major source of water pollution was found. The tube well, hand pumps, natural water seeping out from mountain locally called as "Naula" and natural water springs lacally called as "Gadhera" represent the ground water sources in the district. There are no major sources of water pollution in terms of point or non-point sources aside from natural landslides leading to deposition of debris in streams. Proposed sub project are not expected to have any impact on the project proponent through Supervision Consultant during EIA study of the proposed project site.

FIGURE 7.4: SHOWING DRAINAGE PATTERN OF SURFACE WATER

Ground water quality had been assessed by selecting 3 sampling stations in impact zone. The details of sampling locations and analysis reports are given below:

TABLE-7.8: GROUND WATER QUALITY & MONITORING STATIONS

Construction of Solid Waste Treatment							
RESULTS							
WATER QUALITY ANALYSIS							
S. No	Parameters	Unit	Max Requirement as per (IS-10500-2012), Limit		Passindang	Singhik	Mangan
			Desirable	Permissible			
Physical Parameters							
1	pH value	-	6.5-8.5	No Relaxation	7.46	7.36	7.43
2	Color	Hazen	5	15	<5	<5	<5
3	Turbidity	NTU	1	5	<1	<1	<1
4	Total Dissolved Solids	mg/l	500	2000	148	165	132
5	Total Alkalinity as $CaCO_3$	mg/l	200	600	62	72	54
6	Total Hardness (as $CaCO_3$)	mg/l	200	600	82	94	76
7	Calcium (as Ca)	mg/l	75	200	19	22	18
8	Magnesium (as Mg^{2+})	mg/l	30	100	8.4	9.5	7.6
9	Chlorides (as Cl)	mg/l	250	1000	26	28	24
10	Fluoride (as F)	mg/l	1	1.5	0.3	0.2	0.3
11	Sulphate (as SO_4)	mg/l	200	400	14	16	12
12	Iron (as Fe)	mg/l	1	No Relaxation	0.15	0.11	0.13
13	Nitrate(as NO_3)	mg/l	45	No Relaxation	8.2	9.2	7.8
14	Copper (as Cu)	mg/l	0.05	1.5	<0.05	<0.05	<0.05
15	Boron (as B)	mg/l	0.5	2.4	<0.1	<0.1	<0.1
16	Manganese(as Mn)	mg/l	0.1	0.3	<0.05	<0.05	<0.05
17	Phenolic Compounds (as C_6H_5OH)	mg/l	0.001	0.002	<0.001	<0.001	<0.001
18	Sulphide (as H_2S)	mg/l	0.05	No Relaxation	<0.05	<0.05	<0.05
19	Zinc (as Zn)	mg/l	5	15	0.22	0.28	0.33
20	Cadmium (as Cd)	mg/l	0.003	No Relaxation	<0.003	<0.003	<0.003
21	Cyanide (as CN)	mg/l	0.05	No Relaxation	<0.05	<0.05	<0.05
22	Lead (as Pb)	mg/l	0.01	No Relaxation	<0.01	<0.01	<0.01

23	Mercury (as Hg)	mg/l	0.001	No Relaxation	<0.001	<0.001	<0.001
24	Total Arsenic (as As)	mg/l	0.01	0.05	<0.01	<0.01	<0.01
25	Total Chromium (as Cr)	mg/l	0.05	No Relaxation	<0.05	<0.05	<0.05
26	Total Coliform	per 100ml	Shall not be detectable		Absent	Absent	Absent
27	*E.Coli*	*E.coli*/100ml	Shall not be detectable		Absent	Absent	Absent

Water Requirement for Project:

The water requirement for operating the proposed Solid Waste Treatment Plant is about 5 KLD. The water requirement during construction is expected to be about 4 KLD.

S. No.	Description	Water Requirement (KLD)	Waste Water Generation (KLD)	Treated Water (KLD)
1.	Domestic Purpose	1.8	1.6	1.4
2.	Vehicle/Tier Washing	0.5	0.3	0.2
3.	Dust Suppression	0.5	-	-
4.	Green Belt Development	2.2	-	-
5.	Process water	1.6	1.5	1.2
	TOTAL	**6.6**	**3.4**	**2.8**

- Domestic Wastewater will be in STP & reused for greenbelt purpose.
- Leachate will be treated in LTP of 25 KLD capacity and treated water will be reused for greenbeltpurpose.
- Treated water from LTP & STP will be used for greenbelt development, dust suppression etc.
- 1.6 KLD of treated water will be recirculated in the process. Hence, the water requirement for the proposed project is 5 KLD which will be sourced.

Tank Capacity:

The size of the tank must be suitable for the number of people that intend to use it, so

C = 42P + 2000

C = (42 X 30) + 2000

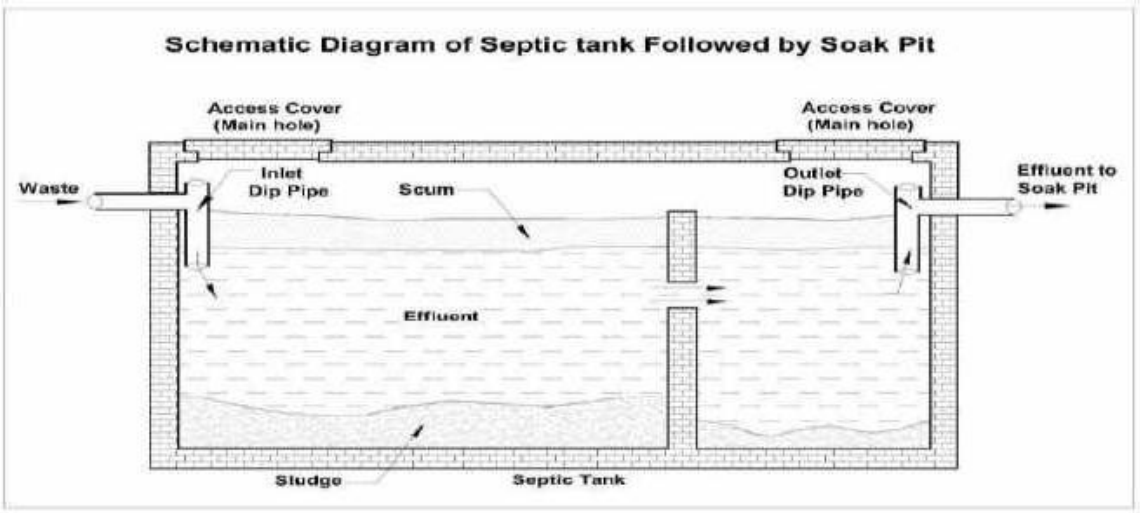
= 3260 liters (for 1 year)

C = Capacity of the tank in liters

P = The Population served

a) Construction of Tanks, Soak Pits etc. with diagram.

FIGURE 7.5: SOAK PIT



Impact & Mitigation measures of Hydro-geology

Impact: Following are the impacts identified on HG due to proposed project as North Sikkim districtis lying mostly in hilly terrain, as below:

- Rainwater harvesting in tough on account of less available flat area.
- Sort term negative impacts due to water consumption & sewage disposal are envisaged due to the proposed project.
- The wastewater generation will be from the domestic activities.
- Due to hydro-geological setup in perennial spring along with eco-hydrological changes as evident due to other development in the area (not specifically because of present project).
- Impact of deforestation, rainfall intensity, rise in temperature, seismicity, landslide, etc. in decline of discharges of springs (not specifically because of present project).

Mitigation Measures: Following mitigation measures are suggested to be adopted in construction and operational phase, given as below:

- Water requirement for construction phase will be very limited and for short period only. Thus, there will not be any significant impact on water environment.
- Domestic effluent will be disposed of through septic tank into soak pit.
- Greenbelt development will have positive impact on ground water table.
- Measures will be implemented to prevent seepage of liquid materials into ground where it could contaminate groundwater and soil.
- Ensure prompt cleaning up of accidental spillages measures will be followed to prevent the contamination of hydrological features by diesel, grease, oil, etc. derived from the working area.
- Provisions will be made to ensure the construction vehicles stick to the access track to prevent mud & dirt being deposited on roads.
- Fence will be constructed around the site to trap sediments from runoff water.
- All mud & dirt deposited on the roads from the construction activities will be cleaned.
- The sewage generated during the operation phase will be treated in proposed STP at site and treated water will be reused for flushing and on land irrigation matching CPCB norms for on-land irrigation which will reduce the fresh water demand. The surplus treated sewage will be disposed into municipal sewer drain with prior permission.
- Separate drainage will be proposed for storm water and for sewage to avoid run off contamination as well as any contamination of surface water sources.

- Rainwater harvesting will be proposed and recharge the ground water as well as rain water will be reuse in project premises so overall water demand will be reduced.
- Drip irrigation system will be provided for landscaping to reduce fresh water demand.

CHAPTER-VIII
PROJECT BENEFITS

CHAPTER - VIII

PROJECT BENEFITS

CHAPTER - VIII

CHAPTER - VIII

PROJECT BENEFITS

8.1 INTRODUCTION

Solid waste Treatment project for Mangan at north sikkim district of sikkim by UD & HD will be established to handle about 16.0 TPD.

8.2. BENEFITS OF LANDFILL

Landfills minimize the natural impact of solid waste on the environment by the following ways:-

- Isolation of inert waste through containment
- Elimination of polluting pathways

8.3. RECYCLING

A number of recyclable materials, for example paper, glass, plastic, rubber, ferrous and non-ferrous metals present in the MSW are suitable for recovery and reuse. This will benefit rag pickers.

8.4 IMPROVEMENT IN PHYSICAL INFRASTRUCTURE

The proposed project is expected to yield a positive impact on the socio economic environment. It helps sustain the development of this area including further development of physical infrastructural facilities.

8.5 IMPROVEMENT IN SOCIAL INFRASTRUCTURE

Agriculture & plantation are one of the basic sectors of employment for the local people in this area. The project will lead to indirect and direct employment opportunity. Employment is expected during operation period, garbage lifting and other ancillary Services. Employment in these sectors will be temporary or contractual and involvement of unskilled labour will be more. A major part of this labour force will be mainly from local villagers who are expected to engage themselves both in agriculture and project activities. This will enhance their income and lead to overall economic growth of the area.

The proposed solid waste treatment system would lead to improvement of social infrastructures. Few of the benefits, which could be:

- ✓ Reduction, reuse and recycle of the waste.

- ✓ Source Segregation & collection of waste (Systematic Door to Door collection has been proposed in the project)
- ✓ Conversion of waste into a useful and marketable product (Manure) as recirculation of soil nutrients.
- ✓ Good market for compost sale.
- ✓ Public and private participatory mechanism to ensure a long-term sustainability of the project.
- ✓ Commercially viable project and long term sustainability.
- ✓ Clean, hygienic and better infrastructure of the city and surrounding.
- ✓ Improved and mechanized services for the community.
- ✓ Increase in employment opportunities in collection and transportation, door to door collection and in processing and disposal facility.
- ✓ Regulatory compliant system.
- ✓ Reduce financial burden and operational hassles on the municipal corporation.

8.6 SOCIAL BENEFITS

Better living Conditions

No open dumping will be carried out during the course of this project. This will reduce the chances of air, water & soil contamination and also will reduce odour emission. This will improve the living standards of society & will provide safe & hygienic surroundings.

Improved Health Conditions

Efficient waste collection & disposal of waste will make the living & health condition in the area better. Dumping of waste in open areas harms the aesthetic appearance of a place and emits foul odors. It also provides ground for breeding of mosquitoes & disease causing pathogens. The proposed solid waste treatment project will ensure timely collection of waste, efficient treatment & disposal in a scientific & environment-friendly manner. This will reduce the spread of diseases and improve the sanitary conditions of the area.

Enhancement of Aesthetic Value of Area

Cattles & other stray animals roam around the existing open dumpsite. This creates disturbance to society. Scavenging birds hover above the open dump site which may pose significant threat to aircrafts. Open dumping of waste also creates an unpleasant view and leads to emission of foul odour. The proposed project will use scientific technology and methods for management of waste. This will reduce bird menace. An entry gate & wired fence will be provided around the project site to prevent

entry of stray animals & cattle. A thick green belt will also be developed around the project site. The project will lead to improvement in aesthetic value of the area.

Direct & Indirect Employment Opportunities

Development of the project will provide employment opportunities to local skilled, unskilled & semi-skilled people during both construction & operation phases. Also, indirect employment may be generated during the construction phase of the project.

8.7 ECONOMIC BENEFITS

Revenue from Waste

Solid waste Treatment plants are economically sound investments that provide multiple financial and environmental benefits to the communities that utilize them. Waste is material that is being rejected as it has no use for the people. Project comprises of collection of waste, waste processing & safe disposal. From waste following products will be recovered, which can generate revenue:

1) Recyclables
2) Inert waste as filler material.

Improved Economic Status

The proposed project will generate both direct & indirect employment. Local people will be preferred for giving employment. This will improve the economic status of the area. Migration of local people to other parts of state/country due to unavailability of employment will be reduced.

8.8 ENVIRONMENTAL BENEFITS

Prevention of Air, Water & Soil Contamination

This project involves scientific management of waste which will prevent environmental pollution & spread of disease.

Environmental Benefits:

Regular monitoring of the surrounding will keep the area environmentally safe and under any adverse circumstance, immediate measures will be taken and enacted upon.

The overall effect will improve buying power of employees and thus a higher standard of living viz. better education, improved health and sanitation facilities housing and acquisition of consumer durable. This is envisaged as a major positive benefit.

A solid waste treatment system would lead to an effective management of the solid waste of the city along with a commercially viable and sustainable implementation plan for the solid waste. Few of the benefits, which could be:

- Transportation of waste in covered /closed vehicles to the site.
- Source Segregation & collection of waste (Systematic Door to Door collection has been proposed in the project)
- Reduction, reuse and recycle of the waste.
- Conversion of waste into a useful and marketable product (Manure) as recirculation of soil nutrients.
- Only inert/processing rejects to be land filled which is about 10% of total dry waste quantity shall be disposed off into the landfill. This would save upon the future requirements of area for land filling.
- Reduction of greenhouse gases (carbon foot prints) because of waste processing.
- Organized and a scientific land fill site with 20 years of life in order to prevent water & soil Contamination.
- Regulatory compliant system.

Development of Green Belt

Green belt developed along with lawns & green buffer at site. This will help in attenuating dust & noise level at site.

8.9 OTHER PROJECT BENEFITS

Benefit to the Urban Local Body: Due to implementation of this project, the UD & HD will comply with the Municipal Solid Waste Management Rules 2016, wherein it has been stated that the ULBs are responsible for scientific collection, transportation, segregation and disposal of municipal solid waste within this limits.

Organized Collection of MSW: The systematic collection, transportation, segregation and disposal of the municipal wastes will lead to an organized, accountable and reliable mechanism of disposal of waste.

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CHAPTER-IX
COST BENEFIT ANALYSIS

CHAPTER – IX

COST BENEFIT ANALYSIS

9.1 Cost Benefit Analysis

The Cost Benefit Analysis is not prescribed in the granted Terms of Refrence (ToR). Hence, the same is not carried out for the project.

CHAPTER-X ENVIRONMENT MANAGEMENT PLAN

CHAPTER – X

ENVIRONMENT MANAGEMENT PLAN

10.1 Environment Management Plan

Environmental Management Plan (EMP) is a site-specific plan developed to ensure that the project is implemented in an environmental sustainable manner. This EMP also describes the role and responsibilities of staff supervising the project from Head office, personnel deployed at the project site and contractors, if any, who will be responsible for implementing this EMP.

10.2 Environmental and Social Management Cell

For the effective and consistent functioning of the project, an Environmental Management Cell (EMC) will be established for the project.

The major duties and responsibilities of Environmental Management Cell will be as follows

- To implement the environmental management plan.
- To assure regulatory compliance with all relevant rules and regulations.
- To ensure regular operation and maintenance of pollution control devices.
- To minimize environmental impacts of operations as by strict compliance to the EMP.
- To initiate environmental monitoring as per approved schedule.
- Review and interpretation of monitored results and corrective measures in case monitored results are above the specified limit.
- Maintain documentation of good environmental practices and applicable environmental laws as ready reference.
- Maintain environmental related records.

Record Keeping and Reporting

Record keeping and reporting of performance is an important management tool for ensuring sustainable operation. Records should be maintained for regulatory, monitoring and operational issues. Typical record keeping requirements summarized in **Table 10.1** below:-

TABLE -10.1 RECORD KEEPING PARTICULARS

Parameters	Particulars
Solid Waste Handling and Disposal	• Daily quantity of waste receive • Daily quantity sent to landfill
Waste water	• Daily quantities of treated effluent disposed • Quantity and point of usage of treated wastewater • Treated wastewater quality
Regulatory Licenses (Environmental)	• Environmental Permits / Consents from State PCB
Monitoring and Survey	• Records of all monitoring carried out as per the • finalized monitoring protocol
Accident reporting	• Date and time of the accident • Sequence of events leading to accident • Chemical datasheet assessing effect of accident on health and environment • Emergency measure taken • Step to prevent recurrence of such events
Others	• Log book of compliance • Employee environmental, health and safety records • Equipment inspection and calibration records, where applicable • Vehicle maintenance and inspection records

10.3 Environmental Management Plan for Mangan

Although the impacts on the environment during the construction phase would be temporary in nature and are expected to culminate on completion of the construction activities, implementation of management plans for various environmental attributes will further reduce the impact in terms of its spread, duration and intensity.

TABLE-10.2. ENVIRONMENTAL MANAGEMENT DIFFERENT PHASES

Description of Impact	Magnitude of Impact	Mitigation Measures Proposed	Responsibility Implementation
DESIGN STAGE			
Existence of residences adjacent to the sub-project site.	Permanent/ low	Layout has been finalized giving maximum clearance to the adjacent development. High compound wall and green belt around the site have been provided to form a physical separation and visual screen to the development.	UD & HD
Ground water contamination due to high water table at the site.	Permanent/ medium	Design of the system finalized to minimize ground water contamination. Design includes with leachate collection and treatment facilities. Two tier leachate collection system (leachate collection at the bottom of the compost pad and catch drain all around the site) Higher capacity for treatment plant to accommodate the shock load.	UD & HD
Existence of surface water source. Water quality may be affected due to storm over run.	Permanent/ low	Design includes diversion of storm water from other areas by providing diversion drains/ channel all along the periphery of the site.	UD & HD
CONSTRUCTION STAGE			
Silt run off from construction operations causing	Temporary / low	Site preparation to minimize clearance to adjoining vegetation and natural	Contractor

soil erosion and damage to water quality/adjacent land		resources; Protection of unstable soil surface from high velocity runoff with interception drains and stabilization; Proper siting and protection of construction materials;	
Noise, dust or hazardous materials arising from construction activity.	Temporary / low	Plant and equipment employed in the construction will comply with environmental standards. Regular wetting of stock piles of sand, metals; Dust curtain will be provided to the construction site.	Contractor
Contamination of land and water due improper disposal of waste by workers	Temporary / low	Proper sanitation facilities will be provided to the labour quarters/ settlement.	Contractor
Contamination due to indiscriminate disposal of spoil/silt	Temporary / low	Proper stock piling of silt/spoil at site; Examine the reuse opportunities for silt/ spoil; Identification of site for disposal of silt/ spoil; proper covering the disposal site on completion of work; Protection against pollution during transportation; and maintenance of the transportation vehicles	Contractor
Exposure of workers to site during construction	Temporary/medium	Provision of appropriate protective gears (Gum boots, gloves, masks etc.); training to workers regarding the	Contractor

		potential dangers and health effects and need for the use of protective gears	
O&M STAGE			
Hazards to health and safety of workman	Permanent /low	Develop and implement Occupational Safety Plan for the workforce; provision of appropriate protective gears to the workers at the site; Training to the workers at site regarding the dangers including the potential health effects of waste.	O&M Contractor
Fugitive Dust, loading & unloading	Temporary/low	Paving of roads inside the site; daily compacting, spreading and covering of incoming waste; select the working face to minimize the truck movement.	O&M Contractor

TABLE 10.3 PROPOSED ENVIRONMENTAL MITIGATION MEASURE

S. No.	Pollution Source	Pollution Emitted	Mitigation Measures
Air pollution Mitigation Measures			
1.	Construction activities	SO_2,NO_X, Particulates , Odour etc.	• Dust suppression by water sprinkling. • Bitumen covered internal roads. • Wheel Washing Bay at the entry point. • Vehicles carrying of construction materials and waste to be covered with tarpaulin / plastic sheet. • Proper ventilation and moisture in the compost plant and biomethanation area to be maintained and herbal insecticides to be sprayed around odour generation areas at regular intervals. • Secured landfill except the current waste
2.	Vehicular Movement		
3.	Loading and unloading of Trucks		
4.	DG Set		
5.	Processing of waste		

			handling area rest to be covered by polyethylene sheets • Green belt would be provided along the internal roads and plant boundary.
Water Pollution Mitigation Measures			
6.	Domestic Waste	Suspended Solids, BOD etc.	• Leachate Holding Tank. • ETP for recycling. • Impermeable liner in the landfill pit. •Storm water drainage system for recycling
7.	Leachate from Biomethanation Compost Plant		
8.	Leachate from landfill		
Solid Waste Management			
9.	Construction	Construction materials e.g. coarse aggregate, fines aggregate, bricks, steel etc.	• Recycled or used for filing/ levelling of low-lying areas within the site or transported outside.
10.	ETP sludge or evaporation pond	ETP sludge or evaporation pond settled particulates	• Sanitary Landfilling

TABLE 10.4 ODOUR, LITTER & INSECT CONTROL MANAGEMENT PLAN

S. No.	Impact	Mitigation
1.	**Odour:** Odour is one of the main concerns in vicinity to the proposed project. However, the impacts due to odour nuisance have been envisaged to be low as the designing of the facility has been planned in such a manner that the odour will be contained within the boundaries of the facility. Although the odour emanating from site is an inescapable problem,	• Adequate compaction • Speedy disposal and burial of malodorous wastes • Effective use of covering material • Progressive capping and restoration • Effective leachate and gas management • The proposed project proposes to cover the wastes with daily and intermediate covers of soil on a regular basis to ensure that odour generation is minimized. • Waste storage & processing of waste is in a completely cover shed, this complete shed area is maintained under

	but the problem can be mitigated if proper measures are taken Offensive odors at landfill sites may emanate from a number of sources such as waste material which has decomposed significantly prior to land filling, leachate and small amount of landfill gas	negative pressure by sucking odour gases so that the foul smell can't escape outside. • Foul smelling gases like CH_4 and H_2S creates major impact if Biomethanation operation is not done properly. • Spray of herbal sanitizers and inoculums will be done to remove odour. The compost facilities, roads, equipment and the surrounding area shall also be cleaned regularly to remove the odor generating wastes. The processed compost is stored in sheds so as to avoid attraction to birds and runoff due to rain or windblown entrainment of particles. • Plantation will also help to get rid from foul smell.
2.	**Litter:** Poor litter control, both on and off site is particularly offensive to neighbours	• Consideration of prevailing wind direction • Strategically placed mobile screen close to the tipping area or on the nearest downwind crest. Etc...
3.	**Birds & insects:** Birds are attached to the landfill site in large numbers mainly where site receive appreciable amounts of food wastes	• Employment of good landfill practice • Working in a small active areas • Progressive prompt covering of waste

TABLE 10.5. ENVIRONMENTAL MONITORING PLAN FOR THE PROPOSED PROJECT

S.NO.	Parameter	Location	Measurement	Frequency
Construction Phase				
1.	Ambient air quality	Construction Site and the vicinity	Suspended Particulate Matter (SPM),Sulphur dioxide, Methane, Ammonia (24 hour average) and Carbon monoxide (1hour average)	Quarterly
2.	Noise	Just outside landfill site on all 4 sides and at one location away from the landfill	Sound level, Leq, (day time and night time)	Quarterly
Operation Phase				
1.	Ambient air quality	At landfill site and at vicinity	Suspended Particulate Matter (SPM, Sulphur dioxide, Methane, Ammonia (24 hour average) and Carbon monoxide (1hour average)	Half-yearly
2.	Noise	Just outside landfill site on all 4 sides and at one location away from the site.	Sound level, Leq, (day time and night time)	Half-yearly

10.4 Leachate Management Plan

The landfill facility essentially generates significant quantity of leachate due to biodegradation of the organic matter present in the waste body. The leachate is impregnated with harmful chemicals and pollutants. It is to be collected, removed from the landfill facility and treated before final disposal.

10.5 Occupational Health & Safety Management Plan

The Occupation Health & Safety Management Plan (OHSMP) is applicable for all project operations which have the potential to adversely affect the health and safety of construction workers, SWT Plant operators and other labours.

The Occupation Health & Safety Management Plan (OHSMP) have been formulated to address the occupational health and safety related impacts that may arise from proposed project activities particularly during waste handling and segregation, waste unloading, processing and disposal.

Management Measures

- Providing workers with appropriate protective clothing, gloves, respiratory face masks and slip-resistant shoes for waste transport workers and hard-soled safety shoes for all workers.
- The workplace shall be equipped with fire detectors, alarm systems and fire-fighting equipment. The equipment shall be periodically inspected and maintained in good working condition.
- Providing adequate personnel facilities, including washing areas and areas to change clothes before and after work.
- All the employees shall be required to undergo a medical check-up before joining the facility.
- First aid facilities required to attend immediately for meeting emergency situations shall be made available at the facility.

Community Health & Safety Management Plan

The Community Health & Safety Management Plan shall be applicable construction as well as operation phase so as to minimize adverse impacts on health and safety of nearby community.

Management Measures

Efforts will be made for best housekeeping practices within the project site, so that no water get accumulated in small depressions or low lying areas or within any empty tanks, containers, tyres or debris , which can become breeding areas for mosquitoes. To minimize odour generation from the facility, maximum efforts will be put in to maintain anerobic conditions in the Compost to facilitate decomposing of biodegradable waste in oxygen rich environment, thereby minimizing chances of production of odorous gases like methane, ammonia and hydrogen sulphide. Regular monitoring of ambient air quality and noise levels will be undertaken in and around the facility.

10.6 Green belt development

In order to arrest air-borne fugitive dust, a 3 – 5 m wide green belt shall be developed and maintained around the plant boundary which will consist of locally available plant species. An area of more than 33% would be earmarked for development of greenbelt/greenery along the boundary, roads, and in open places available inside the facility. The green belt developed would help to capture the fugitive emissions, attenuate the noise generation, odour control and improve the aesthetics. All open spaces, where tree plantation may not be possible, would be covered with shrubs and grass to prevent erosion of topsoil. Apart from a green belt all around the site, a green cover will be developed on the top of capped landfills. The plant species suitable for greenbelt development need to be selected based on the following criteria:

- Fast growing, non-edible perennial plants.
- ability to thrive on low-nutrient soil

- Thick canopy cover;
- Large leaf area index;
- High sink potential;
- Efficient in absorbing pollutants without significantly affecting their growth; and
- Suitable for the local seasons.

Methodology

In order to assure proper greenbelt development, following management plan will be adopted:

- Greenbelt shall be constructed in 5m-6m width in 3 rows around the plant periphery.
- Healthy and established sapling having 1m height will be selected for planting in greenbelt to avoid mortality.
- Pit measurements of 0.6 m x 0.6 m x 0.6 m will be dug up at desired point in triangular pattern at an interval of 2m × 2m and shall be filled with topsoil, Farm Yard Manure (FYM) and vermin-compost.

Post-Plantation Care

- Watering at least once a week during dry spells.
- Organic fertilizer and manure.
- Weeding thrice in the first year and twice a year, during the subsequent two years and soil working
- Plugging and mulching.
- Protection from pests.
- Pruning and thinning

The proposed project area is 2 Ha. and more than 33% of the total project area land is proposed to be developed and maintained as green belt. The green belt will be developed considering the native species and CPCB/SPCB guidelines will be followed.

TABLE 10.6 PROPOSED PLANTATION SPECIES

S.No	Common Name	Botanical Name
1	Chir	*Pinus roxburghii*
2	Himalayan cedar	*Cedrus deodara*
3	Banj oak	*Quercus leucotrichophora*
4	Box berry or Kaphal	*Myrica esculenta*

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CHAPTER-XI SUMMARY & CONCLUSION

CHAPTER – XI

SUMMARY & CONCLUSION

11.1 INTRODUCTION

The Urban development & housing department, government of Sikkim has proposed Solid Waste Treatment Plant due to absence of any proper scientific solid waste treatment facility in entire north Sikkim under Swachhata Action Plan (SAP) of NLCPR Scheme and in order to comply with Solid Waste Management (SWM) Rules, 2016 and its subsequent amendments, project is proposing waste collection system, processing unit and engineered sanitary landfill Facility.

This project is a solid waste Treatment project and proposed for the setting up of processing facilities and sanitary landfill facility. The proposed project is planned in accordance to the Solid Waste Management rules, 2016 and its subsequent amendments which consist of waste collection & transportation system, segregation facility, waste processing unit and a sanitary landfill.

The objective of the project is to design a solid waste treatment system for Mangan town in an environmentally and economically sustainable manner.

The Urban Development & Housing Department proposed to setup a Solid Waste Management System for Mangan at Ringdang, Mangan, Sikkim in an area of 2.0Ha with total processing capacity of 16.0 TPD of municipal solid waste which includes Bio Methanation and sanitary landfill.The objective of the project is to design an solid waste treatment system for Mangan town while redesigning & improving the existing MSW management system in an environmentally and economically sustainable manner.

11.2 IDENTIFICATION OF PROJECT PROPONENT & PROJECT

Identification of project proponent

Applicant	**Authorize signatory**
The Urban Development & Housing Department Sikkim	Secretary Urban Development & Housing Department, Sikkim Address: Paljor Stadium Rd, Arithang, Gangtok, Sikkim 737101

Identification of project-

Management of solid waste is of growing concern to the general public at large, local authorities and business communities in cities and towns across India. The problem is exacerbating in urban areas due to rapid strides in population growth, coupled with an economic boom that encourages the consumption of goods and hence, generation of waste. The Government of India has taken several initiatives to improve the existing SWM practices in the Country.

The proposed project is categorized under Item "7(i) Common Municipal Solid Waste Management Facility (CMSWMF)" in the EIA Notification, dated September 14, 2006 issued by Ministry of Environment Forest & Climate Change (MoEF & CC), New Delhi and needs prior Environmental Clearance. The proposed project falls under Category 'B', and thus, being appraised by the SEIAA at SEIAA, Sikkim.

In this regard, ATMOS Sustainable Solutions Pvt Ltd. a QCI-NABET accredited consultancy organization, has been engaged by UD & HD to carry out an Environmental Impact Assessment (EIA) study and to seek prior environmental clearance as per the process defined in the EIA Notification, dated September 14, 2006 and the amendments thereafter.

TABLE-11.1: SUMMARY OF THE PROJECT

Sr. No.	Particulars	Details
A.	Nature of the Project	Solid Waste Treatment Project for Mangan In Sikkim at Ringdang, Mangan, North Sikkim (Sikkim)
B.	**Size of the Project**	
1.	Area	2.0 ha
	Waste Generation	The per capita garbage generation is taken from the data provided by the Department as 363 gm per person per day after adding for Municipal wastes, road sweepings, institutions etc., the per capita generation is 443 gm (for 2015). This is projected to **482 gm/day for 2021 and 636 g/day for 2041** with 1.40 % annual growth as per data provided.
2.	Expected Waste Quantity	The per capita garbage generation is taken from the data provided by the Department as 363 gm per person per day after adding for Municipal wastes, road sweepings, institutions etc., the per capita generation is 443 gm (for 2015). This is projected to 482 gm/day for 2021 and 636 g/day for 2041 with 1.40 % annual growth as per data provided.
C	**Location Details**	
1.	Village	Ringdang

Sr. No.	Particulars	Details
2.	Tehsil	Mangan
3.	District	North Sikkim
4.	State	Sikkim
5.	Plot/Survey/ Khasra No.	-
6.	Location (Lat-Long)	Latitude- 27°30'43.96"N Longitude- 88°31'49.46"E
D	**Environmental Settings of the Area**	
1.	Ecological Sensitive Areas	khangchendzonga national park is at a distance of 3.45 km in NNW direction from Eco sensitive zone notified in khangchendzonga national park final ESZ notification S.O. 2166(E). —dated 27.08.2014. And as per OM dated 08.08.2019 of MoEF & CC, NBWL Clearance is not applicable.
2.	River / water body	The nearest water body is Teesta River adjacent to the project site in East from Project Site.
3.	Nearest Town / City	Mangan is nearest town densely populated area which is about 1.6 Km from project site. (SE)
4.	Nearest Railway Station	Mangan is nearest town densely populated area which is about 1.6 Km from project site. (SE)
5.	**Nearest Road**	New Jalpaiguri Railway Station (92 km) S
6.	Nearest Airport	NH-310A- 1.0 km (E)
7.	Seismic Zone	Pakyong Airport – 32 Km South East direction (Aerial distance from the proposed site)
E	**Cost Details**	

Sr. No.	Particulars	Details
1.	Estimated Project Cost	INR 15.99 crores
F	**Requirements of the Project**	
1.	Water Requirement	Construction: 4 KLD Operation Phase: 5 KLD **Source:** JMunicipal Corporation
2.	Manpower Requirement	**Construction Phase:** Approx. 40 **workers (skilled & semi-skilled workers),** rest outsourced based on need. **Operation Phase:** The swacchhta team consists of 42 karmacharis, rest outsourced based on need. With 33 permanent, 2 Supervisor, 7 on contractual. Rest Outsourced as per requirement of ULB.

11.3 NEED OF PROJECT

Indiscriminate and open burning of waste results in air pollution. Indiscriminate dumping of waste and leachate from waste dumpsites, and contaminated lands leads to land pollution, surface water contamination and ground water contamination. Also a significant delay between waste generation and final disposal results in odour nuisance, environmental degradation, fly and rodent infestation etc. It is highly necessary to establish a Solid Waste Treatment Plant with provisions such as Composting Plant and Sanitary Landfill.

11.4 LAND DETAILS

The existing land is vacant and will be developed as Municipal Solid Waste Management Facility with the combination of following technologies:

1. Composting facility - Biomethanization
2. Sanitary Landfill

The project will be developed as Solid Waste Treatment Plant for Mangan, North Sikkim District, Sikkim. The proposed land belongs to Urban Development & Housing Department, Sikkim.

11.5 DESCRIPTION OF PROPOSED SITE FACILITY

- **Water Requirement**

Construction Phase- During construction phase water will be requiring about 4 KLD.

Operational Phase- Total water requirement in the project during operational phase will be about 5 KLD which will be sourced from Municipal Corporation.

TABLE - 11.2 WATER REQUIREMENT

Sr. No.	Description	Water Requirement (KLD)	Waste Water Generation (KLD)	Treated Water (KLD)
1.	Domestic Purpose	1.8	1.6	1.4
2.	Vehicle/Tier Washing	0.5	0.3	0.2
3.	Dust Suppression	0.5	-	-
4.	Green Belt Development	2.2	-	-
5.	Process water	1.6	1.5	1.2
Total		6.6 (5KLD +1.6KLD)	3.4	2.8

- Domestic Wastewater will be in STP & reused for greenbelt purpose.
- Leachate will be treated in LTP of 25 KLD capacity and treated water will be reused for greenbelt purpose.
- Treated water from LTP & STP will be used for green belt development, dust suppression & horticulture activities.
- 1.6 KLD of treated water will be recirculated in the process. Hence, the water requirement for the proposed project is 5 KLD.

- **Power requirement**

  D.G set of 250 KVA will be utilized for power during construction phase and in emergency use during power failure.

  During operation phase of proposed facility will be 250 KVA and it will be sourced from Energy and power department, sikkim and for emergency 1 D.G set of 250 KVA will be utilized asbackup.

- **Manpower requirement**

  During construction phase approx. 40 workers (skilled & semi-skilled workers), rest will be outsourced based on need.

  During operation phase the Swachha team will be consists of approx 42 Workers (skilled & semi-skilled workers, contract labour, drivers, sweepers & supporting staff) with 33 permanents, 2 Supervisors, 7 contractual. Rest will be outsourced as per requirement of ULB.

11.6 BASELINE MONITORING STATUS

The generation of primary data as well as collection of secondary data and information from the site and surroundings was carried out during summer season i.e. Dec. 2021 to Feb. 2022. The various environmental components which are thoroughly studied during the study period include:

- ❖ Water Environment (surface and ground water)
- ❖ Air Environment
- ❖ Noise Environment
- ❖ Biological Environment
- ❖ Socio- Economic Environment

11.6.1 WATER ENVIRONMENT-

In order to conduct EIA Studies, baseline data pertaining to water environment of the proposed project was carried out evaluating the basic characteristics, drainage pattern, and hydrology. Water Environment of the area has been studied by locating ground water sources. Three ground water samples were collected during the study period. The quality of ground water was studied by collecting water samples from representative, dug wells, tube wells and surface water by from different water sources. These samples were taken and were analysed for various parameters and compared with standards IS: 10500.

- The pH limit fixed for drinking water samples as per IS 10500-2012 is 6.5 to 8.5 beyond this range the water will affect the mucus membrane and or water supply system. During study period the pH in the ground water samples was varying from 7.36to 7.46. The pH's of all samples were falling within the acceptable limit.
- The acceptable limit for total dissolved solids as per IS 10500:2012 is 500 mg/l, whereas the permissible limit in absence of alternate source is 2000 mg/l, beyond this palatability decreases and may cause gastro intestinal irritation. In water samples collected from the study area, the total dissolved solids in groundwater are varying from 132 to 165 mg/l. The TDS of all samples were falling within the acceptable limit.
- The acceptable limit for chloride is 250 mg/l as per IS 10500:2012 whereas the permissible limit of the same is 1000 mg/l beyond this limit taste, corrosion and palatability are affected. The Chloride levels in the ground water samples collected in the study area were ranging from 24 to 28 mg/l. All samples are falling within acceptable limit.
- The acceptable limit as per IS 10500:2012 for hardness is 200mg/l whereas the permissible limit for the same is 600mg/l beyond this limit encrustation in water supply structure and adverse effects on domestic use will be observed. In the water samples collected from the study area, the hardness is varying from 76 to 94 mg/l.

Surface water:

- Phosphates were found below detectable limit of 0.1 mg/l.
- All the Surface water samples were meeting the Class 'A' norms as per IS: 2296-1992.

11.6.2 AIR ENVIRONMENT

Ambient air quality monitoring was carried out during the study period (Dec 2021 to Feb. 2022) to establish the ambient air quality.

- PM_{10} value recorded during the study period ranges between 38.2 to 83.8 µg/m^3.
- $PM_{2.5}$ value recorded during the study period ranges between 15.5 to 37.3 µg/m^3.
- SO_2 value recorded during the study period ranges between 5.2 to 9.1 µg/m^3
- NO_2 value recorded during the study period ranges between 7.5 to 19.6 µg/m^3
- CO value recorded during the study period ranges between 0.21 to 0.55 mg/m^3

Conclusion

From the baseline monitoring result, it is observed that the monitored parameters (PM_{10}, $PM_{2.5}$, SO_2, NO_2,) are within the permissible limits as per NAAQS, 2009 during the study period.

11.6.3 NOISE ENVIRONMENT

The values of noise observed in some of the rural areas are primarily owing to vehicular traffic and other anthropogenic activities. In rural areas wind blowing and movements of birds would contribute to noise levels especially during the nights. The day equivalents during the study period are range between 49.2 to 60.2 dB (A), whereas the night equivalents were in the range of 35.7 to 53.6 dB (A). From the results it can be seen that the day equivalents and the Night equivalents were within the Ambient Noise standards of residential.

11.6.4 BIOLOGICAL ENVIRONMENT

The biological study of the area has been conducted in order to understand the ecological status of the existing flora and fauna to generate baseline information and evaluate the probable impacts on the biological environment. No Threat & endangered species found in the core & buffer zone.

11.6.5 SOCIO- ECONOMIC ENVIRONMENT

As per Census 2011 the population of Mangan is 4644 assuming a floating population of 2000, the base figure for design is kept as 6644 for Mangan. Similarly, for other areas are under consideration.

11.7 ENVIRONMENT MONITORING PLAN

Construction phase works include site clearance, site formation, building works, infrastructure provision and any other infrastructure activities. The impacts due to construction activities are short term and are limited to the construction phase. The impacts will be mainly on air quality, water

quality, soil quality and socio-economics, necessary control measures will be taken to minimize the impacts.

During the operation phase of the proposed project there would be impacts on the air Environment, water environment, Land environment and socio-economic aspects. The Main sources of air pollution are as follows.

- Area source emissions from landfill operations.
- Point source emissions from DG set.

TABLE 11.3 ENVIRONMENTAL MEASURES DURING OPERATION PHASE

S.No	Potential Impact	Detailed Action to be Followed as per EMP	Parameters for Monitoring	Frequency of Monitoring
1)	Air Emissions	Gas quality from landfill areas	VOC, H2S, Methane & CO2	EC norms given by MoEF&CC and CPCB protocol.
		Stack emissions from DG sets	As per CTE conditions PM, SO2, NOx	
		AAQ within the Project premises.	As per NAAQ Standards	
		All vehicles to be PUC Certificate.	Vehicle logs to be maintained	
		Meteorological data	Wind speed, direction, temp., relative Humidity and rainfall.	
2)	Noise	Noise generated from operations to be monitored	Spot noise level recording	Periodic during operation phase Once in month by third party
3)	Wastewater Discharge (leachate)	Compliance to wastewater discharge standards	pH, TSS, TDS, BOD, COD and Oil & grease (heavy metals, if required)	Daily at regular intervals Once in a month by third party
4)	Solid waste/Hazardous Waste	Check compliance to SWM rules	Quality & quantity monitoring	Periodically / CPCB norms.
5)	Ground Water Quality	Monitoring ground water quality, through piezometers	As per CPCB guidelines	Periodically & as Per CPCB norms.

6)	Flora and Fauna	Vegetation, greenbelt / green cover development	No. of plants, species	Once a year
7)	Soil quality	Checking & Maintenance of good soil quality around	Physico-chemical parameters and Heavy Metals.	Once a year
8)	Health	Employees and migrant labour health check ups	All relevant parameters (BP, HIV, Chest X-ray, Eye vision, etc.) and HIV for workers	Regular check-ups as per Factories act.

11.8 RISK ANALYSIS

The principal objective of the risk assessment study is to identify and quantify the major hazards and the risk associated with various operations of the proposed project, which may lead to emergency consequences (disasters) affecting the public safety and health.

All necessary measures to minimize the risk due to the proposed project will be taken during design stage and also during operation period viz. fire & safety control measures, Emergency preparedness plan, disaster management plan, etc.

11.9 PROJECT BENEFITS

From the proposed project the major benefits, include improving the degraded environment by establishing Solid Waste Treatment plant.

- It will be the showcase for other states for management of solid waste with additional benefit of green and clean environment.
- It minimizes the pollution load on environment from municipal solid waste.
- Compliance with prescribed regulatory norms which in turn avert the risk of closure on account of violation of rules.
- It reduces the number of Municipal Solid Waste dump sites in the area and also eliminates the pollution potential.
- The management of wastes is relatively easier & economically viable at common facility.
- Cost of environmental monitoring is less at common facility.
- Prevention of natural resource contamination thereby improving overall environmental status of the region.

11.10. Environment Management Plan

The Environmental Management Plan (EMP) is required to ensure sustainable development in the area of the proposed project site. Hence, it needs proper **Environmental Management Plan (EMP)** to meet these objectives. The purpose of the Environmental Management Plan is to minimize the potential environmental impacts from the project and to mitigate the adverse impacts. Details of Environment Management Plan are given in **Table 11.4.**

TABLE 11.4 ANTICIPATED IMPACTS DURING DIFFERENT STAGES OF PROJECT

Description of Impact	Magnitude of Impact	Mitigation Measures Proposed	Responsibility Implementation
DESIGN STAGE			
Existence of adjacent to the project site.	Permanent/ low	Layout has been finalized giving maximum clearance to the adjacent development. High compound wall and green belt around the site have been provided to form a physical separation and visual screen to the development.	UD & HD
Ground water contamination	Permanent/ medium	Design of the system finalized to minimize ground water contamination. Two tier leachate collection system (leachate collection at the bottom of the compost pad and catch drain all around the site) Higher capacity for treatment plant to accommodate the shock load.	UD & HD
Existence of surface water source. Water quality may be affected due to storm over run.	Permanent/ low	Design includes diversion of storm water from other areas by providing diversion drains/ channel all along the	UD & HD

		periphery of the site.	
CONSTRUCTION STAGE			
Silt run off from construction operations causing soil erosion and damage to water quality/adjacent land	Temporary / low	Site preparation to minimize clearance to adjoining vegetation and natural resources; Protection of unstable soil surface from high velocity runoff with interception drains and stabilization; Proper siting and protection of construction materials;	Appointed Contractor
Noise, dust or hazardous materials arising from construction activity.	Temporary / low	Plant and equipment employed in the construction will comply with environmental standards. Regular wetting of stock piles of sand, metals; Dust curtain will be provided to the construction site.	Appointed Contractor
Contamination of land and water due improper disposal of waste by workers	Temporary / low	Proper sanitation facilities will be provided to the labour quarters/ settlement.	Appointed Contractor
Contamination due to indiscriminate disposal of spoil/silt	Temporary / low	Proper stock piling of silt/spoil at site; Examine the reuse opportunities for silt/ spoil; Identification of site for disposal of silt/ spoil; proper covering the disposal site on completion of work; Protection against pollution during transportation; and maintenance of the	Appointed Contractor

		transportation vehicles	
O&M STAGE			
Hazards to health and safety of workman	Permanent /low	Develop and implement Occupational Safety Plan for the workforce; provision of appropriate protective gears to the workers at the site; Training to the workers at site regarding the dangers including the potential health effects of waste.	Appointed O&M Contractor
Fugitive Dust, loading & unloading	Temporary/low	Paving of roads inside the site; daily compacting, spreading and covering of incoming waste; select the working face to minimize the truck movement.	Appointed O&M Contractor

TABLE 11.5 ANTICIPATED IMPACTS & MITIGATION MEASURES FOR THE PROPOSED PROJECT

S. No.	Pollution Source	Pollution Emitted	Mitigation Measures
Air pollution Mitigation Measures			
1.	Construction activities	SO_2, NO_X, Particulates, CO, Methane, HC Odour etc.	• Dust suppression by water sprinkling. • Bitumen covered internal roads. • Wheel Washing Bay at the entry point. • Vehicles carrying of construction materials and waste to be covered with tarpaulin / plastic sheet. • Proper ventilation and moisture in the compost plant and Biomethanation area to be maintained and herbal insecticides to be sprayed around odour generation areas at regular intervals. • Secured landfill except the current waste handling area rest to be covered by polyethylene sheets • Green belt would be provided along the internal roads and plant boundary
2.	Vehicular Movement		
3.	Loading and unloading		
4.	DG Set		
5.	Processing of waste		

Water Pollution Mitigation Measures			
6.	Domestic Waste	Suspended Solids, BOD etc.	• Leachate Holding Tank. • Leachate Treatment Plant • LTP for recycling. • Impermeable liner in the landfill pit. •Storm water drainage system for recycling
7.	Leachate from Biomethnation Compost Plant		
8.	Leachate from landfill		
Solid Waste Management			
9.	Construction	Construction materials e.g. coarse aggregate, fines aggregate, bricks, steel etc.	The generated waste from construction will be recycled or used for filing/ leveling of low-lying areas within the site or transported outside to authorized vendor for reuse.
10.	LTP sludge	LTP sludge	Final disposal at Landfill

CHAPTER-XII DISCLOSURE OF CONSULTANT

CHAPTER – XII

DISCLOSURE OF CONSULTANT

ATMOS Sustainable Solutions Pvt Ltd is accredited by QCI/NABET having certification number **NABET/EIA/2023/IA0063 VALID TILL 8/09/2023.**

Declaration by Experts contributing to the EIA/EMP of Solid waste Treatment Plant for Mangna at Ringdang. Mangan, North Sikkim, Sikkim - Sector-37, MoEF&CC-7 (i) Common Municipal Solid Waste Management Facility (CMSWMF), **Category –B.**

I, hereby, certify that I was a part of the EIA team in the following capacity that developed the above EIA.

EIA coordinator

Name: Mr. Mervyn Gilbert

Signature:

Period of involvement: November 2021 till date

Contact information: info@atmosorg.com

Functional area experts:

S. No.	Functional Area	Name of the Expert	Involvement Period and Task
1.	AP	Jitendra Kumar Goel	01.11.2021 - till now Finalization of Air monitoring location, check the air quality data and evaluate the data & identification the Impact.
2.	WP	Sonu Thakur	01.11.2021 - till now Finalization of the Ground and Surface water location and validate the baseline monitoring data and Interpreted the data. Identify the impact and assess mitigation Measures.
3.	SHW	Mervyn Gilbert	01.11.2021 - till now Identify the waste management strategies and for the contribution in EIA report
4.	SE	K.N. Dutta	01.11.2021 - till now Field survey, assessment of different aspect related to socio economic issues due to the development of the project for the contribution in the EIA

5.	EB	Sonu Thakur	01.11.2021 - till now Site, Survey and assessment of impact on biological environment due to the development Of the project.
6.	HG	P. Radha Krishnamoorthy	01.11.2021 - till now Finalization of GW location and identify the impact and mitigate the measure and incorporate in the EIA
7.	GEO	P. Radha Krishnamoorthy	01.11.2021 - till now Geology, Geomorphology survey of the project area and incorporate in the report
8.	LU	P. Radha Krishnamoorthy	01.11.2021 - till now Site Visit, develop land use map of the Buffer and core zone of the project area using GIS which contribute to EIA study
9.	SC	Vivek Kumar Diwedi	01.11.2021 - till now Finalization of soil sample location and validation of the soil baseline data and contribution to the EIA documentation
10	AQ	Arun Kumar	01.11.2021 - till now Developing Micro Meteorological data for modeling & air quality model in prediction of dispersion of pollutant and incorporated in EIA
11	NV	Jitendra Kumar Goel	01.11.2021 - till now Noise monitoring data finalization & identify impact and suggest mitigation of noise pollution
12	RH	Anil L Choumal	01.11.2021 - till now Identify the risk assessment of risk and mitigate the measures and contribute to the Finalization of EIA report.

Declaration by the Head of the accredited consultant organization/ authorized person

I Mervyn Gilbert hereby, confirm that the above mentioned experts prepared the EIA for Mangan. I also confirm that EIA Coordinator (EC) has gone through the report, and the consultant organization shall be fully accountable for any misleading information.

It is certified that no unethical practices, plagiarism involved in carrying out the work and external data / text has not been used without proper acknowledgement while preparing this EIA report.

Signature:

Name: Mr. Mervyn Gilbert

Designation: Managing Director

Name of the EIA consultant organization: ATMOS Sustainable Solutions Pvt Ltd

NABET Certificate No. & Issue Date: NABET/EIA/2023/IA0063 VALID TILL 8/09/2023.

Annexures