EXECUTIVE SUMMARY

The Corporation of the City of Panaji has prepared a detailed project Report (DPR) and allied Engineering Drawings on Solid Waste Management Plan for Panaji City on an integrated approach line with the guidelines of MoEF / CPCB and MSW Rules 2000.

The detailed Project Report covers an introduction to project, background of the planning area, Status of the existing Solid Waste Management System, proposed MSW Management system with cost estimate, equipment’s and their specifications, route plans, design of waste Management facility with cost estimates, conceptual design of sanitary landfill with cost estimates and engineering drawings, operational and Maintenance aspects, Cost of proposed system, Financial frame work including public private participation in establishing the MSW facility.

Panaji City has a population of 59066 souls (census 2001). It is spread in an area of 8.12 sq.kms. The length of the road is 77 kms. There are 68 nos of decentralized composting facilities spread all over the city. Corporation has about 550 nos of Sanitary workers which include 315 nos of safai karmcharis on daily wage basis and a fleet of 38 vehicles of different type / age to carry out MSWM activity. The Panaji city is bin free and the waste from the generators is collected from the source through door-to-door collection system. The waste is segregated at source into wet and dry fractions. About 60% of the residential complexes have been covered under 4 way segregation of dry waste namely Paper, Plastics, Metal/Glass and others. The wet waste is composted in the composting units / stations spread all over the city. The dry waste is transported to the sorting centres for further sorting and recovery of recyclables.

The Corporation of the City of Panaji incurs significant expenditure on MSWM. The capital expenditure on this activity is financed mainly from the grants received from the Government.

An analysis of the data indicates that a total quantity of 72.2 TPD waste is generated in Panaji city out of which 37% (27 TPD) is organic, 17% (22.2 TPD) is non Bio-degradable, 34% (25 TPD) is conception and demolition waste, 11% (8 TPD) is garden waste. The calculations also suggest that per capita waste generation is 0.255 kgs / capita / day. This proposed 100 TPD Municipal Solid Waste (MSW) Project Comprising of MSW Collection, Storage & Transportation System and Integrated MSW processing Facility at baigunium Village of Tiswadi Taluka in North Goa, District, Goa.

The Existing Municipal solid waste is stored in a segregated form at the generator level viz. houses, hotels, restaurants, commercial area. The residential units and all the commercial establishments in the city other than Hotels & Restaurants store their waste in a 2-bin system i.e Biodegradable (wet waste) and Non-biodegradable (dry waste). All the hotels and restaurants are covered under 4 way dry waste segregation. The dry waste is stored in four fractions in LDPE bags. Each fraction is stored in a specific colour LDPE bags specified by the Corporation. 60% of the residential complexes are also covered under 4-way segregation of dry waste. The dry waste from these residential complexes is stored in 240 litre trolley bins provided by Corporation. The four dry waste fractions are paper, plastics, metal / glass and others (multi layered material, foils, thermocole, textile etc). The waste is collected door-to-door in a segregated manner through
CCP Workers. Bio-degradable waste is collected on daily basis. Non-biodegradable waste from residential units and commercial establishments is collected bi-weekly basis. Non Bio-degradable waste from residential complexes covered under 4 way segregation and hotels and restaurants is collected on daily basis. Manual transfer of bio-degradable waste up to the decentralised composting units is done by means of 240 liter bins through CCP workers. Manual transfer of non-biodegradable waste up to the pick-up points is done by means of 240 liter trolley bins through CCP workers. Transfer of waste from 240 liter bins into the hydraulic trucks with side lifting mechanism and rear loading compactors is carried out by the CCP workers. Transportation of bio-degradable waste from Municipal market up to the Bulk composting station located in the market complex is carried out by means of 240 litres trolley bins. Transportation of the non-biodegradable waste collected from pick-up points is done to the sorting centre located at St. Inez, Panaji. At present the non-recyclable waste material is bailed and forwarded to cement companies in Karnataka and the rejects from the sorting centre are transportated and dumped at one of the temporary site located in the city.

1. **The brief about the existing waste management system with respective MSW Rules 2000 is provided as under.**

- Municipal solid waste is stored in a segregated form at the generator level viz. houses, hotels, restaurants, commercial area. The residential units and all the commercial establishments in the city other than Hotels & Restaurants store their waste in a 2-bin system i.e Biodegradable (wet waste) and Non-biodegradable (dry waste). All the hotels and restaurants are covered under 4 way dry waste segregation. The dry waste is stored in four fractions in LDPE bags. Each fraction is stored in a specific colour LDPE bags specified by the Corporation. 60% of the residential complexes are also covered under 4-way segregation of dry waste. The dry waste from these residential complexes is stored in 240 litre trolley bins provided by Corporation. The four dry waste fractions are paper, plastics, metal / glass and others (multi layered material, foils, thermocole, textile etc).
- The waste is collected door-to-door in a segregated manner through CCP Workers.
  - Bio-degradable waste is collected on daily basis.
  - Non-biodegradable waste from residential units and commercial establishments is collected bi-weekly basis.
  - Non Bio-degradable waste from residential complexes covered under 4 way segregation and hotels and restaurants is collected on daily basis.
- Manual transfer of bio-degradable waste up to the decentralised composting units is done by means of 240 liter bins through CCP workers.
- Manual transfer of non-biodegradable waste up to the pick-up points is done by means of 240 liter trolley bins through CCP workers.
- Transfer of waste from 240 liter bins into the hydraulic trucks with side lifting mechanism and rear loading compactors is carried out by the CCP workers.
- Transportation of bio-degradable waste from Municipal market up to the Bulk composting station located in the market complex is carried out by means of 240 litres trolley bins.
- Transportation of the non-biodegradable waste collected from pick-up points is done to the sorting centre located at St. Inez, Panaji.
• At present the non recyclable waste material is bailed and forwarded to cement companies in Karnataka and the rejects from the sorting centre are transported and dumped at one of the temporary site located in the city.

2. **Disadvantages of the Existing System**

• Sanitary workers involved in door-to-door collection, transferring of waste to the pick-up points and in the composting operation have not been provided with appropriate Personal Protective Equipment (PPEs)

• The existing number of composting units are insufficient in numbers to process the biodegradable component of waste generated and collected at present and beyond.

• Finding areas in Panaji city for setting up of new de-centralized compost units is a difficult proposition due to the fact that in Panaji city, land is scarce commodity and not available for setting up the required MSW facilities.

• De-centralized composting units are becoming difficult to manage and monitor considering the total number of units setup in the city.

• Present sorting centre for non-biodegradable waste (dry waste) is not sufficient enough for the quantum of non biodegradable waste received at the centre and not efficient because of being completely manual in operation.

• Crude disposal of Construction & demolition waste is happening without any facility for disposal and resource recovery.

• Most of the vehicles involved in the waste transportation have surpassed their economic life.

• Present workshop located at CCP is lacking in space for parking the vehicles and also in equipments for undertaking major repair works.

• Crude dumping of waste is happening at various locations in the outskirts of the city due to the absence of a centralised Engineered MSW treatment facility.

• Un-scientific management of slaughter house waste with no proper arrangements for its safe disposal.

3. **Proposed system**

**Brief about the proposed system**

• The ISWM system has been proposed for the design year 2040, for a total capacity of 100 TPD. Out of 100 TPD, 19 TPD is dry recyclable waste, 37 TPD of wet biodegradable waste, 33 TPD of construction debris and 11 TPD of tree waste.

• The primary storage of solid waste at the household level in segregated manner to be done in 10 liter (for bio-degradable waste) capacity bins of green colour and 20 liter (for non-biodegradable waste) capacity bin of black colour.

• Primary storage of solid waste in segregated manner at the Hotels, Restaurants etc., to be done in 240 liter bins and colour coded bags.

• Primary Storage of solid waste in segregated manner at the Municipal Market to be done in 240 lites capacity trolley bins.

• Locations for temporary storage of Construction & Demolition (C&D) Waste at Zone level.

• For primary collection of Solid waste from the generators, 240 liter trolley bins have to be provided.

• The Secondary Storage at the public places such as parks, ferry points and tourist places such as beached to be done in 240 liter capacity trolley bins.
In case of the household waste, the transfer of waste from the household to the nearest pick-up point to be done by means of 240 litres capacity trolley bins. Bio-degradable waste and non Bio-degradable waste to be collected on daily basis by separate vehicles and transported to the ISWM facility at Bainguinim.

At the Municipal Market, waste from 240 litre capacity trolley bins will be transferred directly into 8 cum capacity refuse collector.

In case of other generators such as Hotels, restaurants and commercial areas, the Bio-degradable (wet) waste put in green polythene bags and stored in the 240 liter capacity bins to be collected directly by 8 cum capacity refuse collectors and the non Bio-degradable (dry) waste shall be segregated in four fractions and put in different colour coded polythene bags prescribed by CCP.

Cattle lifting machine to be provided for preventing the stray animal menace.

A centralized MSW facility to be provided with the following facilities,

- A material recovery facility (MRF) for sorting and recycling of the dry fraction
- Waste-to-Energy plant based on bio-methantion & composting facility. Electricity generated to be used for in-house plant operation
- Reuse of construction debris for filling of low lying area
- Reuse of mulched tree waste as structure material in the compost plant
- Storage and safe disposal of the E-waste.

The centralized facility shall be using proper treatment equipment and conveyors for handling the waste. The plant to be operated using programmable logic controller and Scada based automation to ensure process efficiency and minimum manual operation.

A tree mulcher with a trailer system to be provided to mulch the tree cutting waste generated in large quantity in the city daily.

Bio-medical Waste to be sent at the Goa Medical college facilities for the final disposal in environmentally sound manner.

### 4. Advantages of the Proposed System

- All the workers involved in collection & transportation of waste as well as those involved in street sweeping to be provided with personal protective equipments.
- Transportation of waste from the pickup points by rear loading compactors would avoid manual handling and spillage of leachate on the roads.
- Direct transfer of waste from mini-tipper to refuse Collector completely avoiding manual contact with waste.
- Refuse collector bins for storage of market waste leading to increased capacity for storage
- Direct transfer of waste from Refuse collector bins in to Refuse Collector completely avoiding manual contact with waste.
- A Centralized Integrated Solid Waste management (ISWM) Facility with provisions for MRF Facility, Biomethantion system along with gas engines, In-Vessel Composting system, Sanitary Landfill, Mobile vehicles, workshop, Facility centre for operators having canteen, shower area and medical room, Administration building, laboratory, Resource centre, Car & Vechile parks, effluent treatment and recyle plant, Container storage yard, road network, peripheral drains, green buffer belt, site & street lighting, ESR, fire water system, borewell, ground water monitoring wells and plant fencing.
• Complete facility to have automatic operation and a PLC/Scada control from a central control station.
• State-of Art, centralized Material recovery facility for recovering recyclables out of the non-biodegradable component of city waste with provisions for screening, manual sorting on a conveyor belt, magnetic separator, bailing, packing and storage facilities.
• Biodegradable fraction shall be extruded, and converted into bio-gas/ electricity using anaerobic bio-methanition technology. The residue shall be composted using completely enclosed rotating in-vessel composting drums followed by storage, screening and bagging operation.
• Engineered Sanitary Landfill facility with provisions for leachate management to scientifically landfill the reject component from the MRF as well as the inert residue from the bio-degradable fraction.
• Electricity generated from the plant to be used to run in-house plant operations and reduce operation cost.
• Sale of various recycled products, compost and RDF to provide a revenue source reducing the plant operating cost and making the operation extremely viable and profitable.
• Local manpower to be trained in operating the facilities to improve skill sets and competence.
• A special Resource centre to exhibit the potential of converting waste into useful products and also conducting regular tours for visitors, students and other academicians involved in sustainable waste management solutions.
  - In the DPR Municipal Solid Waste Management, operation, Primary and Secondary collection and transportation are proposed in accordance with the guidelines issued by CPCB / MoPF, actual site conditions as depicted from the extensive services conducted and in line with MSW Rules 2000.
  - New containers and bins have been proposed for primary collection and secondary storage of waste. Along with the utilization of some of the existing vehicles, modern transport vehicles have been proposed for waste transportation.
  - For the design of sanitary landfill, important issues like waste to be handled, access road, land area, evaluation of geology and hydrology of the site, surface drainage, operational plan, layout of MSw landfill, completed waste fill features, estimation of landfill capacity, embankment, foundation, selection of liner systems, selection leachate control facilities, selection of landfill gas control facilities, aesthetic consideration, post closure care, ground water protection, monitoring facility, determination of equipment requirement, estimated cost of the project design life have been carefully analysed and a rational concept has been developed.
  - Design has also been developed for the processing facility, material recovery facility and other facilities. The cost estimates are prepared an area requirement work out.
1. **COST OF THE PROPOSED SCHEME**

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<th>Sr. No.</th>
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<td>Grand Total with Contingencies.....3+4</td>
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CHAPTER 1.0
PROJECT BACKGROUND
1.0 PROJECT BACKGROUND

1.1 Solid Waste Management (SWM)….a definition

Solid Waste Management (SWM) is an organized process of storage, collection, transportation, processing, treatment and safe disposal of solid refuse residuals in an engineered sanitary landfill. It is an integrated process compromising several collection methods, varied transportation equipment, storage, recovery mechanisms for recyclable material, treatment and reduction of waste volume and quantity by methods such as bio-methantion (waste-to-energy), composting, refuse derived fuel (RDF), waste-to-energy, and disposal in a designated engineered sanitary landfill.

The selection of a suitable SWM process is driven by the source and quality of waste produced. Solid waste is generated from a number of sources which include households (kitchen and yard), commercial areas (shops, hotels and restaurants), industries (raw material and packaging), institutions (schools, hospitals and offices), construction and demolition sites, waste from slaughterhouse, manure, parks (fallen branches, leaves from trees), and streets (sand, silt, clay, concrete, bricks, asphalt, residues from air deposition, and dust).

Waste Disposal is one of the major problems being faced the world over and India is no exception. Management of Solid Waste, though an essential service, is given low priority. This, coupled with lack of financial resources, institutional weakness, improper choice of technology & rapid urbanization, whose ramifications are more pronounced with uncontrolled growth rate of population, has made this service far from satisfactory, thus creating serious environmental and health problems.

1.2 PROBLEMS DUE TO SOLID WASTE

Accumulation of solid waste in open areas is an eyesore, diminishing real estate and property value, a breeding ground for insects, and other vectors (rats and mice, wild and domesticated animals). It also causes odour nuisance, reflects the unorganized nature of the community, and creates a poor environment for growing children.

Improper and unorganised disposal of Municipal Solid Waste (MSW) in open areas and landfills have a negative impact on the living conditions of human beings as well as the overall environment. It results in spread of communicable and non-communicable diseases among human beings and animals, thus affecting the welfare, livelihood, and economic productivity. In addition, it causes contamination of soil, surface water, ground water and generation of toxic and green house gases. However, using adequate information, resources, and efficient management practices, one can turn solid waste into a useful resource.

1.3 CURRENT STATUS OF SWM IN INDIA

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, wastes generation. As per Census 2001, the urban population accounts for 28% of the total population.

<table>
<thead>
<tr>
<th>Average Rate of MSW</th>
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<tbody>
<tr>
<td>MSW generated in small, medium, and large cities in India is about 0.1 kilograms (kg), 0.3-0.4 kg, and 0.5 kg per capita per day, respectively (Central Pollution Control Board [CPCB])</td>
<td></td>
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</tbody>
</table>
The Local Governing Bodies (LGBs) and municipalities are responsible for providing SWM services in the urban areas. In most of the urban areas, insufficient funds, use of obsolete/inefficient technologies, lack of awareness, and improper infrastructure have resulted in a state of poor management of solid waste.

1.4 Initiatives To Improve SWM

In recent years, the Government of India (GoI) has taken several initiatives to improve existing SWM practices in the country. Some of the key initiatives and recommendations are briefly discussed below,

1.4.1 Hon'ble Supreme Court of India Recommendations

In recent years, the current SWM system in India has received considerable attention from the Central & State Governments and local municipalities. The first initiative was taken by the Hon'ble Supreme Court of India in 1998, which resulted in the formation of a committee to study the current status of SWM in Indian cities. This committee identified the deficiencies/gaps in the existing SWM system in the country and prepared the "Interim Report on SWM Practices in Class I Cities" (class I cities are cities with a population ranging between one lakh to ten lakhs). The recommendations of the Committee that pertains to MSW design criteria are provided in Annexure 1.1 of this report.

1.4.2 Municipal Solid Waste Management Rules

As a second initiative, the Ministry of Environment and Forests (MoEF), GoI, published "Municipal Solid Waste (Management and Handling) Rules, 2000" (MSW Rules 2000). These rules were developed in conformance with sections 3, 6 and 25 of the Environment Protection Act, 1986 and aim at standardization and enforcement of SWM practices in the urban sector. These rules dictate that, "Every municipal authority shall, within the territorial area of the municipality, be responsible for the implementation of the provisions of these rules and infrastructure development for collection, storage segregation, transportation, processing and disposal of municipal solid wastes". In addition, "CPCB shall coordinate with State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs) in the matters of MSW disposal and its management and handling". A summary of SWM rules of 2000 document is provided in Annexure 1.2

1.4.3 Jawaharlal Nehru National Urban Renewal Mission (JNNURM)

The Jawaharlal Nehru National Urban Renewal Mission is the third notable initiative undertaken by Government of India. JNNURM provides funding for urban infrastructure development in 63 cities and towns of the country. This mission was initiated in 2005-06 and will continue for seven years. The objectives of this mission are included in Annexure 1.3.

Average Composition of MSW

MSW primarily comprises of 30-35% of organic fraction, 3-6% of recyclables (paper and plastics), 40-45% of inert material, and less than one-percent glass and metal (National Environmental Engineering Research Institute [NEERI])
1.4.4 Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT)

The primary objective of this scheme is to improve the urban infrastructure in towns and cities in a planned manner and to promote public-private partnership (PPP) in infrastructure development. This scheme was introduced in the year 2005-06 and will continue for seven years. This scheme is applicable to all cities/towns as per 2001 census, except the cities/towns covered under the JNNURM. One of the components of this scheme is to renew the old sewerage and solid waste disposal systems in inner (old) town/city areas.

1.4.5 Twelfth Finance Commission (TFC) Recommendations

The Twelfth Finance Commission under Department of Expenditure, Gol, has recommended measures to augment the Consolidated Funds of the States to supplement resources of the Rural Local Bodies (RLBs) (Panchayats) and Urban Local Bodies (ULBs) (Municipalities). These funds are allocated to the RLBs and ULBs, based on the recommendations made by the State Finance Commissions (SFCs). In addition, in accordance with the recommendations made by the TFC, sum of Rs.20,000 crores and Rs.5,000 crores has been allocated for RLBs and ULBs, respectively, for the period 2005-10.

The funds allocated to the RLBs are being utilized for providing water supply and sanitation in rural areas while the funds allocated to the ULBs are being utilized for enhancing the solid waste management services in urban areas under public-private partnership. In addition, municipalities with population of over 100,000 (as per 2001 census) are required to prepare a comprehensive scheme including composting and waste-to-energy systems to be undertaken in the private sector for appropriate allocation of funds. The main recommendations by the TFC are summarized in Annexure 1.4.

1.5 PROJECT BACKGROUND & OBJECTIVES

There is a need to enhance the existing SWM system for Panaji city and thus improve the health and hygiene standards of its residents. The purpose of the Detailed Project Report (DPR) is to identify the existing SWM practices within Panaji, recognize deficiencies gaps in the present system and propose a comprehensive Integrated plan for SWM in Panaji city in compliance with the MSW Rules, 2000.

1.6 SCOPE OF STUDY

The scope of work includes the following:

- Detailed survey of the prevailing conditions
  - Quantification and characterization of the MSW
  - Gap analysis based on the MSW Rules 2000
- Design an MSW management system in accordance with MSW Rules, 2000
  - Collection and Transportation System (CTS)
  - Centralised Waste Treatment facility
  - Integrated Sanitary Landfill Facility (ISLF)
- O&M Plan addressing
  - Stakeholders’ complaints
Detailed Project Report – Volume 1  Solid waste management in Panaji, Goa

- Management of Information Systems (MIS)
- Environment, Health and Safety (EHS)
- Preparation of Bill of Quantities (BOQ)
- Capital and Operation & Maintenance (O&M) cost estimates
- MSW management model including privatization aspects

1.7 Approach and Methodology

This DPR proposes a comprehensive SWM management and implementation plan for Panaji city. In order to address each of the problems associated with the current SWM system in Panaji city, a series of steps were adopted, which are summarized in Figure 1.1.

![Figure 1.1 Approach and Methodology](image)

1.8.1 Problem Identification

Following are the major points considered during the problem identification stage:
- The total area of Panaji city.
- The 12 waste management zones.
- The present waste management system being practiced in Panaji city.
- Existing sanitary worker strength.
- Tools and equipments for collection, storage and transportation.
- Population growth and growth of commercial activities.
- Existing Infrastructure facilities for processing, treatment, and scientific disposal of waste in the city.
- Availability of land for establishing the infrastructure in the city area.
- The awareness level of the people.

### 1.8.2 Primary and secondary data collection

The following preliminary information available with CCP was studied and taken for framing the methodology for primary & secondary data collection.

- CDP
- Organization structure of CCP
- The different waste generators
- The number of residential units and Commercial Establishments.
- Number of persons involved in MSWM.
- Tools, equipments and vehicles available for MSWM.
- Quantity of waste generated based on normative standards.
- Physical and Chemical Composition based on studies conducted by NEERI & CPCB in various Indian cities.

Based on the evaluation of available data the strategy and approach to complete each and every stage of the project was framed.

### 1.8.3 Gap Analysis

Gaps in the existing waste management system were identified with reference to the MSW Rules, data available and existing scenario.

The following are the observation made:
• The awareness level of the people, regarding waste management practiced in the city is not very high.

• Lack of civic sense and bad habits of people in some areas to litter.

• Lack of stringent panel provision.

• Lack of power to levy spot fines.

• Lack of wide publicity through electronic and print media regarding segregation of waste.

• Lack of litter bins in public areas.

• Excessive leave and absenteeism of sanitary workers.

• Lack of awareness among sanitary workers on use of personal protective equipment.

• No uniform benchmark, or yardstick, prescribed for street sweeping.

• Sanitary workers not keen for change in use of some tools that could be advantages.

• The schedule of collection of waste (time & frequency) from commercial establishments (shops) is not synchronized.

• Vehicles are poorly maintained because of inadequate workshop facilities and maintenance procedures as well as skilled personnel.

• The procurement system is slow

• Vehicle movement is not monitored in terms of quantity of waste carried and optimum use of personnel.

• Unplanned routing of vehicles.

• The existing infrastructure for composting not adequate to process the total quantity of organic waste generated. Non availability of land for expansion of existing facilities.

• The composting facilities are spread over the entire city and are not being effectively managed.

• No facility for disposal of construction and demolition waste

• Disposal of street sweeping and garden waste in unscientific manner in the city due to non availability of centralised engineered MSW treatment facility.

• Un-scientific management of meat & fish waste

• No proper system for collection of waste from Banquet halls, eating joints located in different parts of the city.

1.8.4 Evaluation & Proposal, Detailed Engineering, BOQ and Cost estimates of MSW Management plan
Based on the outcomes of the Primary and Secondary data study alternatives were considered and evaluated and a most suitable MSW management model is proposed for implementation.

Further, detailed engineering, cost and estimates for this plan were developed and considered for producing a finance model.
CHAPTER 2.0

Evolution of Solid Waste Management
2.0 EVOLUTION OF SOLID WASTE MANAGEMENT

Solid wastes comprise all the wastes arising from human and animal activities that are normally solid and are discarded as useless or unwanted. It is an all-inclusive, encompassing heterogeneous mass of throwaways from urban community as well as homogeneous accumulation of agricultural, industrial and mineral wastes.

2.1 Solid Waste… a consequence of life

From the days of primitive society, human and animals have used the resources of the earth to support life and to dispose-off wastes. During the early times, the disposal of human and other wastes did not pose a significant problem, for the population was small and amount of land available for the assimilation of wastes was large. Although emphasis is currently being placed on recycling the energy and fertilizer value of solid wastes, indications of recycling may still be seen in the primitive, yet sensible agricultural practices in many of the developing nations where farmer recycle solid wastes for fuel or fertilizer values.

Problems with disposal of wastes can be traced from the times when humans first began to congregate in tribes, villages & communities and accumulation of wastes became a consequence of life. Littering of food and other solid wastes in medieval towns - the practice of throwing wastes on unpaved streets, roads, streets and vacant land, led to breeding of rodents with their attendant fleas. It was not until 19th century that public health control measures became vital and food wastes were collected and disposed off in manner to control rodents and flies, the vectors of disease.

Ecological phenomena such as water and air pollution have also been attributed to improper management of solid wastes. For example, liquid (leachate) from dumps and un-engineered landfills have contaminated ground water. Although nature had the capacity to dilute, disperse, degrade, absorb or otherwise reduce the impact of unwanted residues in the atmosphere, ecological imbalances have occurred where the natural assimilative capacity has been exceeded.

2.2 Waste Generation In The Technological Society

The development of technological society can be traced to the beginnings of the Industrial Revolution (renaissance era), unfortunately, so can a major increase in solid waste disposal problems. Thus, along with the benefits of technology, have also come the problems associated with the disposal of resultant wastes.

2.2.1 Materials Flow and Waste Generation

An indication of how and where the solid wastes are generated in our technological society is shown in simplified materials flow diagram in fig. 2.1. Solid wastes (debris) are generated at the start of the process, beginning with mining of raw materials. It is apparent from figure that one of the best ways to reduce the amount of solid wastes that must be disposed off, is to limit the consumption of raw materials and increase the rate of recovery and reuse of waste materials. Although the concept is simple, effecting the change in a modern technological society has proved extremely difficult. Unlike water borne and air dispersed wastes, solid waste will not go away.
"Where the waste is thrown today, is. where it will be found in future".

2.2.2 The Effects of Technological Advances

Modern technological advances in the production and packaging of goods create a constantly changing set of parameters for designing solid waste facilities. For example, the latest trend of use of frozen food and packaged meals reduce the quantities of food wastes in the homes but increase the quantities at agricultural processing plants. These continuing changes present problems in designing engineering structures for processing solid wastes as they involve large capital expenditures and must be designed to be functional for atleast 25 years.

Therefore, every possible prediction technique must be used in this ever changing technological society so that flexibility and utility can be designed into facilities. In short, a facility should be functional and efficient over its useful life.

2.3 The Development of Solid Waste Management

Solid Waste Management may be defined as discipline associated with the control of generation, storage, collection, transfer & transport, processing and disposal of solid wastes in a manner, that is in accord with the best principles of public health, engineering, conservation, aesthetics and other environmental considerations and also, responsive to public attitudes.
2.3.1 Historical Development

The most commonly recognized methods for the final disposal of solid wastes at the turn of the century were dumping on land, dumping in water, plowing into the soil, feeding to dogs, reduction and incineration. However, not all these methods were applicable to all type of wastes. Plowing into the soil was used for food wastes and street sweepings whereas feeding to dogs and reduction were used specifically for food wastes.

Enlightened solid waste management, with the emphasis on controlled tipping (popularly known as sanitary landfilling), began in the early 1930s in the developed countries and much later in the developing countries. However, absence of efficient and proper methods of disposal resulted in scenic blights, created serious hazards to public health including water and air pollution, increased vectors of disease and adversely affected land values.

2.3.2 Functional Elements of Solid Waste Management System

The activities associated with the management of solid wastes from the point of generation to final disposal are divided into following functional elements:

i. Waste Generation
ii. Waste Handling & Separation at Source
iii. Collection
iv. Separation, Processing & Transformation
v. Transfer & Transport
vi. Disposal

The inter-relationship between these functional elements is identified in fig. 2.2.

![Fig.2.2 Inter-relationship between functional elements in SWMS System](image-url)
i. Waste Generation
Waste generation encompasses activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal. It is important to note that in waste generation, there is an identification step and that this step varies with each individual waste. Waste generation is, at present, an activity that is not very controllable. Source reduction, though not controllable, is now included in system evaluation as a method of limiting the quantity of waste generated.

ii. Waste Handling & Separation at Source
Waste handling and separation involves the activities associated with the management of wastes until they are placed in storage containers for collection. Handling also encompasses a movement of loaded containers to the point of collection. Separation of waste components is an important step in the handling and storage of solid waste at source. From the standpoint of material specifications and revenue from sale of recovered material, the best place to separate the recovered materials for reuse and recycling is the source of generation. On-site storage is of primary importance because of public health concerns and aesthetic considerations. Open ground storage and unsightly makeshift containers, both of which are undesirable, are often seen at many residential and commercial sites.

iii. Collection
The functional element of collection includes not only the gathering of wastes but also the transport of these materials, after collection, to an intermediate location, where the collection vehicle is emptied. This intermediate location can be a materials processing facility (waste storage depot, WSD) or a transfer station. In small cities, where final disposal sites are nearby, the hauling of waste is not a serious problem. But in large cities, where the haul distance to the point of final disposal is often greater, the haul may have significant economic implications. Where long distances are involved, transfer and transport facility is normally used.

iv. Separation, Processing & Transformation
The recovery of separated materials, separation & processing of solid waste components and transformation of solid wastes that occur primarily in locations away from source of waste generation are encompassed by this functional element. Processing often includes separation of bulky items, separation of ferrous metals, manual separation of waste components and volume reduction by compaction.
Transformation processes are used to reduce volume and weight of waste requiring disposal and to recover conversion products. The most commonly used biological transformation process is biomethanation and composting. The selection of given set of processes depends on the waste management objectives to be achieved.

v. Transfer and Transport
This element involves two steps, viz. transfer of waste from smaller collection vehicles to larger transport equipment and second, subsequent transport of wastes to final disposal site.
vi. Disposal
Disposal is the final functional element in the solid waste management system. Today, disposal of waste by landfilling is the ultimate fate of all solid wastes. A modern sanitary landfill is not a dump, rather it is an integrated, engineered facility used for disposing solid waste on land without creating nuisance or hazards to public health and safety.
In most cities, planning for waste disposal involves dealing with municipality, development authority and other agencies. Thus, land-use planning becomes a primary determinant in the site selection, design and operation of processing facilities and landfills. Environment Impact Assessment (EIA) is required for any new landfill site to ensure compliance with public health, aesthetics and future use of land.
CHAPTER 3.0

Brief About the Project Area
3.0 BRIEF ABOUT THE PROJECT AREA

This chapter provides an overview of the location, current extents of Panaji city, existing population and existing physical and social infrastructure. It also details the current financial status of CCP and its administrative setup for MSW management.

The information provided in this chapter is based on the available data with CCP, discussions with the local residents, City Development Plan (CDP) Regional Plan Goa – 2021 (RPG-2021) and other site investigations performed by CCP officials.

While some of this information directly forms the basis of the design for the components of MSW management, the rest gives the feel of the city and its parameters for which the MSW management system is being proposed.

3.1 Location and Extents

Location on the banks of River Mondovi, Panaji city is the one of the smallest cities in terms of area. The geographical co-ordinates are 15.25°N Latitude and 73.50°E Longitude.

Panaji or Ponnji as popularly known means “Land that never gets flooded”. In the heart of city lies church of our Lady of Immaculate Conception, originally built in 1541. Bound by Mondovi river in the north, a hill in the south and crisscross creeks in the east and west, it creates a picturesque setting to the city. The administrative status of Corporation of City of Panaji (CCP) was upgraded from Municipal Council to Corporation in the year 2002. The jurisdiction of Panaji City Corporation was restructured from 22.63 Sq.km to 8.12 Sq.km and the remaining area forming part of the erstwhile Municipal Council have been given planning autonomy. The city of Panaji encompasses an area of 8.12 sq. kms (approx.) (CCP limits) (Source: CCP, Panaji). The corporation area is divided into 30 administrative divisions called ‘wards’. For the purpose of Solid Waste Management, the city of Panaji is divided into 12 zones. This area has been used to design the MSW collection and transportation system (refer drawing no. Tt/3201/Panaji SWM/01)

3.2 Climate

City of Panaji features a tropical monsoon climate and is generally humid due to proximity to the sea. The climate of Panaji is hot in summer and equable in winter. During summers (from March to May) the temperature reaches up to 35°C and in winter (from December to February) it is usually between 30°C and 20°C.

The monsoon period is from June to September with heavy rainfall and gusty winds. The annual rainfall is 3200mm (125.9 inches).

3.3 Population

Panaji the capital of Goa State has a population of 59,066 souls as per 2001 census with growth rate of 3.6% in the decade 1991 – 2001. Panaji is a major tourist destination and gateway to beautiful and famous beaches of North Goa. Table -3.2 shows growth of population in Panaji city from 1960 to 2001.
In addition to huge influx of tourist around the year with Peak arrival between November to December each year, city of Panaji has a floating population from adjoining areas on daily basis.

The Population projections have been made after studying the population growth trend from 1961 onwards and tourist population published by Goa Tourism Department. The Population projection included in the City Development Plan (CDP) have also been study in detail in order to project population upto 2040 A.D.

In order to project population of Panaji city, projection methods as recommended by CPHEEO Manual for Solid Waste Management have been used. Similarly, tourist population figures published by State Tourism Department, Government of Goa. While Projecting the population peak tourist month in Panaji i.e December have been used. The month wise arrival of tourist in Panaji (Tiswadi,Taluka ) in the year 2004 and 2007 (refer table 3.1 & 3.2 ) indicates that November to February is the best period for foreign tourist October to January had been ideal for the domestic tourist. The tourist population has increased from 639177 in the year 2004 to 729572 in 2007.

The study conducted by Tourism Department indicates that average duration of State of domestic tourist in Panaji is 5 days and a foreign tourist is 9 days.

Population projection for Solid Waste Management in Panaji city are summarized in table 3.3. It may noted that the projected population of year 2018 has been used for planning collection and transportation infrastructure while the projected population 2040 is used for designing for sanitary landfill facility. The plan, however, proposes phased land fill.

3.3.1 Population Projections

a) Resident Projection Population for Panaji

The demographic projections are based on assumption made about future fertility, mortality, net migration, Inter-State Mobility, Leaving arrangement tite and labour force participation patterns of the population. After studying the population data of CDP and growth trend, population projection have been made based on the methods laid down in the manual on MSW to work out the population data.

The population of Panaji is spread over an area of 8.12 Sq.km, with a density of 72.12 persons per Hectare (i.e 7212 Persons per Sq.Km). The population has grown from 0.35 lakhs in 1960 to 0.59 lakhs by the year 2001 with growth rate ranging from < 1 % to a maximum of 2.66%. The average annual growth rate is 1.09% and an average decadal growth rate is 10.9%

As the city is more of an administrative capital and a service oriented commercial hub, in the core area there is not much of residential population and accordingly it would mean that there are other areas that are denser thean the average of 7000 per Sq.km.

The households in Panaji city during the census year 1991 were 9097 and during the census year 2001 it was about 13581. The growth percentage observed is 33%. The household size during 1991 was 4.76 and in the year 2001 it was 4.35.

After examining the various population forecast methods and examining the existing scenario of economic development, the forecast based on incremental increase method is perceived to be acceptable.
b) Tourist Population (considering annual arrival of tourist based on 2004 & 2007 data)

Assumptions for forecasting:

The tourist statistics obtained from Tourism Department is considered as the base data for the floating population.

The available data is pertaining to the district and Taluka wise, then to obtain the city floating population; it is considered that 80% of the visitors visiting the North Goa also visits the city.

The base floating population data is :

<table>
<thead>
<tr>
<th>Table 3.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panaji city</td>
</tr>
</tbody>
</table>

Source : CDP

c) Floating Population

Panaji is a major Town and the State capital with all institutional, educational and commercial facility in North Goa. The people staying around Panaji and North Goa mainly come to Panaji for their daily needs. The 2001 census data indicates that outgrowth area of Panaji have a population of 11012 souls, which depends on Panaji for their needs. Therefore it has been considered that 50% of this population comes to Panaji daily for their work, say around 5000 souls.

An average annual growth rate of 2% have been considered for population projection.

<table>
<thead>
<tr>
<th>Table -3.2 : Area and Population Dynamics of City Panaji</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
</tr>
<tr>
<td>1960</td>
</tr>
<tr>
<td>1971</td>
</tr>
<tr>
<td>1981</td>
</tr>
<tr>
<td>1991</td>
</tr>
<tr>
<td>2001</td>
</tr>
</tbody>
</table>
Detailed Project Report – Volume 1    Solid waste management in Panaji, Goa


(Table 3.3)

Month-wise arrival of Tourist in 2004

<table>
<thead>
<tr>
<th>Period</th>
<th>Total Tourists</th>
<th>Domestic Tourists</th>
<th>Foreign Tourists</th>
<th>Total Tourist in Goa State</th>
<th>Percentage Share of Goa</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>48321</td>
<td>7321</td>
<td>40910</td>
<td>174690</td>
<td>27.6</td>
</tr>
<tr>
<td>February</td>
<td>35738</td>
<td>6774</td>
<td>28964</td>
<td>121987</td>
<td>29.3</td>
</tr>
<tr>
<td>March</td>
<td>47203</td>
<td>6261</td>
<td>40942</td>
<td>164693</td>
<td>29.7</td>
</tr>
<tr>
<td>April</td>
<td>46224</td>
<td>3159</td>
<td>43065</td>
<td>166831</td>
<td>27.7</td>
</tr>
<tr>
<td>May</td>
<td>44723</td>
<td>2653</td>
<td>42070</td>
<td>164863</td>
<td>27.1</td>
</tr>
<tr>
<td>June</td>
<td>30174</td>
<td>1236</td>
<td>28938</td>
<td>83714</td>
<td>36</td>
</tr>
<tr>
<td>July</td>
<td>21923</td>
<td>976</td>
<td>20947</td>
<td>72643</td>
<td>30.2</td>
</tr>
<tr>
<td>August</td>
<td>32839</td>
<td>1916</td>
<td>30923</td>
<td>108518</td>
<td>30.3</td>
</tr>
<tr>
<td>September</td>
<td>48495</td>
<td>2793</td>
<td>45702</td>
<td>152361</td>
<td>31.8</td>
</tr>
<tr>
<td>October</td>
<td>45637</td>
<td>4821</td>
<td>40816</td>
<td>156923</td>
<td>29.1</td>
</tr>
<tr>
<td>November</td>
<td>63244</td>
<td>12119</td>
<td>51125</td>
<td>243674</td>
<td>26</td>
</tr>
<tr>
<td>December</td>
<td>174746</td>
<td>25427</td>
<td>149319</td>
<td>474832</td>
<td>36.8</td>
</tr>
<tr>
<td>Total</td>
<td>75456</td>
<td>563721</td>
<td>2085729</td>
<td></td>
<td>30.6</td>
</tr>
</tbody>
</table>

Source:- CDP

(Table 3.4)

Month-wise Arrival of Tourist in Panaji (Tiswadi taluka) in 2007

<table>
<thead>
<tr>
<th>Month</th>
<th>Foreign</th>
<th>Domestic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>15523</td>
<td>53948</td>
<td>69471</td>
</tr>
<tr>
<td>February</td>
<td>12948</td>
<td>36187</td>
<td>49135</td>
</tr>
<tr>
<td>March</td>
<td>10310</td>
<td>41591</td>
<td>51901</td>
</tr>
<tr>
<td>April</td>
<td>3825</td>
<td>44304</td>
<td>48129</td>
</tr>
<tr>
<td>May</td>
<td>2248</td>
<td>46472</td>
<td>48720</td>
</tr>
<tr>
<td>June</td>
<td>826</td>
<td>24874</td>
<td>25700</td>
</tr>
<tr>
<td>July</td>
<td>813</td>
<td>18641</td>
<td>19454</td>
</tr>
<tr>
<td>August</td>
<td>1256</td>
<td>26920</td>
<td>28176</td>
</tr>
<tr>
<td>September</td>
<td>1376</td>
<td>36678</td>
<td>38054</td>
</tr>
<tr>
<td>October</td>
<td>4172</td>
<td>75358</td>
<td>79530</td>
</tr>
<tr>
<td>November</td>
<td>12754</td>
<td>98392</td>
<td>111146</td>
</tr>
<tr>
<td>December</td>
<td>16533</td>
<td>143623</td>
<td>160156</td>
</tr>
</tbody>
</table>

(Table 3.5)

Population Projection carried out for Project Design

<table>
<thead>
<tr>
<th>YEAR</th>
<th>RESIDENTS</th>
<th>TOURIST POPULATION / DAY</th>
<th>FLOATING POPULATION / DAY</th>
<th>DESIGN POPULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>DOMESTIC</td>
<td>FOREIGN</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>59066</td>
<td></td>
<td></td>
<td>5000</td>
</tr>
<tr>
<td>2002</td>
<td>59953</td>
<td></td>
<td></td>
<td>5100</td>
</tr>
<tr>
<td>2003</td>
<td>60895</td>
<td></td>
<td></td>
<td>5202</td>
</tr>
<tr>
<td>2004</td>
<td>61891</td>
<td></td>
<td></td>
<td>5306</td>
</tr>
<tr>
<td>2005</td>
<td>62941</td>
<td></td>
<td></td>
<td>5412</td>
</tr>
<tr>
<td>2006</td>
<td>64045</td>
<td>5050</td>
<td>836</td>
<td>5520</td>
</tr>
<tr>
<td>2007</td>
<td>65203</td>
<td>5213</td>
<td>857</td>
<td>5631</td>
</tr>
<tr>
<td>2008</td>
<td>66415</td>
<td>5381</td>
<td>878</td>
<td>5743</td>
</tr>
<tr>
<td>2009</td>
<td>67681</td>
<td>5555</td>
<td>900</td>
<td>5858</td>
</tr>
<tr>
<td>2010</td>
<td>69002</td>
<td>5734</td>
<td>923</td>
<td>5975</td>
</tr>
<tr>
<td>2011</td>
<td>70376</td>
<td>5920</td>
<td>946</td>
<td>6095</td>
</tr>
<tr>
<td>2012</td>
<td>71805</td>
<td>6111</td>
<td>970</td>
<td>6217</td>
</tr>
<tr>
<td>2013</td>
<td>73287</td>
<td>6308</td>
<td>995</td>
<td>6341</td>
</tr>
<tr>
<td>2014</td>
<td>74824</td>
<td>6512</td>
<td>1020</td>
<td>6468</td>
</tr>
<tr>
<td>2015</td>
<td>76415</td>
<td>6722</td>
<td>1045</td>
<td>6597</td>
</tr>
<tr>
<td>2016</td>
<td>78060</td>
<td>6939</td>
<td>1072</td>
<td>6729</td>
</tr>
<tr>
<td>2017</td>
<td>79759</td>
<td>7163</td>
<td>1098</td>
<td>6864</td>
</tr>
<tr>
<td>2018</td>
<td>81513</td>
<td>7395</td>
<td>1126</td>
<td>7001</td>
</tr>
<tr>
<td>2019</td>
<td>83320</td>
<td>7634</td>
<td>1154</td>
<td>7141</td>
</tr>
<tr>
<td>2020</td>
<td>85181</td>
<td>7880</td>
<td>1183</td>
<td>7284</td>
</tr>
<tr>
<td>2021</td>
<td>87097</td>
<td>8135</td>
<td>1213</td>
<td>7430</td>
</tr>
<tr>
<td>2022</td>
<td>89067</td>
<td>8398</td>
<td>1244</td>
<td>7578</td>
</tr>
</tbody>
</table>
Summary of population projection:

1. Resident population for design year 2040: 133778 souls
2. Tourist population & floating population for design year 2040: 27659 souls

Solid waste generation and plant treatment capacity for design year shall be worked out based on above figures.
3.4 Existing Infrastructure

3.4.1 Physical Infrastructure

Panaji has witnessed rapid increase in population with annual growth rate of around 3.6% in addition to increase in tourist population. However, Panaji city's civic infrastructure could not keep pace with the requirement of infrastructure with increasing resident and tourist population leading to tremendous pressure on existing infrastructure. An in-depth study of various infrastructure facilities within the city such as roads, storm water drains, sewage, water supply, electricity and social infrastructure was carried out.

3.4.1.1 Roads

Corporation of the City of Panaji has approximately 77 kms of road network. Most of the roads in inner areas are narrow, giving the city a congested appearance. Almost all the roads are bitumen (black top) type with carriageway ranging from 3 to 20m.

3.4.1.2 Water Supply System

There is no exclusive water supply scheme for Panaji city alone but the said city has been covered under 'Regional Water Supply Project namely OPA Water Supply Scheme'. The OPA scheme has been originally conceived in Portuguese Regime with River Khanderpah as a source in the year 1957 with a designed capacity of 8 MLD. Further, the said scheme has been envisaged covering cities such as Panaji, Vosco, Marmagao, Ponda, Margo, etc. Subsequently, the OPA water supply scheme has been limited to only two Talukas namely Tiswadi and Ponda. Hence, the water supply for Panaji has been covered under Tiswadi Talukas.

The Original 8 MLD capacity scheme has been augmented with capacities of 12 MLD in the year 1967 and subsequently, 54 MLD in 1972 with allocation of 35 MLD water for Ponda Taluka and 40 MLD of water for Tiswadi taluka. The said waterworks were about 37 kms from the Panaji city and the transmission is through pumping up to Curti and thereby gravity from Curti to Altino. The ultimate distribution from Altino to Panaji area was through gravity.

3.4.1.3 Storm Water Drains

Many Areas of Panaji City are reclaimed low lying areas prone to flood water from three sides i.e. Zuari river on the South, Mandovi river on the North and Arabian Sea in the West. General slope of the city is east to west. The Panaji peninsula receives an average rainfall of about 3200 mm per annum.

As the general level of the city is lower than the high tide level, when the level of Mandovi river rises, reverse flow takes place which was absorbed by the creeks/ nallahs/ marshy land/ ponds, etc.

Over the years, surface drains were constructed along most of the roads & streets which flows in to the storm water gutters which were laid during Portuguese period. The drainage system can be divided into the following zones:
i. Run-off from the Altino Hill flows in to the Mala & Fontainhas area of the city and reaches the Mala lake and from the lake, water flows in to Ourem Creek and then to the Mandovi river.

ii. Run off from the Core city area (northern part) flows in to Mandavi river through surface drains and gutters.

iii. Run off from St. Inez areas flow in to the St. Inez Nallah and then the Mandavi river.

iv. Run off from the Southern parts of the city flows in to the Sea.

3.4.1.4 Sewerage System

The existing underground sewerage scheme covers only the main Panaji city core area and does not cater to the urban fringe areas like Ribander, Dona Paula, etc. The entire sewage area is divided into 12 drainage blocks serviced by 8 pumping stations with 3 outfall sewers carrying the sewage to treatment plant located at Tonca area.

3.4.1.5 Solid Waste Management

Corporation of City of Panaji is managing the collection, transportation, treatment and disposal of Municipal Solid Waste generated in Panaji city. Biodegradable waste is collected on daily basis and converted into compost in various decentralized composting stations spread over Panaji city. Non-biodegradable waste is collected twice a week and sent to sorting center located in St. Inez.

3.4.1.6 Industries

There are no major industrial establishments within Panaji city. However, there are few small scale workshops especially of printing press, two and four wheeler services stations in the city. Household and cottage industries generally function within the residential and commercial areas, which are catering about 1.61% of the total worker population. Ship building activity is slowly gaining prominence with a number of private players mushrooming in the outskirts of the city.

3.4.2 Social Infrastructure

3.4.2.1 Fire Fighting Services

Panaji city has one Fire Station (Head Quarters) and training academy located in St. Inez.

3.4.2.2 Communication Services

Panaji city has an extensive communication/telecommunication network, involving both private and public sector as key service providers. Communication facilities are readily available in the private and public sector in Panaji city. In the private sector along with courier services, there are Sub Post Offices. Besides the Telecommunication Department, the private sector is involved in providing telecommunication services connecting Panaji city with surrounding areas and far off rural areas through STD, ISO and mobile networks. Young people and entrepreneurs are enthusiastic users of internet as for many it is an important link to rest of the world.
3.5 **Financial Status of Corporation Of City Of Panaji (CCP)**

The cash flow statement for the 2 year period ended March. 31, 2012 for CCP has been summarized in Table 3.6:

<table>
<thead>
<tr>
<th>Major Head of Income</th>
<th>Amount (INR)</th>
<th>Major Head of Expenditure</th>
<th>Amount (INR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receipt from Octroi</td>
<td>31500000.00</td>
<td>Paidfor</td>
<td>137578436.00</td>
</tr>
<tr>
<td>Taxes on Houses</td>
<td>80159894.00</td>
<td>Pension, Gratuities &amp; P.F</td>
<td>9811809.00</td>
</tr>
<tr>
<td>Advertisement &amp; Signboards</td>
<td>4828041.00</td>
<td>Benefits to employees</td>
<td>1575425.00</td>
</tr>
<tr>
<td>Exhibitions and Fairs</td>
<td>3174365.00</td>
<td>Office Administration</td>
<td>6133478.00</td>
</tr>
<tr>
<td>Parking fees</td>
<td>997747.00</td>
<td>Honorarium to Mayor and Corporators</td>
<td>2804304.00</td>
</tr>
<tr>
<td>Trade &amp; Occupation fees</td>
<td>5981196.00</td>
<td>Publications</td>
<td>383090.00</td>
</tr>
<tr>
<td>Rent of plots &amp; Buildings</td>
<td>6693989.00</td>
<td>Maintenance of Buildings &amp; toilets</td>
<td>280532.00</td>
</tr>
<tr>
<td>Income from Market</td>
<td>1723500.00</td>
<td>Repairs / Developments work</td>
<td>4313986.00</td>
</tr>
<tr>
<td>Construction licences</td>
<td>24218814.00</td>
<td>Electricity &amp; Water charges</td>
<td>1887201.00</td>
</tr>
<tr>
<td>Cemeteries &amp; crematorium fees</td>
<td>301035.00</td>
<td>Maintenance of vehicles</td>
<td>8125076.00</td>
</tr>
<tr>
<td>Salary grants from Govt.</td>
<td>12156000.00</td>
<td>Support to Solid Waste Management Scheme</td>
<td>2223713.00</td>
</tr>
<tr>
<td>Interest on Investment</td>
<td>16134790.00</td>
<td>Legal fees / consultancy charges</td>
<td>1261228.00</td>
</tr>
<tr>
<td>Income from Waste Management</td>
<td>11866727.00</td>
<td>Development of open spaces</td>
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</tr>
<tr>
<td>Process fees / NOC charges</td>
<td>4257559.00</td>
<td>Other expenditure</td>
<td>440403.00</td>
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<td>Other income</td>
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<td>Purchase of vehicle</td>
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<tr>
<td></td>
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<td>Acquisition of machinery</td>
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<td><strong>Total</strong></td>
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</tr>
</tbody>
</table>

Source: CCP, Panaji
3.6 Administrative Setup For Msw Management In Panaji

The main organization which is responsible for urban governance and civic management is the Corporation of the City of Panaji (CCP).

The Commissioner is the highest administrative officer of CCP. SWM department is responsible for management of solid waste in the town. The administrative structure of CCP is shown in Figure 3.1 below:

Figure 3.1 Administrative Setup of CCP
CHAPTER 4.0

Existing SWM SYSTEM IN PANAJI
4.0 EXISTING SWM SYSTEM IN PANAJI

This section discusses the existing SWM practices prevalent in Panaji city. The various sources of waste generation, current primary & secondary waste collection practices, waste transportation & disposal mechanisms and gaps in the existing SWM system are identified in this section.

Further, the solid waste generated from various zones is quantified and characterised in terms of the constituents of solid waste.

4.1 Waste Generation and its Management

This section describes the various sources of waste generation, existing waste handling & management methods prevalent in Panaji city. The primary source of waste generation in Panaji city are the local households, markets and commercial establishments such as hotels, restaurants, shops etc. Construction activity is also significant.

Estimation of quantity of waste generated in each waste management zone is done for seven consecutive days. The 240 litre trolley bin used for storage of waste collected is weighed at the collection points in the zones and the total quantity of waste generated is calculated.

Table: 4.1 Dry waste generation in the zones

<table>
<thead>
<tr>
<th>ZONE</th>
<th>Weight in kg DAY 1</th>
<th>Weight in kg DAY 2</th>
<th>Weight in kg DAY 3</th>
<th>Weight in kg DAY 4</th>
<th>Weight in kg DAY 5</th>
<th>Weight in kg DAY 6</th>
<th>Weight in kg DAY 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>720</td>
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<td>11</td>
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Source : Field Survey
Table: 4.2 Wet waste generation in the zones

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<thead>
<tr>
<th>ZONE</th>
<th>Weight in kg DAY 1</th>
<th>Weight in kg DAY 2</th>
<th>Weight in kg DAY 3</th>
<th>Weight in kg DAY 4</th>
<th>Weight in kg DAY 5</th>
<th>Weight in kg DAY 6</th>
<th>Weight in kg DAY 7</th>
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Source: Field survey
Table: 4.3 Street Sweeping waste generated in zones

<table>
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<th>Weight in kg DAY 1</th>
<th>Weight in kg DAY 2</th>
<th>Weight in kg DAY 3</th>
<th>Weight in kg DAY 4</th>
<th>Weight in kg DAY 5</th>
<th>Weight in kg DAY 6</th>
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Source: Field survey
Table 4.4 Wet waste generated in zones by Hotels & Restaurants

<table>
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<th>Weight in kg DAY 1</th>
<th>Weight in kg DAY 2</th>
<th>Weight in kg DAY 3</th>
<th>Weight in kg DAY 4</th>
<th>Weight in kg DAY 5</th>
<th>Weight in kg DAY 6</th>
<th>Weight in kg DAY 7</th>
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<td>637</td>
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<tr>
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<td>890</td>
<td>860</td>
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</tr>
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<td>12104</td>
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<td>11989</td>
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</table>

Source: Field survey
Table 4.5 Wet waste generated in Market

<table>
<thead>
<tr>
<th>Weight in kg DAY 1</th>
<th>Weight in kg DAY 2</th>
<th>Weight in kg DAY 3</th>
<th>Weight in kg DAY 4</th>
<th>Weight in kg DAY 5</th>
<th>Weight in kg DAY 6</th>
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</tr>
</thead>
<tbody>
<tr>
<td>4900</td>
<td>4800</td>
<td>5100</td>
<td>5125</td>
<td>5175</td>
<td>4875</td>
<td>5075</td>
</tr>
</tbody>
</table>

Source: Field survey

### 4.1.1 Street Sweeping

Street sweeping is done in morning. All the main streets are swept on daily basis. Street sweeping waste consists mainly dry leaves/ horticulture waste & littered waste. Lifting of street sweeping waste is done on daily basis.

### 4.1.2 Drain Silt

Most of the drains are covered with perforated slabs. Drain silt is removed once in a week or as and when the drain gets choked and before on set of monsoons. The silt so removed is disposed off in the temporary land in the city.

### 4.1.3 Construction & Demolition Waste

The percentage of construction and demolition waste is quite significant. However, its generation depends upon construction & demolition (C&D) activities in the city. At present at the new development sites the C & D waste generated is disposed by the developer. Now only in the case of repair undertaken for existing structures teh C & D waste generated is collected by CCP on a fee based on a volume. The waste so collected is disposed at one of the temporary site identify in the city.

### 4.1.4 Municipal Market

Municipal market houses all types of shops selling garments, gifts, hardware, mobiles, etc. In addition, it also has separate sections for fruits, vegetables, fish and meat.

A separate trip is made; daily for collection of dry waste and the same is transported to the sorting centre at St. Inez.
4.1.5 Meat / Chicken & Fish waste from the Market

There are stalls selling meat, chicken and fish in the market complex. In addition there are several small units/ meat shops spread over the city. Approximately 1 metric tons per day of waste is collected from such units.

4.1.6 Garden waste (Horticulture waste)

This waste is collected from all the zones on daily basis. It is estimated that 8.0 MT/day is generated.

4.1.7 Waste from Hospitals, Nursing homes & clinics

MSW and Bio-Medical waste is stored separately at each Medical Establishment. Separate collection service is provided to medical establishment for collection of Bio-Medical waste generated. The waste collected is sent to Goa Medical College facilities for disposal.

4.2 MSW COLLECTION SYSTEM IN PANAJI

4.2.1 Primary Waste Collection System

- The waste is stored at the source of generation in segregated manner into Bio-degradable waste (WET) & Non-Biodegradable waste (dry).
• Segregated waste is collected through door-to-door collection by CCP workers by visiting individual units in the area allotted to each sanitary worker. The biodegradable component is transferred manually to the nearest composting station for processing by using 240 liter capacity trolleybins or to the nearest collection point to transport the waste to the bulk composting facility. At present there are 68 decentralized composting station.

Picture – 2: Waste Collection by CCP Sanitary Workers

Picture – 3: Decentralized Composting Station

• The dry waste is collected and transported from the 240 Litre bins collection points in each zone by means of trucks available with CCP. The waste is taken to the sorting centre. The waste collection from the houses starts at 2.00 P.M and continue still 6.00 P.M.

• The wet (biodegradable) waste is collected on daily basis and the dry (non-biodegradable) waste is collected twice a week from house hold units (Mondays & Thursdays). The wet waste from hotels and restaurants is collected twice in a day. The dry waste from the hotels and
restaurants is collected once in a day. The dry waste segregated in 4 different fraction from the colonies covered under 4 way segregation is also collected on daily basis.

Picture – 4: 4-Way Segregation Bins at Residential Colonies & Hotels / Restaurants

- CCP levies Re.1/day per household & Rs.100/- to Rs.7500/- per month to commercial establishment for collection of MSW from their premises.

- Non-biodegradable waste from residential establishments and commercial areas is sent to St. Inez for sorting and is ultimately sold to scrap dealers (kabadjwallahs). Non recyclable waste material is bailed and sent to cement companies in Karnataka as per the MOU by the cement companies with the State Government.

Picture – 5: Sanitary Workers at CCP Sorting Centre
Picture – 6: Sanitary Workers baling Non-recyclable Materials to be sent to Cement Factories

Picture – 7: Baled Materials of Size 1’ x 1’ x 1’ stored for Transportation at CCP Sorting Centre
Picture – 7: Baled Recyclable Fractions at CCP Sorting Centre

Picture – 8: Manual Sorting of different Dry Fractions at CCP Sorting Centre
Waste collection from hotels, restaurants and guest houses is done twice a day. The wet waste is collected on daily basis twice in a day in the morning and evening.

Primarily organic waste generated from municipal market of which 50% is sent for composting at market premises itself. The remaining 50% is taken to the bulk composting facility at Patto, Panaji.

All the main roads are swept on daily basis. The sweepers use wheeled trolleys to collect and deposit the swept waste.
Figure 4.1 summarizes existing waste management system in Panaji city.

Source of waste generation

- Segregation waste at source of generation
  - Households
  - Commercial Hotels /Markets

Bio-degradable waste collected in 240 litre wheeled and taken to Composting station

Note: Bulk Composting stations also cater to those residential areas having no Composting stations, Bio waste gets transferred from here by means of hydraulic Trucks /compactors.

Non-bio-degradable Carried in 240 liter Wheeled bin to Collected Points Manually

Collection Point

St. Inez sorting centre

- Recyclable sorted out at centre
  - Recyclable sorted at centre

- Non Recyclable bailed and forwarded to cement factory in Karnataka
- Inert carried to dump site for final disposal

Final Disposal on the outskirts of the city
4.2.2 Secondary Waste Storage System

The Panaji city was made bin-free in 2003 A.D. and the requirement of the bins/secondary storage was gradually nullified through systematic implementation of segregation of waste at source (SAS) initiative. As such, there are no secondary storage points in Panaji city.

CCP has also placed street corner litter bins of 15liter capacity at various locations around Panaji city. 240litre bins are used for transportation of waste from households to composting stations or from establishment to collection points as the case may be.

4.3 MSW Transportation System

This section describes the current MSW transportation practices followed in Panaji city.

4.3.1 Workshop

CCP has a workshop located behind its administrative block. At present, only minor repairs/washing/welding are done at the workshop. All major repairs are outsourced locally.

4.3.2 Transportation Machinery & Equipment

There are 38 vehicles used for Municipal Solid Waste Management.

<p>| Table 4.6 Waste Transportation Infrastructure with CCP |
|---------------------------------|---------------------------------|---------------------------------|</p>
<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Vehicle Number</th>
<th>Vehicle Type Make</th>
<th>Year of Purchase</th>
</tr>
</thead>
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<td>TATA PICKUP VAN TATA 709E</td>
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<td>33</td>
<td>GA 07 F 3169</td>
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<td>2012</td>
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</table>
4.3.3. Routing of vehicles

There are specific routes which need to be followed by drivers. The waste is collected from specific collection points along the route.

Allocation of fuel depends upon the requirement. This again is verified by workshop in-Charge. The drivers are required to make entries in log book when they return from work regarding the amount of fuel used, no. of locations visited, time etc.

Each vehicle makes three trips per day to collect & transport MSW for disposing off at the facilities in the city. It takes about an hour or two to make one trip depending on the distance to be covered, traffic conditions prevailing at that time, and location of site where the waste is to be unloaded.

4.3.4 Transfer Station

At present there is no transfer station in Panaji city.

4.3.5 Manpower Engaged in MSW Management System.

For the purpose of waste management, CCP has divided Panaji city into 12 zones. There are 4 Sr. Supervisors, 27 Supervisors. At present, 550 personnel are engaged in MWS activity in Panaji city including drivers, helpers and sanitary workers.

4.4 Waste processing & Disposal mechanisms

This section deals with the existing processing and disposal mechanisms w.r.t. municipal solid waste prevalent in Panaji city.
4.4.1 Bio- Degradable Waste

Bio-degradable waste is processed through aerobic composting methods at the de-centralized composting stations spread over various areas of the Panaji city. At present, there are 68 composting stations spread over 12 zones in Panaji city.

The process of composting followed by CCP involves inspection of organic waste, and removal of any material that is a contaminant / non-biodegradable. Layering of the waste into the cell, spreading the waste evenly, applying of odour control cultures such as effective microbe solution, Bokashi or Cow Manure over this waste and finally covering the waste layer with an equal amount of leaf litter. A few days later, aeration is done by means of poking air holes through this waste, turning the waste in layers. After 20-25 days of this operation, the waste has reduced its volume, and turned into pre-compost with little or no odour. This is then transported to the bulk composting facility at Patto, where compost is allowed to mature, dry before sieving the compost for sale. At the bulk composting facilities Organic waste convertor machines (OWC-500) machines with curing systems are installed at market and at patto sites. The capacity of each machine is 3MT/day. A total of 6 nos. of OWC-500 machines have been installed in Panaji city.

Compost is sold by CCP at Rs. 10/- per kg. On bulk purchases of 100 kgs. & above, CCP sells it at Rs. 3/- per kg.

Location of composting stations in various zones of Panaji city is given in table 4.10 below:

Table 4.7 Zone-wise location of various composting stations in Panaji city

<table>
<thead>
<tr>
<th>Zone No.</th>
<th>No. of Composting Stations</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>2</td>
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<td>11</td>
<td>9</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>68</strong></td>
</tr>
</tbody>
</table>

Source: Field Survey
4.4.2 Non-biodegradable Waste

The non-biodegradable waste generated from various parts of the city is first sorted for recyclables at St. Inez which are sold to scrap dealers. The non recyclable waste is bailed and sent to cement companies. And the residual waste is dumped in the temporary site located in the city.

4.4.3 Existing Method of Final Disposal of Non-Biodegradables and Inerts

At present there is no designated dumping site and sanitary land filling area for the Corporation of the City of Panaji. Inert/residual waste is dumped at one temporary site located in Panaji.

4.5 Status of proposed Municipal Solid Waste Management site

The proposed site for integrated Solid Waste Management Facility is located at Baiguinim village at a distance of about 8 kms. from the city. The total area of the site is around 17 hectares. The land has been acquired by CCP.

4.6 Quantification and Characterization of Waste

The data from the different waste management zones estimate that the non biodegradable waste generated is 7.2 MT/day, biodegradable waste generated is 27 MT/day, street sweeping is 5 MT/day and Horticulture waste is 8 MT/day. The future waste projection upto 2040 is calculated for designing the MSW facility. The projections are obtained on the basis of projected population and 1% per capita increase per year as per NEERI report.

Physical and Chemical Characteristics of MSW is based on NEERI and CPCB reports for indian Cities. Considering waste segregation at source and 4-way segregation of dry waste the recyclable constituents is increased.

The values of the recyclable constituents as measured at source and as measured at disposal site as per the report by CBCB is show in the table below

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Source (% by weight)</th>
<th>Disposal Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>6.61</td>
<td>3.98</td>
</tr>
<tr>
<td>Plastics</td>
<td>5.47</td>
<td>3.85</td>
</tr>
<tr>
<td>Glass</td>
<td>3.48</td>
<td>2.8</td>
</tr>
</tbody>
</table>

4.7 Gaps in existing MSW Management W.R. T. MSW Rules, 2000

The MSW Rules, 2000 has laid out very detailed and specific criteria for management of solid waste. It has also laid down the guidelines, guidance notes and specific work standards to be adopted by municipal personnel or personnel involved with solid waste management (directly or indirectly) for organized SWM practices (starting from waste collection, segregation, transportation, to environmentally safe waste disposal practices).

The SWM system in Panaji city requires significant improvements to meet the performance standards as laid down in MSW Rules 2000

Some of the significant gaps are as under:

4.7.1 Handling of waste:
Personal protective equipment are not being used by sanitary workers.

4.7.2 Secondary storage of Solid Waste is unorganized
It is observed that no secondary storage infrastructure is available for secondary storage of MSW in public areas such which is Gardens & Parks, Markets, Tourist Centres etc. CCP has placed 15 liter capacity litter bins at strategic locations around the city. In the absence of proper secondary storage facility for MSW of adequate capacity, littering of waste is common sight.

4.7.3 Collection and disposal of construction & demolition waste is not appropriate
The construction/demolition waste generated by developers is transported in open vehicles and disposed off in open areas.

4.7.4 Processing of Municipal Solid Waste
The existing number of decentralized facilities are no enough to handle the amount of waste received.

Unscientific management of slaughter house waste. There is no treatment facility or engineered sanitary landfill site for safe disposal of residual solid waste.

Lack of awareness among city residents.

Lack of awareness about the Municipal solid waste management practice followed and ignorant about the Rules by the public.
CHAPTER 5.0

Proposed MSW Management System
5.0 PROPOSED MSW MANAGEMENT SYSTEM

The integrated SWM plan for primary & secondary waste collection and transportation system for Panaji city has been included in this chapter. The proposed plan also includes the infrastructure requirements, quantities and corresponding cost estimates for the collection and transportation systems. The proposed SWM system is broadly based on the 4REnvironmental Protection Rules (Reduce, Recycle, Reuse, and Recover) and is in accordance with the MSW Rules, 2000. The primary aspects of the proposed plan include the following:

- Compliance with Municipal Solid Waste Management & Handling Rules of 2000.
- Encourage 4-way segregation at the source for all households as well as commercial establishments.
- Provision of segregated infrastructure at all stages of collection and transportation.
- Waste to be covered at all stages of handling.
- 100% collection and transportation of the generated waste.
- Elimination of manual handling of waste as far as possible, and provision of proper PPEs and elevated sorting line, to the workers.
- Maximum recovery of resources by segregating recyclables and biodegradable. Advocate 4R's i.e. reduce, recycle, reuse, and recover materials in MSW management. Adopt proven and proper waste treatment technologies, which can convert bio-degradable waste into energy (electricity) and compost. Electricity thus generated can be used for running the equipments in the plant and reduce operating cost.
- To create a modern fully automatic centralized MSW treatment facility, which is a profit centre rather than a cost centre. Revenue generation from the plant to ensure a major portion of the operating costs are met.
- Promote Information, Education and Communication (IEC) across the stakeholders to ensure system efficiency and sustainability.
- Ensure economic sustainability of the proposed system by introducing public private partnership (PPP) in MSW management.
- Adequate health and safety provisions for workers at all stages of waste handling. Regular environmental monitoring at waste processing and disposal facilities. Have robust complaint-handling system in place.
- Conduct regular internal and external independent audits on the efficiency of entire SWM system.
5.1 Basis of Design of Proposed Swm Plan

The proposed waste management plan and infrastructure/equipment for primary & secondary waste collection and transportation system for Panaji city have been framed based on the following:

- Past population estimates based on Census surveys.
- Projected populations for the design period
- Spread of Panaji city
- Current MSW quantities as per survey data
- Projected MSW quantities are based on the present waste generation data
- Projected Characterization of waste based on current characterization
- Existing waste collection location have been considered for primary & secondary collection of waste

The field survey shows that the total waste which is collected can be classified into 4 main heads,

1. Non-biodegradable or dry waste including dry waste collected from households, street sweeping, commercial complexes like hotels, restaurants, offices.
2. Biodegradable or wet waste collected from household, commercial establishments, market area, slaughter house.
3. Construction debris and silt
4. Tree cutting waste from the streets of Panji City

The Non-Biodegradable waste mainly is approximately 17% of the total waste, while bio-degradable component is approximately 37% of the total waste. Construction debris is around 34% and Tree cutting waste is approximately 11% of the total waste. While the segregation of waste is carried out efficiently, about 7-8% of the waste is received in mixed form also.

The current and projected populations, waste quantities, and per-capita waste for Panaji city, used for proposed SWM plan and infrastructure design are summarized in table 5.1.

**Table 5.1.**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>RESIDENT POPULATION</th>
<th>DOMESTIC TOURIST</th>
<th>FOREIGN TOURIST</th>
<th>FLOATING POPULATION</th>
<th>TOURIST &amp; FLOATING POPULATION PER DAY</th>
<th>Per capita per day generation with 1% increase per capita per year as per NEERI report in kg per day</th>
<th>Total Quantum of waste in kgs/day</th>
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<td>6308</td>
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<td>Projected Design Tourist &amp; floating Population</td>
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<td>27658 souls</td>
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<td>Present quantum of waste generated</td>
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<td>Total waste generation based on Population Projection (2040)</td>
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<td><strong>TOTAL DESIGN WASTE QUANTITY</strong></td>
<td></td>
<td>100 TPD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 1(d)+2(a)+3(a) )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5.2 (B) Waste Characterization for future design year 2040

<table>
<thead>
<tr>
<th>Sn o.</th>
<th>Parameter</th>
<th>Present (2013) TPD</th>
<th>% of total waste</th>
<th>Design year (2040) TPD</th>
<th>% of total waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Non-biodegradable or Dry waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A Non- Biodegradable waste collected in mixed manner from</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i Street sweeping</td>
<td>5.0</td>
<td></td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii Households</td>
<td>5.0</td>
<td></td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>10.0 TPD</td>
<td></td>
<td>11.2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>B Non- Biodegradable waste collected in segregated manner from house holds and commercial establishments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i Metal and Glass in black bags</td>
<td>0.2</td>
<td></td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii Paper in pink bags</td>
<td>0.5</td>
<td></td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii Plastics in orange bags</td>
<td>0.5</td>
<td></td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv Packaged plastic, foils, etc in white bags</td>
<td>1.0</td>
<td></td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2.2 TPD</td>
<td></td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Biodegradable waste collected from</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i Households</td>
<td>2 TPD</td>
<td></td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii Hotels/ restuarants/ guest houses</td>
<td>12 TPD</td>
<td></td>
<td>19.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii Market place</td>
<td>5 TPD</td>
<td></td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv Slaughter house</td>
<td>1 TPD</td>
<td></td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>v Green cuts from market place</td>
<td>5 TPD</td>
<td></td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>vi Compost from house holds</td>
<td>2 TPD</td>
<td></td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Total Bio-degradable waste</td>
<td>27.0 TPD</td>
<td></td>
<td>39.0 TPD</td>
<td>39%</td>
</tr>
<tr>
<td>5</td>
<td>Total waste generated due to population</td>
<td>39.2 TPD</td>
<td></td>
<td>54 TPD</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Construction debris + Silt</td>
<td>25.0 TPD</td>
<td>34%</td>
<td>35 TPD</td>
<td>35%</td>
</tr>
<tr>
<td>7</td>
<td>Mulched Tree waste</td>
<td>8.0 TPD</td>
<td>11%</td>
<td>11 TPD</td>
<td>11%</td>
</tr>
<tr>
<td>8</td>
<td>TOTAL WASTE (2+4+8+9)</td>
<td>72.2 TPD</td>
<td></td>
<td>100 TPD</td>
<td></td>
</tr>
</tbody>
</table>
5.2 Proposed MSW Management Plan

The Panaji city is one of the few cities in the country where Municipal Solid Waste (MSW) is collected, stored and transported in segregated manner. The household's and commercial establishments store the waste in a segregated manner into Bio-degradable & Non-Biodegradable fractions. In 60% of the housing societies, and all the Hotels and Restaurants a 4 way dry waste segregation system is also followed. The collection & transportation of the aforesaid components of waste is done in segregated manner and in separate vehicles at present.
Bio-medical waste shall be collected separately and sent to Goa Medical Collage facilities for disposal.

While planning the proposed management system, the collection, storage & transportation of waste has been planned in segregated manner, segregated waste would be collected on daily basis. While the wastes will be largely stored and collected in a segregated manner, while designing the Integrated MSW facility provision has also been made to accept mixed waste coming into the facility, by providing an extrusion based technology which segregates the waste into biodegradable and non biodegradable fraction at the plant. The proposed facility has been designed keeping in view that 70 to 80% of the total waste shall be collected in a segregated manner and about 20-30% of the non-segregated mixed waste can also be segregated and treated at the plant, by using organic extrusion technology.

Please refer the detailed process flow diagram drawing no. 100 TPD MSW / Panaji / A2/PFD-02 attached as Annexure III.

The integrated facility has the following sections as part of the overall design concept,

Section – 1: Material Recovery Center for Non-biodegradable or Dry Recyclables Waste

(Here the non-biodegradable fraction shall be sorted, baled, recycled)

Section – 2: Separation and Treatment of Wet / Bio-degradable / Organic Waste comprising Organic extrusion based segregation, Bio-methanation, composting technology

(Here the biodegradable fraction shall be segregated, pulped, taken to a biomethanion reactor, compost facility)

Section – 3: Landfill of inert residue generated in the Processing Plants.

(Here the residues and inerts as generated in the processing shall be land filled)

Section – 4: Container storage yard for storage of recycled material

(Here the baled recyclables shall be stored prior to sale to the recycling vendor)

Section – 5: E-waste storage shed

(Here the e-waste shall be stored prior to sorting and sale to the recycling vendor)

Section – 6: Other miscellaneous common facilities comprising security cabin, Weighbridges, Weighbridge Control Station, Administration Building, Facility Center, Resource Center, Drivers’ Restroom, HT Substation Building, MCC and Control room, Biogas Genset Building, Vehicle Washing Facility, Effluent Treatment Plant, Roads, Pathways, Storm Water Drains, Plant drains, Fencing around existing Quarries, Bore
Well, Elevated Service Reservoir (ESR), Landscaping, Fire Fighting System, Conveyors, Piping, flushing water network, Valves, electrical work, plant lighting, mobile equipment etc.

*(These are all auxiliary units which shall help in the proper functioning of the plant)*

All waste fractions and streams shall be transported to proposed Integrated MSW facility at Bainguinim village for processing. The construction & debris waste shall be used for filling the quarry pits in the site, or for filling low lying areas in and around the city.

This section describes a step by step approach for safe & efficient collection, storage and transportation of MSW for Panaji city. They include primary waste collection, secondary waste collection & storage and waste transportation for subsequent processing and disposal. For estimation of collection, and transportation infrastructure, year 2018 is taken as the design year and appropriate infrastructure is provided to ensure that infrastructure is sufficient to handle waste for the next five years.

The management plan has been designed to comply with MSW Rules 2000.

### 5.2.1 Storage of Waste at Source (Primary Storage)

The efficiency of the proposed waste management plan is driven by the segregation of waste in to Biodegradable and Non-Biodegradable at primary level.

The waste will be stored by the households and other generators in two separate bins, one for biodegradable and one for non-biodegradable. Use of green plastic or metal containers with lid is advised for the storage of bio-degradable waste and a similar size bin of black colour may be used for storage of non-biodegradable waste. One container of 10 litre capacity for wet waste and one container of 20 litre capacity for dry waste a family of 5-6 members would ordinarily be adequate.

**Table 5.3: Infrastructure required at the source of waste generation**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
<th>Nos. of units</th>
<th>Existing No. of units having bins</th>
<th>Required Bins (No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covered bins for storage of bio-degradable waste at household level</td>
<td>10 liter capacity of bin (Green)</td>
<td>23342</td>
<td>13342</td>
<td>10,000</td>
</tr>
<tr>
<td>Covered bins for storage of non-biodegradable waste at household level</td>
<td>20 liter capacity of bin (Black)</td>
<td>23342</td>
<td>13342</td>
<td>10,000</td>
</tr>
</tbody>
</table>

Note:
Storage of Bio-degradable waste in Green colour bin
Storage of Non-Biodegradable waste in Black colour bin
5.2.2 Primary Waste Collection System

- Door to Door collection of Bio-degradable waste would be done by waste collector in 240 liter capacity LLDPE/HDPE bin on daily basis.

- The Present system of door-to-door collection is functioning properly therefore will remain the same.

- Street sweeping will be done on daily basis. The street sweeping waste will be collected in trolley bins by municipal staff and stationed at pre-determined locations and transferred to the ISWM facility at Baiguinim village.

- The existing infrastructure for primary collection of waste will be upgraded to comply with MSW Rules 2000.

- Construction and demolition waste will be collected separately, zone-wise, for transportation to Integrated Solid Waste Management (ISWM) Facility for processing and landfilling.

- The sanitary workers employed by CCP shall be well equipped with Personal Protective Equipments (PPEs) to avoid direct contact with waste.

5.2.3 Collection of Waste from Generators

The door-to-door collection of waste shall be done on a day-to-day basis in single shifts. The CCP shall ensure that infrastructure is made available for undertaking this activity in compliance with the MSW Rules 2000.

The proposed infrastructure for primary waste collection is given below. The waste collection infrastructure for construction and demolition shall be provided by the CCP on need basis.

5.2.4 Required Infrastructure for Door to Door Collection from Households

The infrastructure is calculated at zone level. Based on field survey, it is proposed to use 240 litre bins (two wheel type) for door-to-door collection of waste.

It is proposed to collect biodegradable waste and non-biodegradable waste on daily basis. The number of bins required has been estimated based on quantity of waste generated.

The quantity of waste generation from each zone is estimated based on its population and per capita waste generation in Panaji.
Sample Calculation for infrastructure requirement for primary collection.

**a) Biodegradable Waste**

Quantity of waste generated = 27 TPD

Number of HDPE/LLDPE bins (green) of 240 litre capacity required for collection of biodegradable waste. Average quantity of waste in kgs per 240 litre bins is considered as 50 kg. the total quantity of bins required will be 540 nos

**b) Non-Biodegradable Waste**

It is proposed that non-biodegradable waste will be collected daily in black LLDPE/HDPE bin of 240 liter capacity.

**Calculation for infrastructure**

Quantity of Non-Biodegradable waste generated = 12.2 TPD. Average quantity of waste in kgs per 240 litre bins is considered as 30 kg. The total quantity of bins required will be 406 nos, SAY 400 NOS

**Total Number of Bins required for Door to door Collection of Bio-degradable & non-Biodegradable waste for all zones**

Total no. of Green HOPE bins required with 5% back-up = 540x1.05 = 567 Bins

Total no. of Black HOPE bin required with 5% back-up = 400x1.05 = 420 Bins

Number of workers employed for MSW management is 500 nos (existing strength)

**Required Tools and Equipments**

The workers involved in SWM also need to be equipped with adequate personal protective equipments (PPEs). Each worker engaged in door-to-door collection of MSW shall be provided with gloves, boots and uniform.

Therefore,

Required number of pair of gloves = 500
Required number of pair of boots = 500
Required set of uniform = 500
A uniform for a worker will include two sets of uniform/protective wear and two aprons. Storage Area for Day to Day keeping Tools & Equipments

It is proposed to provide one storage area in each zone of 6 m x 5 m x 3 m at the composting unit/location where the required area would be available. Sanitary workers can keep the personal protective equipments, tools and bins in this store.

5.2.5 Storage & Collection of Waste from Municipal Market

Based on waste generation at municipal market, it is proposed to place 240 litre trolley bins (green). The shopkeepers themselves shall dispose off their waste into these bins in segregated manner. The waste would be collected in segregated manner by refuse Collectors for direct transportation to processing facility.

5.2.6 Storage & Collection of Waste from Beaches/Ferry Points

It is proposed to have 4 way bin of 240 litre capacity with two wheels at every 200 metre distance from each other for collection of non-biodegradable waste and one bin of 240 litre capacity with two wheels for collection of biodegradable waste. These bins would be emptied by manned collection unit. It is proposed that workers shall transport the waste in a separate collection vehicle provided for beach cleaning.

It is also proposed to setup 4 way bin station at the ferry points for non biodegradable waste collection and one bin of 240 litre for biodegradable waste. Total of 10nos of 4 way bin stations have been proposed. Both the Bio-degradable as well as the Non-Biodegradable waste shall be transported to proposed ISWM facility plant at Bainguinim village for processing.

Therefore Number of 240 litre capacity bins required is 50 nos.

5.2.7 Collection of Bulky Items

The bulky items organic or inorganic in nature would be collected on demand from the residents using tippers available with CCP and transported to ISWM facility for processing and disposal. The organic bulky items like banana trunks and trunks of other type of plants would be send to pre-processing area of the compost plant for composting after shredding for which shredder has been provided in pre-processing area of the MRF. The bulky inorganic waste would be taken to MRF facility for processing and disposal.

5.2.8 Collection of Dairy Waste

All dairy waste shall be sent to the MSW facility. Existing trucks with CCP can be used for this purpose.

5.2.9 Street Sweeping
The street sweeping shall be done on a day-to-day basis. It is desirable to split the 8 hours of duty of sweepers into two shifts, 4 hrs in the morning and 4 hrs in the afternoon. The street sweeping is to be done by CCP sanitary workers as per the proposed plan.

The total length of roads in Panaji = 77 kms (almost all are bituminous roads)

**Required Infrastructure for Street Sweeping**

**Manual Street Sweeping**

It is assumed that 20% of these roads have divider. Hence, the total length to be cleaned = 77*1.2 = 92.4 km say 92 km

In 92 kms, approximately 60% of the roads will be cleaned daily and remaining 40% of the roads will be cleaned on alternate days.

As per the work norms, on an average every street sweeper can clean 500m length of road in a day, therefore total number of workers required per day = \( \frac{(92 \times 0.6) + (92 \times 0.4)}{2} / 0.50 = 147 \) nos

To ensure that street sweeping is done properly and there is accountability at individual level, it is proposed that teams of two sweepers each shall be made responsible for a stretch of road. As mentioned above, it is assumed that each sweeper will clean approximately 500m of road stretch, therefore two sweepers between themselves are responsible for cleaning 1 km of road. One wheelbarrow (with brakes) shall be shared by a team of two sweepers. The sanitary supervisors will have the complete road map with area-wise responsibility distribution marked on it. The sanitary supervisor will be responsible for making surprise checks and identifying if any team is not working properly. This activity will be undertaken by existing CCP workers.

MSW services will be provided 365 days a year. Assuming that one government worker will work on 80% days a year, total workforce required to run operations 365 days = 147x1.2 = 176

CCP sanitary worker shall do street sweeping daily. The infrastructure required for street sweeping is also estimated based on length of roads in Panaji and sanitary workers required for street sweeping.

The total requirement of infrastructure for primary collection has been tabulated along with estimated cost as per table 5.6

**Table 5.4 Infrastructure Required & Cost Estimates for Primary Waste Collection and secondary storage**

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Equipment</th>
<th>Description</th>
<th>No.</th>
<th>Unit Rate INR</th>
<th>Total Cost INR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Covered Bins for Households (Green)</td>
<td>10 Liter Capacity Plastic Bins</td>
<td>10,000</td>
<td>98.7</td>
<td>9,87,000</td>
</tr>
</tbody>
</table>
5.2.3 Waste Transportation System

The MSW transportation system for Panaji city is proposed in conjunction with the waste collection system described in the preceding section. The requirement of transportation vehicles has been estimated based on the following plan:

- High deck load body vehicles for collection segregated non-biodegradable waste 4nos.
- Dome shape truck for horticulture waste 3 nos.
- Refuse collectors 3 nos for collection of biodegradable waste.
- Cattle lifting van 1no.
- Utility van

Table 5.5: Quantity and Cost Estimates for Transportation Infrastructure

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Equipment</th>
<th>Description</th>
<th>No.</th>
<th>Rate INR</th>
<th>Total Cost INR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High deck load body vehicles</td>
<td>15m3 capacity</td>
<td>4 nos</td>
<td>719011.00</td>
<td>2876044.00</td>
</tr>
<tr>
<td>2</td>
<td>Dome shape truck</td>
<td>7.8m3 capacity</td>
<td>3 nos</td>
<td>1105740.00</td>
<td>3317220.00</td>
</tr>
<tr>
<td>3</td>
<td>Refuse collectors</td>
<td>7 m3 capacity</td>
<td>3 nos</td>
<td>2439536.00</td>
<td>7318608.00</td>
</tr>
<tr>
<td>4</td>
<td>Cattle Lifting Vehicle (with Chasis)</td>
<td></td>
<td>1no</td>
<td>1542000.00</td>
<td>1542000.00</td>
</tr>
<tr>
<td>5</td>
<td>Utility van</td>
<td></td>
<td>2 nos</td>
<td>526588.00</td>
<td>1053176.00</td>
</tr>
<tr>
<td>6</td>
<td>GPS / GPRS based Vehicle Tracking System</td>
<td>GPS Server Installation, Software Application and Proprietary Maps etc.</td>
<td>Ls</td>
<td></td>
<td>2000000.00</td>
</tr>
<tr>
<td></td>
<td>GPS Instruments including Installation Charges in Vehicles</td>
<td>30nos</td>
<td>15000.00</td>
<td>450000.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total Cost</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
i. Workshop

The auto workshop shall be fully equipped to undertake maintenance of transportation vehicles and shall have all infrastructure including waste water treatment plant, etc. as per the statutory requirements. The auto workshop will be located within the Integrated Solid Waste Management Facility.

5.3 Summary of Collection and Transportation Infrastructure

Total Outlay for collection and transportation is given below.

Table 5.6: Summary of Cost Estimate for Collection and Transportation infrastructure

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Amount (Rs) lakhs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection</td>
<td>57,91,350</td>
</tr>
<tr>
<td>Transportation</td>
<td>1,85,57,048</td>
</tr>
<tr>
<td>Total cost</td>
<td>2,43,48,398</td>
</tr>
</tbody>
</table>

5.4 OPERATION & MAINTENANCE (O&M) COSTS FOR COLLECTION & TRANSPORTATION SYSTEM

Table 5.7: O&M Cost for Waste Transportation Infrastructure and Personnel

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>Annual Cost (INR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Salary to Sanitary workers</td>
<td>7,00,00,000.00</td>
</tr>
<tr>
<td>2</td>
<td>Salary to temporary sanitary workers</td>
<td>2,45,00,000.00</td>
</tr>
<tr>
<td>3</td>
<td>Upkeep of vehicles</td>
<td>17,88,000.00</td>
</tr>
<tr>
<td>4</td>
<td>Petrol &amp; Lubricants</td>
<td>62,00,000.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>10,24,88,000.00</td>
</tr>
</tbody>
</table>

Source: CCP Budget 2013-14

The detailed operation and maintenance plan for MSW collection and transportation system will be developed at the Project Management & Construction Stage. At this stage, operation and maintenance cost is estimated for MSW transportation system proposed in table 5.7. These costs include salaries for the O&M personnel and O&M costs for waste transportation infrastructure.
CHAPTER 6.0
Resource Recovery
6.0 RESOURCE RECOVERY

6.1 Introduction
The Integrated Solid waste management facility has been designed to treat all fractions of municipal solid waste as generated in the city of Panaji.

The main resources as generated are as followed,

A. Non biodegradable or Dry fractions

1. Recyclables collected from households, commercial establishments
   a. Paper – Cardboard, newspaper, office paper, Tetra packs
   b. Plastic – Recyclable thick micron, Non-recyclable thin micron, Coated foils, HDPE, PET
   c. Metal – ferrous and non Ferrous
   d. Glass – White, Green and Brown colored
   e. Cloth & textile
   f. Styrofoam and Thermocoal
   g. Refuse derived Fuel (RDF)

2. Construction debris
   a. Filling material, earth, bricks, cement concrete
   b. Stone
   c. Steel bars, metal frames, GI pipes
   d. Wooden panels
   e. Glazed tiles, glass panes

B. Bio-degradable Fractions
   a. Electricity generated from bio-methanation of organic fraction
   b. Compost

6.2 Calculation for Resource Recovery from Dry Waste

1. Non-biodegradable or Dry waste
   The recyclable component of the non-biodegradable dry waste is collected in 2 forms, mixed as well as segregated.

   a. Segregated fraction
   The total quantum of the segregated non-biodegradable fraction is 2.2 TPD. Refer Table 5.2 B. This fraction is stored and collected from house holds and commercial establishments. The various fractions present in the waste are as per below table 6.1
Table 6.1: Composition of Segregated non-biodegradable fraction

<table>
<thead>
<tr>
<th>Segregated Non-biodegradable waste (Present)</th>
<th>Quantity (TPD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractions</td>
<td>2.2</td>
</tr>
<tr>
<td>1 Paper</td>
<td>30.0% 0.66</td>
</tr>
<tr>
<td>2 Recyclable plastic</td>
<td>32.0% 0.70</td>
</tr>
<tr>
<td>3 Glass (mixed color, brown, green, white)*</td>
<td>5.00% 0.11</td>
</tr>
<tr>
<td>4 Metal (Fe/Non Fe)*</td>
<td>5.00% 0.11</td>
</tr>
<tr>
<td>5 Styrofoam/ thermocol</td>
<td>3.00% 0.06</td>
</tr>
<tr>
<td>6 RDF (Mixed with light plastic &amp; non recyclable thick plastic)</td>
<td>25.0% 0.55</td>
</tr>
<tr>
<td>7 Total</td>
<td>100% 2.2</td>
</tr>
</tbody>
</table>

b. Non- Segregated fraction
The total quantum of mixed waste is 10 TPD, out of which 5 TPD is the street sweeping fraction. The Non segregated fraction would contain dirt, earth, soil, sand, plastic bottles, paper wrapping, tetra packs, packaged chips wrappers, snacks coated foil wrappings thermocol, glass, metal etc. It is assumed that out of the total 10 TPD of mixed waste 70% will be recyclables and 30% will be non-recyclable residue matter.

Recyclable = 70% of 10 TPD = 7.00 TPD
Non- Recyclables = 30% of 10 TPD = 3.00 TPD

The various fractions present in the waste are as per below Table 6.2

Table 6.2: Composition of Mixed non-biodegradable fraction (Present)

<table>
<thead>
<tr>
<th>Mixed Non-biodegradable waste</th>
<th>Quantity (TPD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractions</td>
<td>7.00</td>
</tr>
<tr>
<td>1 Paper</td>
<td>30.0% 2.1</td>
</tr>
<tr>
<td>2 Recyclable plastic</td>
<td>32.0% 2.24</td>
</tr>
<tr>
<td>3 Glass (mixed color, brown, green, white)*</td>
<td>5.00% 0.35</td>
</tr>
<tr>
<td>4 Metal (Fe/Non Fe)*</td>
<td>5.00% 0.35</td>
</tr>
<tr>
<td>5 Styrofoam/ thermocol</td>
<td>3.00% 0.21</td>
</tr>
<tr>
<td>RDF (Mixed with light plastic &amp; non recyclable thick plastic)</td>
<td>25.0% 1.75</td>
</tr>
<tr>
<td>7 Total</td>
<td>100% 7.00</td>
</tr>
</tbody>
</table>
Summary of recyclables from non-biodegradable fraction

Both the above fractions shall be sorted and recycled in the Material sorting and recovery section of the ISWM facility. The total quantity recovered from the facility is calculated based on suitable recycling rates as shown in Table 6.3

Table 6.3 Total quantity of recyclable material recovered from the MRF

<table>
<thead>
<tr>
<th>Waste fraction</th>
<th>Segregated Non-biodegradable waste</th>
<th>Mixed Non-biodegradable waste</th>
<th>Total</th>
<th>Recycling rate</th>
<th>Quantum of waste recovered</th>
<th>Rate at which material can be sold at the ISWM site</th>
<th>Resource recovery from Non-biodegradable fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Items</td>
<td>TPD</td>
<td>TPD</td>
<td>TPD</td>
<td>%</td>
<td>TPD</td>
<td>Rs/kg</td>
<td>Rs/day</td>
</tr>
<tr>
<td>1 Paper</td>
<td>0.66</td>
<td>2.1</td>
<td>2.76</td>
<td>60</td>
<td>1.65</td>
<td>1.5</td>
<td>2475</td>
</tr>
<tr>
<td>2 Recyclable plastic</td>
<td>0.70</td>
<td>2.24</td>
<td>2.94</td>
<td>60</td>
<td>1.76</td>
<td>1.5</td>
<td>2640</td>
</tr>
<tr>
<td>3 Glass (mixed color, brown, green, white)</td>
<td>0.11</td>
<td>0.35</td>
<td>0.46</td>
<td>70</td>
<td>0.32</td>
<td>0.4</td>
<td>128</td>
</tr>
<tr>
<td>4 Metal (Fe/Non Fe)</td>
<td>0.11</td>
<td>0.35</td>
<td>0.46</td>
<td>70</td>
<td>0.32</td>
<td>2.00</td>
<td>640</td>
</tr>
<tr>
<td>5 Styrofoam/ thermocol</td>
<td>0.06</td>
<td>0.21</td>
<td>0.27</td>
<td>60</td>
<td>0.16</td>
<td>0.3</td>
<td>48</td>
</tr>
<tr>
<td>6 RDF (Mixed with non recyclable plastic)</td>
<td>0.55</td>
<td>1.75</td>
<td>2.3</td>
<td>30</td>
<td>0.69</td>
<td>0.50</td>
<td>345</td>
</tr>
<tr>
<td>7 Total</td>
<td>2.2</td>
<td>7.00</td>
<td>9.2</td>
<td>4.9</td>
<td></td>
<td></td>
<td>6276</td>
</tr>
</tbody>
</table>

1. Expected Resource recovery from the Recyclable material is = Rs 6276 /day

2. Biodegradable or wet waste

The Biodegradable waste is collected in 3 forms,

a. In unstabilized form, from households, hotels & restuarants, slaughter house, market place
b. As pre-stabilized compost from households and composting centres
c. As large green cuts from vegetable market
Composition of these 3 forms as collected from different areas is given in the table 6.6 below,

Table 6.4 Composition of bio-degradable waste as collected from different areas

<table>
<thead>
<tr>
<th>Sno.</th>
<th>Source of waste</th>
<th>Type of waste</th>
<th>Unstabalized</th>
<th>Pre-compost</th>
<th>Large green cuts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Households</td>
<td></td>
<td>3</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Hotels &amp; Restaurants</td>
<td></td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Market place</td>
<td></td>
<td>6.5</td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Slaughter house</td>
<td></td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Mulched tree waste</td>
<td></td>
<td></td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total (TPD)</td>
<td></td>
<td>30</td>
<td>2.5</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>Grand total (TPD)</td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
</tbody>
</table>

Out of the above 3 fractions, the unstabalized fraction shall be taken to a biomethanation system, wherein the waste shall be anaerobically digested to generate biogas. The large green cuts shall be shredded using a shredder and mixed with the pre-compost stream, along with the digestate fraction from the bio-methanation process to make compost. Mulched tree waste shall be used as a structure material as required.

**Calculation of resource recovery from bio-degradable fraction**

Resource is recovered as Electricity and Compost.

**a. Calculation for Electricity generation**

Table No 6.5: Electricity generation via biomethanation

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description</th>
<th>=</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Biogas Generation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wet Fraction</td>
<td>=</td>
<td>22.50</td>
<td>TPD</td>
</tr>
<tr>
<td>a</td>
<td>Organic Fraction</td>
<td>=</td>
<td>85.00</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>=</td>
<td>19.13</td>
<td>TPD</td>
</tr>
<tr>
<td>b</td>
<td>Moisture content</td>
<td>=</td>
<td>70.00</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>13.39</td>
<td>TPD</td>
</tr>
<tr>
<td>c</td>
<td>Solid fraction (a-b)</td>
<td>=</td>
<td>5.74</td>
<td>TPD</td>
</tr>
<tr>
<td>d</td>
<td>Inorganic or Non VSS content in the solid matter</td>
<td>=</td>
<td>15.00</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.86</td>
<td>TPD</td>
</tr>
<tr>
<td>e</td>
<td>Organic or VSS content (c-d)</td>
<td>=</td>
<td>4.88</td>
<td>TPD</td>
</tr>
<tr>
<td>f</td>
<td>VSS destroyed</td>
<td>=</td>
<td>55%</td>
<td>%</td>
</tr>
</tbody>
</table>
## Detailed Project Report – Volume 1  Solid waste management in Panaji, Goa

### 2. Electricity Generation

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Biogas generated</td>
<td>2414 m³/day</td>
</tr>
<tr>
<td>b</td>
<td>Methane Content of Biogas</td>
<td>60 %</td>
</tr>
<tr>
<td>c</td>
<td>Power Generation Potential of Methane</td>
<td>10.40 KW.hr/m³</td>
</tr>
<tr>
<td>d</td>
<td>Power Generation Potential of Biogas</td>
<td>6.24 KW.hr/m³</td>
</tr>
<tr>
<td>e</td>
<td>Power Generation Potential</td>
<td>15064 KW.hr/day</td>
</tr>
<tr>
<td>f</td>
<td>Electrical Efficiency of Biogas Genset</td>
<td>40 %</td>
</tr>
<tr>
<td>g</td>
<td>Electricity generated</td>
<td>6025 KW.hr/day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>251 KW</td>
</tr>
<tr>
<td></td>
<td>Thermal Efficiency of Biogas Genset</td>
<td>40 %</td>
</tr>
<tr>
<td></td>
<td>Heat Energy available</td>
<td>6025 KW.hr/day</td>
</tr>
<tr>
<td></td>
<td>Heat energy in KW</td>
<td>251 KW</td>
</tr>
<tr>
<td></td>
<td>No. of Biogas Genset provided</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>Capacity of each Biogas Genset required</td>
<td>251 KW</td>
</tr>
<tr>
<td></td>
<td>Capacity of each Biogas Genset provided</td>
<td>300 KW</td>
</tr>
</tbody>
</table>

Electricity generated in the Biomethanation Plant = 6025 Kwh/day

Cost of Electricity : Rs 4.0 per Kwh

Resourse recovery : 6025 x 4.0 = 24100 Rs/day

### b. Calculation for Compost generation

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td>Dry Solids from Bio-methanation plant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Balance Dry Solids from Biomethanation plant</td>
<td>2.6</td>
<td>TPD</td>
</tr>
<tr>
<td>2</td>
<td>Moisture content in the sludge (after dewatering in centrifuge unit)</td>
<td>6.1</td>
<td>TPD</td>
</tr>
<tr>
<td>3</td>
<td>Total sludge including moisture</td>
<td>8.7</td>
<td>TPD</td>
</tr>
<tr>
<td>4</td>
<td>Solid content in the dewatered sludge</td>
<td>30%</td>
<td>%</td>
</tr>
</tbody>
</table>
### Detailed Project Report – Volume 1  Solid waste management in Panaji, Goa

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Pre compost</td>
<td>=</td>
<td>2.5 TPD</td>
</tr>
<tr>
<td>C</td>
<td>Large Green Cuts</td>
<td>=</td>
<td>7.0 TPD</td>
</tr>
<tr>
<td>5</td>
<td>Total (B+C)</td>
<td>=</td>
<td>9.5 TPD</td>
</tr>
<tr>
<td>6</td>
<td>Moisture content</td>
<td>=</td>
<td>65.0 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td>=</td>
<td>6.2 TPD</td>
</tr>
<tr>
<td>7</td>
<td>Solid fraction in B &amp; C (5-6)</td>
<td>=</td>
<td>3.3 TPD</td>
</tr>
<tr>
<td>8</td>
<td>Total Solid content in the composting material (1+7)</td>
<td>=</td>
<td>5.9 TPD</td>
</tr>
<tr>
<td>9</td>
<td>Total Moisture content (2+6)</td>
<td>=</td>
<td>12.2 TPD</td>
</tr>
<tr>
<td>10</td>
<td>Total Composting material (8+9)</td>
<td>=</td>
<td>18.2 TPD</td>
</tr>
<tr>
<td>11</td>
<td>Moisture Loss during Composting</td>
<td>=</td>
<td>50.0 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td>=</td>
<td>6.1 TPD</td>
</tr>
<tr>
<td>12</td>
<td>Carbon Loss in Composting</td>
<td>=</td>
<td>60.0 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td>=</td>
<td>3.6 TPD</td>
</tr>
<tr>
<td>13</td>
<td>Total compost after stabilization &amp; maturation for 30 days (10-11-12)</td>
<td>=</td>
<td>8.5 TPD</td>
</tr>
<tr>
<td>14</td>
<td>Loss on account of screening / structural material recovery</td>
<td>=</td>
<td>65.0 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td>=</td>
<td>5.5 TPD</td>
</tr>
</tbody>
</table>

Compost generated from the bio-degradable fraction = 5.5 Tons/day

Cost of compost : Rs 3.0 per Kg

Resource recovery : 5.5 X 1000 x 3.0 = 16,500 Rs/day

I. Expected Resource recovery from

Biodegradable material is

= Rs 24,100 /day + Rs 16,500 /day

= Rs 40,600 /day

Summary of total resource recovery from Non-biodegradable and biodegradable fractions

1. Non-biodegradable Fraction: 6,276 Rs/day
2. Bio-degradable fraction: 40,600 Rs/day

Total: 46,876 Rs/day

3. Total Waste Treated: 100 TPD
4. Resource generated: 46,876 / 100 = 470 Rs/day

This recovery shall help in meeting the operations and maintenance of the ISWM facility, and reduce the burden on CCP towards meeting the running costs.
CHAPTER 7.0

Integrated Solid Waste Management (ISWM) Facility
7.0 INTEGRATED SOLID WASTE MANAGEMENT (ISWM) FACILITY

For the effective management of the Municipal waste being generated from Panaji City, The City Corporation has earmarked a site located at Baiguinim village in Tiswadi taluka with an area of 171312 sq.m (Approx. 1.7 ha).

An overall plot plan has been enclosed as Annexure, drawing no. 4.

It is in the aforesaid site, that an Integrated Solid Waste Management Facility (ISWM) will be located with provisions for overall management of municipal solid waste.

While the overall layout area of the plant is 17 hectares, major part of the area is covered with deep quarry pits (approx 5 hectares). Also a water pipeline and HT line passes through the plot, for which minimum buffer space has been provided. On the lower south side of the plot there is a fort wall of archeological significance, from which 50 m clear buffer space has been provided.

Further a 30 m wide green belt has been planned around the periphery of the ISWM facility, wherein native crops like cashew, wild karanda, sherbet, negunda etc shall be grown. Treated and recycled waste water from the facility shall be used for the irrigation of the green belt.

Keeping in view the above features in the plot, useable area for providing the ISWM is approx. 7 hecaters, in which the complete facility, for the design year 2038 and secured land fill for upto year 2023 has been proposed.

A modern automatic state of art ISWM facility has been conceived, having the following sections as part of the overall design concept,

**Section – 1:** Material Recovery Center for Recyclables Waste

*(Here the non-biodegradable fraction shall be sorted, baled, recycled)*

**Section – 2:** Treatment of Wet / Bio-degradable / Organic Waste based on Organic extrusion based segregation, Bio-methanation, Composting technology.

*(Here the biodegradable fraction shall be segregated, pulped, taken to a biomethantion reactor, compost facility)*

**Section – 3:** Landfill of inert residue generated in the Processing Plants.

*(Here the residues and inerts as generated in the processing shall be land filled)*

**Section – 4:** Container storage yard for storage of recycled material

*(Here the baled recyclables shall be stored prior to sale to the recycling vendor)*

**Section – 5:** E-waste storage shed

*(Here the e-waste shall be stored prior to sorting and sale to the recycling vendor)*

**Section – 6:** Construction & Demolition storage shed
**Section – 7: Other miscellaneous common facilities comprising**

security cabin, Weighbridges, Weighbridge Control Station, Administration Building, Facility Center, Resource Center, Drivers’ Restroom, HT Substation Building, MCC and Control room, Biogas Genset Building, Vehicle Washing Facility, Effluent Treatment Plant, Roads, Pathways, Storm Water Drains, Plant drains, Fencing around existing Quarries, Bore Well, Elevated Service Reservoir (ESR), Landscaping, Fire Fighting System, Conveyors, Piping, flushing water network, Valves, electrical work, plant lighting, mobile equipment etc.

*(These are all auxillary units which shall help in the proper functioning of the plant)*

**Other Key aspects while designing the ISWM facility,**

1. It is envisaged that the complete plant operation shall be automatic and carried out using PLC/Scada based control system from a central control room.

2. Special focus has been kept to the segregated manner in which waste is stored and transported, so as to have segregated tipping floors / bunkers where different fractions can be unloaded and treated separately.

3. All efforts have been made while designing and selecting various equipments that there is minimum human contact with the waste. Transport of waste from one unit to the other is via conveyors or screws. Separate weigh bridges for incoming and outgoing vehicles has been provided to automatically weigh and monitor the quantum of waste coming into the facility.

4. All treatment units are housed in fully enclosed sheds, so that there is no visible sight of garbage and issue of odor is arrested. An fully in-vessel composting system followed by a completely enclosed maturation shed has been considered, to ensure that there is no odour, lecahte or vector attraction.

5. Well proven and tested methods have been adopted while designing the system, with special emphasis on recovery and recycle of products. Provision has also been made to bale and wrap all recovered material and store the same in enclosed 20 feet containers, so that while transporting the recovered material to various vendors, there is no spillage on the roads and also the contents are visually concealed.

6. As the operation of the facility shall require round the clock operation, with major activity in the general shift from 9 am to 5 pm, a fully equipped facility centre has been planned, having provision of showers (separate male / female sections), rest rooms with bunker beds, canteen, recreational room, gym, and medical assistance room.

7. A fully equipped administration building with conference room, adequate work station for operating and monitoring staff and a laboratory has been considered.
8. All buildings are provided with LED fixtures and solar panel street lighting has been considered to illuminate the streets to save on electricity.

9. Waste water as generated in the facility shall be treated and recycled to be used for flushing, cleaning, fire water, green belt development, landscaping water requirements and washing of the daily incoming truck.

10. As part of the effort to educate and bring awareness to the people, on the positive impact of waste management, a resource centre has been planned, where in officials from CCP shall conduct regular exhibitions, talks, display useful products made out of garbage, tours of the plant and other such activities.

11. Overall all efforts have been made to ensure the success of the operation of the facility, in a smooth and efficient manner so as to have a long term sustainable waste treatment model plant in the state of Goa.
CHAPTER 8.0

Biodegradable waste processing and treatment units
8.0 WASTE PROCESSING & TREATMENT

This chapter discusses the biological treatment of the bio-degradable component of MSW generated in Panaji. The bio-degradable waste primarily comprises of organic material such as kitchen and yard waste, refuse from vegetable markets, and food waste from hotels and restaurants.

As this waste is high in organic material and cannot be directly sent to land fill it as it will start degrading inside the land fill causing formation of hazardous green house gases like methane, ammonia, carbon dioxide, hydrogen sulphide. The waste has to be stabilized by using anaerobic or aerobic process which will also result in the generation of valuable material such as compost and bio-gas and also prevent contamination of the surrounding environment.

Biological treatment of organic material involves using naturally occurring micro-organisms to decompose the bio-degradable component of waste under controlled conditions. Biological treatment can be categorized into aerobic (composting) and anaerobic (bio-methanation) methods.

8.1 Aerobic Processes:

In such process the decomposition of waste takes place in the presence of air. The organic matter present in MSW is converted into stable mass through aerobic decomposition. Various aerobic decomposition processes are given as following:

a. Windrow composting techniques
b. Aerated Static Pile
c. In-vessel Composting
   (i) Vertical Reactor
   (ii) Horizontal Reactors

a. Windrows Composting (Mechanical)

Windrow usually relies on natural convection and diffusion for oxygen supply. Pile size and turning frequency are used to balance heat loss in managing temperature control. The effectiveness and penetration of oxygen supply in a windrow system varies with the rate of microbial activity and porosity of the pile.

Windrows are defined as regularly turned elongated piles, shaped like a haystack in cross section and up to a hundred meters or more in length. Process control is normally through pile management, although forced aeration can also be used. The cross-sectional dimensions vary with feedstock and turning equipment, but most MSW windrows are 1.5 to 3 meters high and 3 to 6 meters wide.
The main features of windrow composting are listed below:

1. It enriches the soil nutrient content.
2. Process results in considerable reduction in volume and mass of the feed stock (garbage). Typical composting periods are between 45 to 60 days.
3. It requires large amount of land area to maintain the size of each windrow and minimum maturation time.
4. The decomposition takes place by providing air through external means which requires frequent manual turning operation using a turner.
5. A balance has to be maintained between turning operation and temperature build up within the windrow so as to ensure, 60 degree centigrade temperature is maintained for atleast 2-3 days to sanitize the compost and kill harmful microorganism. Too much of turning can result in drop in temperature and less turning may result in setting up of anaerobic conditions.
6. The windrows turning operation requires enclosed shed to ensure operation even during monsoon season.
7. Because typically the operation is in an open area problem of odour, leachate and vector attraction is high.
8. Process output product quality is manageable keeping in view demands in various sectors like horticulture, agriculture, high value crops, land remediation, landscaping, etc.

b. Aerated Static Pile Composting

Static piles can be shaped much like windrows or in an elongated pile or bed. The essential difference is in the name; static piles are not mechanically agitated. Once constructed by conveyor, loader or truck, the piles remain in place until the decomposition slows.

The main features of windrow composting are listed below:

1. The lack of agitation requires the maintenance of adequate porosity over an extended period of time.
2. Structure material is essential for the performance of the static piles.
3. As no agitation is carried out by mechanical means time taken for composting is much higher than windrow system.
4. Also there is more odour generation as conditions are anaerobic inside the static pile.
5. Both windows and static piles are often outside and exposed to weather, but can be covered with a roof to minimize the impacts of weather and provide an opportunity for odor capture and treatment.
c. In-Vessel Composting system
   • Vertical Reactor Composting

Vertical composting reactors are generally over 4 meters high, and can be housed in silos or other large structures. Organic material is typically fed into the reactor at the top through a distribution mechanism, and flows by gravity to an unloading mechanism at the bottom. Process control is usually by pressure-induced aeration, where the airflow is opposite to the downward materials flow. Not many working installations are available on this kind of vertical reactors.

• In-vessel Horizontal Reactor

In-vessel composting is the most efficient and hygienic method of composting of organic or biodegradable waste. In this process the entire operation takes place in an enclosed cylindrical vessel, which rotates continuously at very low speed. Temperature rise is monitored using sensors to ensure effectiveness of the composting process. This process reduces the space taken as well as time taken for composting to 6 to 10 days.

The In-Vessel drums provide the following advantages,

1. The decomposition takes place in an accelerated manner due to continuous turning of the enclosed drum. The retention time in the drum is typically 7 days as compared to traditional methods that can take upwards of a 45 to 60 days.

2. As a result 1/10th land is required as compared to conventional windrow system.

3. As the drum rotate continuously, the process is completely automatic and does not require any external turning device.

4. There is no odor, VOC emission since the decomposition process occurs in the vessel and takes place very quickly. Further a negative ventilation system draws off VOC’s and emissions to a bio filter.

5. No leachate formation, as process takes place in an enclosed environment at self-generated high temperature.

6. The power consumption is very low.

7. The process is natural and typically requires no added heat.

8. Very less land area is required because of reduced retention time.

9. The process is weather proof and consistent compost quality is achieved in all seasons.

10. Vectors, such as flies, rodents and birds, are totally eliminated and a very high degree of hygiene is maintained at the operating site.

11. Compost generated is free from Pathogen and virus as proper temperature rise is maintained in the enclosed reactor.
8.2 Anaerobic Process:

The decomposition of waste takes place in the absence of air.

- **Bio-Methanation:**
  
  In this process, the organic fraction of waste is segregated and fed to a closed container (biogas) digester where under an anaerobic conditions, the organic wastes undergo bio-degradation producing methane-rich gas and effluent/sludge. The biogas production ranges from 50–150 m³/ton of waste depending upon the composition of waste. The biogas can be used for cooking/heating applications, or through gas engines or micro turbines for generating motive power or electricity. The residue after 60-65% stabilization in the bio-methanation reactor is practically free from all odour producing substances and can be then composted using any of the composting techniques. By using this combination, the complete processing takes place in minimum land area and in an enclosed manner thereby reducing all possibility of odour or leachate generation.

After studying the various technologies for waste processing, it has been inferred that a combination of Bio-methanation and Composting would be best suited technology under present circumstances:

1) The moisture content of the biodegradable waste is as high as 74% with organic content as high as 80% in the segregated waste collected. In case of the mixed waste more than 50% waste is organic in nature.
2) The Calorific Value of Indian garbage varies between 800-1100 KcaL/Ton

Under these circumstances, Thermal or Incineration/pyrolysis based (waste to energy) plants will not be suitable from techno-economic angle. Therefore in order to process Organic fraction of waste in Panaji, a combination of Bio-methanation and Composting technology has been considered.

8.3 Basis of Biomethanation and Composting plant design

The main function of the Biomethanation and Composting plant design is to digest the Organic / biodegradable waste to generate electricity via biogas and compost via sludge residue. The electricity thus produced shall be used to run the plant and reduce the operating expenses.
Collection Streams of Bio-gedrable waste

1. Bio-degradable waset from hotels, households, market place and commercial establishments

Biodegradable waste shall be collected either in separate green colored plastic bags from households, hotels and commercial establishments or without bags in open trucks / compacters and delivered at the MSW facility. While most of such waste collected as bio-degradable fraction has 80 to 90% biodegradable fraction, some 10-20% inorganics are also observed in the bags or receiving trucks. It is extremely important that this dry inorganic fraction is removed from the bio-degradable fraction, so as to ensure the bio-methanation process works well. One of the main reasons for non-optimum performance of bio-methanation system is the presence of inorganics in the input feed, which hampers the biological activity of microorganism in the reactor. An Extrusion based segregation process has been adopted to segregate the inorganic component from the organic component prior to feeding into the bio-methanation system, which besides segregation also makes a pulp out of the waste converting it into a consistent homogenous solid mass of 18 - 25% solid concentration, having more than 95% organic fraction. After biomethanition, the sludge residue shall be dewatered and taken to the composting line along with primary compost from households.

2. Primary compost from households, Dry green cuts from the vegetable market

Part of the bio-degradable waste from households is already converted into primary compost at the residential level in composting boxes for duration of 40 to 60 days. Such primary compost shall also be delivered to the MSW facility in trucks. A separate household compost-tipping floor shall be provided to store such waste, inside the fully enclosed shed, covered from all sides. All such waste shall be directly taken to the composting line based on in-vessel enclosed composting drums, and shall by-pass the bio-methanation section. The dry green cuts collected from the vegetable market, after shredding shall also be taken to the compost line.

3. Mulched tree waste from tree cutting

Mulched wood waste shall also be delivered to the MSW facility in trucks. A separate mulched tree waste-tipping floor shall be provided to store such waste, inside the fully enclosed shed, covered from all sides. Part of this waste can be used as structure material in the composting line or can be used as green fuel pellets.

The main units in the bio-degradable waste treatment section are as follows,

1. Wet Waste Tipping Floor
3 Nos. of separate tipping floors, each having capacity for a 3-day storage period shall be provided under the enclosed shed.

These are for storing the following wet organic streams,
1. Wet waste from hotels, households, market place and commercial establishments
2. Primary compost from households & green cuts from the market place
3. Mulched tree waste from tree cutting

The tipping floor shall have a RCC flooring of 150 mm above the plinth level. Drains, floor flushing connection and ventilation shall be provided around tipping floor area along with 2 sidewalls of minimum 3 m height to enable proper stacking of bags as well as waste delivered in open trucks / compactors. The bags/ waste shall be unloaded on a tipping floor where waste will be visually inspected for any bulky and disturbing materials (big stones, metal scrap, wood, cadaver etc.), which if any shall be sorted out manually or by a bobcat/ wheel Loader. Greens bags if any sorted at the dry tipping floor area, shall also be brought to the wet waste tipping floor area using the bobcat/ wheel loader.

2. **Wet Waste feed Hopper with Bag Opener**

The bags containing wet / biodegradable waste as well as wet waste delivered in open trucks / compactors shall be transferred by skid stir loader / wheel loader into a wet waste feed hopper bunker with bag opener. The hopper has a chain belt and rotating kickback drum bag opener with knifes, to open the bags and regulate the flow of the waste in a uniform manner to the downstream chute. The less than 80 mm underflow from the lamella screen (loctaed in the MRF) shall also be taken into this hopper and mixed with the other wet fraction coming to the plant. From the hopper bunker the waste shall be fed into the organic extrusion press using screw conveyor.

3. **Organic Extrusion Press**

A screw conveyor conveys the wet waste from the hopper bunker to the Organic Extrusion Press. The hydraulically operated Organic Extrusion Press will separate the waste into two fractions – an organic wet fraction and an inorganic dry fraction. The press will squeeze out the organic matter through an extrusion matrix at a very high pressure. After the pressing process, the residue referred to as the dry fraction shall be discharged and taken to a dry fraction storage area, from where it can be taken out either as RDF or can be land filled. The wet fraction from the organic extrusion press shall be conveyed into a moving floor bunker using a screw conveyor. The moving
floor bunker provides buffer / equalization volume and ensures consistent feed is maintained to the digester over a 24 hr./day basis.

4. **Bio-methanation System**

   The pulped wet fraction from the organic extrusion press shall be conveyed into a buffer holding tank, which shall provide equalization volume for a 24hrs/day operation of the bio-methanation fermenter. The contents shall be transferred into a bio-methanation fermenter using a screw conveyor. A grit removal arrangement shall be provided to avoid accumulation of silt in the fermenter. The fermenter shall be provided with paddle mixers and a heating arrangement to ensure digestion of the contents takes place in a thermophilic range of 55 degree Celsius. Waste heat from biogas engines shall be used for heating the fermenter. After completing the digestion step the digested substrate shall be transferred to sludge dewatering unit.

5. **Sludge Dewatering Units**

   The digested substrate shall be separated into solid (dewatered sludge) and liquid (centrate/filtrate) phases in a dewatering unit. The solid fraction shall have a consistency of minimum 30%. The dewatered sludge shall be then transported to In-Vessel Composting Drums area via bob cats/ wheel loader. The centrate shall be recycled back into the buffer tank and fed into the digester. Part of the centrate shall be pumped to the effluent treatment plant for further treatment and recycled within the plant for various uses like gardening, landfill application or composting purpose.

6. **In-Vessel Composting Drums**

   The dewatered sludge from dewatering equipment shall be transferred to the In-vessel composting drums area using a bobcat/ wheel loader. Wood chips shall be added as structural material to dewatered sludge to improve voidage and therefore to improve compost efficiency. Household compost and mulched tree waste can also be used as structural material. The mixed input material shall be fed into the in-vessel composting drums using a conveyor mechanism. The drums shall be rotating continuously and the composting of the mixed sludge takes place in an accelerated manner within 4 – 5 days due to continuous rotation of the enclosed drums. While the composting material turns inside the drum, it also gets aerated continuously.

   After in-vessel composting, the compost material shall be further stored and matured for a period of minimum 14 days in a closed shed. After maturation, the compost shall be screened to separate structural materials using a star screen of 10 – 30 / 10 mm screening capacity. The large sized fraction shall be grinded to be mixed with the input dewatered sludge as structure material. The finer fraction shall be bagged for further sale as per requirement.
Composting can be achieved using three types of micro-organisms – (1) bacteria, (2) actinomycetes and (3) fungi. In the initial stages, the bacteria, fungi, and protozoa activities cause the temperature in the compost plant to increase to 60-65°C, which is called the thermophilic stage. In this stage, the bacterial and actinomycetes activity causes decomposition, result in gina fall in temperature, when the fungi activity resumes. This stabilized condition is known as mesophilic stage, when the composting material becomes dark brown due to humussynthesis. In addition to temperature, air supply, moisture content, particlesize of MSW, acidity/alkalinity, and chemical characteristics are the other factors which influence the microbial activity in a windrow. Several factors affect the rate of decomposition of the bio-degradable material as described below:

1. **Micro-organisms:** A combination of microorganisms are developed inside the in-vessel composting drums as the waste is retained for a period of 4-5 days.

2. **Moisture content:** The moisture content of the bio-degradable waste needs to be maintained within the range of 55-60%.

3. **Air supply:** Sufficient air supply is required to maintain a high rate of decomposition, removal of carbon dioxide and volatile organic compounds, and buffering of the pH. This is done mechanically by the continuous rotation of the drum.

4. **Temperature:** A temperature range of 50-60°C is conducive for sanitization of MSW. Due to the enclosed nature of the drum operation, this temperature can be easily maintained. In addition, the disease-Gausing micro-organisms are killed and weeds are destroyed at this temperature.

5. **Particlesize of MSW:** Smaller particle size of compostable material provides greater surface area for the micro-organisms to act upon. However, the particlesize should not be too small so as to compact the organic matter and reduce void space. Additional of mulched tree waste and pre-compost from household will add the required voidage in the composting material.

6. **Acidity/ alkalinity:** A pH range of 6.5-7.8 is most suitable for the composting process.

7. **Chemical characteristics:** A C:N ratio between 20:1 to 25:1 is ideal for maximum decomposition of organic matter.
8. **Waste Density**: A waste bulk density of 0.5 to 0.6 MT/m\(^3\) is ideal for composting process.

7. **Biogas Genset based Power Plant**

The fermentation of organic residues in an anaerobic atmosphere in the bio-methanation units shall generate biogas, 50% – 70% of which shall be methane. The biogas shall be stored in an integrated double membrane type gasholder domes anchored on the top of the centrate/ filtrate tank. This biogas shall be passed to biological desulphurization plant followed by moisture removal system and then fed to the gas engine for generation of electricity. Gas cleaning can also be carried out prior to storage in the gasholder.

Electricity as generated shall be utilized to run the entire processing facility including plant lighting, ventilation units, processing units etc. and various auxiliaries of the gas engine. In case there is any excess electricity the contractor is free to export to the same to Goa State Electricity Grid. However contractor will set up its own infrastructure at no additional cost to GSIDC for such export purpose. A part of thermal energy (waste heat) generated during this process shall be used for heating the contents of the bio-methanation units.

**Bio-Degradable waste generation**

The garbage projection in Panaji for year 2038 indicates that a total of 50 TPD of bio-degradable garbage shall be generated on daily basis. Details of the same is refered in the table 8.1 below

<table>
<thead>
<tr>
<th>Sno.</th>
<th>Source of waste</th>
<th>Type of waste</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unstabilized</td>
</tr>
<tr>
<td>1</td>
<td>Households</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Hotels &amp; Restaurants</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>Market place</td>
<td>6.5</td>
</tr>
<tr>
<td>4</td>
<td>Slaughter house</td>
<td>1.5</td>
</tr>
<tr>
<td>5</td>
<td>Mulched tree waste</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td><strong>Total (TPD)</strong></td>
<td><strong>30</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Grand Total</strong></td>
<td><strong>50</strong></td>
</tr>
</tbody>
</table>

On the basis of proposed collection system and practical consequences of segregation and collection efficiency on the bio-degradable waste generation, a 50TPD capacity Bio-methantion cum compost plant is proposed to meet the waste quantity requirements for the design year of 2038.
8.4 Details of the Treatment units

1. Wet waste feed Hopper with Bag Opener

The bio-degradable waste is taken on the tipping floor, which shall have provision to hold 3-days of waste quantity. The waste shall be received in green bags or in loose form via open trucks/compactors. From the tipping floor, the wet waste shall be transferred into a wet feed hopper bunker, using a wheel loader/bobcat.

Wet feed hopper bunker shall have a flat horizontal portion followed by a steep chain belt. The complete hopper shall have side plates. This chain belt hopper shall have an inclination of 30°. Material on top will roll back, because of this steep angle and through friction of the sidewalls. A kick back drum with knives is provided at one end to open the green bags and free the contents for further treatment. After opening the bags, the material from the bags will fall out at the bottom of the chute from where it will be transported into the extrusion press using a screw.

The feed hopper bunker shall be placed on the concrete floor with wall of 300 mm high on all sides to contain any leakage. A small pump shall be provided to pump out leakage liquid to the fermenter. The hopper shall be appropriately placed for feeding with the wheel loader or bobcat and be sufficiently stiffly dimensioned.

The technical specifications are as follows:

Input material: Wet fraction in bags, wet fraction in open trucks/compactors
Quantity (ton/day): ..........................................................maximum 37
(ton/annum): ..........................................................maximum 13,500
Bulk Weight(kg/m³): ..................................................Approx. 400 - 600
Throughput Rate(ton/hr.): ..............................6.5
Capacity of hopper(m³): ........................................minimum 10.0
Size mm (L x W x H): ...........................................Suitable x 1600 x 2000
Maximum handling capacity: ..................8 Tons/batch
Material of construction: ..................5 mm thick, bottom under construction and 3 mm thick side plate
sheet metal S325 hot dip galvanized
Bag Opening Rate (%): ..................................................minimum 90 (bag-in-bag as well)

Bags are only considered “Opened” when their contents are emptied into the immediately following processing Unit (e.g. Screw) and further treatment of the material is guaranteed.

2. Organic Extrusion Press

The waste from hopper bunker shall be fed into the organic extrusion press via a screw conveyor. The hydraulically operated Organic Extrusion Press will separate the waste into two fractions – an organic wet fraction and an inorganic dry fraction. The in feed waste will undergo a very high pressure in a perforated extrusion chamber located in the central portion of the machine. As a result, the organic fraction will be pushed by the difference in pressure between the interior and exterior of the chamber and separated from the parts mechanically more resistant (paper, carton, plastics, rubber etc.).
The extrusion process cycle shall be made of three distinct phases controlled by hydraulic power pack: the feeding phase, the compression phase and the expulsion phase. The waste shall be fed into the in feed hopper from where the cylinder will push the waste into the extrusion chamber and compress it at a very high pressure. During the expulsion phase, the dry fraction shall be evacuated from the extrusion chamber automatically.

Following components are a part of the extrusion press:

Main Body: The Main Body shall consist of the feeding hopper, cylinder(s), extrusion chamber and the evacuation system.

Hydraulic Station: The Hydraulic Station shall consist of the feeding pumps with drive motors, tank with the hydraulic oil, distribution parts, valves and distributors, air operated heat exchangers, steel pipes, flexible pipes for suction and discharge of the pumps, flexible pipes for feeding of the cylinders and other accessories (air filters, oil filters, levels controls, pressure and temperature sensors).

Control Station: The control station shall consist of local PLC panel with provision of Interface with central SCADA.

Main Working Parts:

Main Working Parts shall include principal electric motors, pumps with variable cylinder displacement and pumps with fixed cylinder displacement.

The technical specifications are as follows:

No. of Organic Extrusion Press:.............1 No.
Input material:..............................Wet Waste from Hopper Bunker
Quantity (ton/day):..........................maximum 38
Bulk Weight (kg/m³):.........................Approx. 300 - 500
Throughput Rate (ton/hr.):..................minimum 6.5
Applied Pressure on the material (bar):240
Size of output wet fraction (mm):........maximum 12
In-organic content % by weight:...........maximum 10

3. Bio-methanation system

Bio-methanation system shall include equalization or buffer tank via a moving floor bunker, screw conveyers, heating device, fermenter tank with mixers, integrated sludge cum biogas holding tank, sludge dewatering system, and gas engines/ micro turbines.

a. Buffer Tank – Moving floor bunker type

The wet fraction (pulped organic waste) from the organic extrusion press shall be taken into the buffer tank. The buffer tank will provide adequate equalization to the wet fraction so that it can be fed into the bio-methanation fermenter unit on a 24 hr./day continuous basis.

The buffer tank shall be a moving floor bunker and shall have the following functions:
• Storage and transport of wet fraction from the organic extrusion press.

• Feeding the wet fraction to the fermenter unit at uniform rate through a screw conveyor

The moving floor bunker shall be of sufficient size as per the flow requirements in the technical data. The bunker shall be a hydraulically operated push floor and with option to vary the speed of the floor, from the local control panel. The unit must be equipped with an overload protection device. It should be covered from the top, to prevent odor in the vicinity of the unit, with a gas vent connected to a bio-filter.

The technical specifications are as follows:

Input material: Wet waste
Quantity (m³/day): (maximum) 37
Bulk Weight (kg/m³): Approx. 400 to 700 kg/m³
Capacity of Bunker (m³): minimum 30.0
Unloading capacity (m³/h): 25 m³/h at full speed and max load
Maximum Height of loading Above floor level (m): maximum 2.0 m (including supporting legs)
Floor speed: maximum 0.5 m/minutes

Hydraulic power pack: Required

Movement cycle: Standard step by step cycle and Standard with backward forward bi-directional

Material of construction
Floor-profiles:
Standard high quality aluminum floor profiles 7 mm, Alloy 7116 - F36, hardness HB120 minimum, Profile width 134 mm. Seal type co-extrusion, auto lubricated. Gliders shall be in HDPE. Profile support special designed Ω profiles. Stroke 150 mm


Drive-unit and Cylinder capacity: 1 self-supporting front mounted steel sub frames with 3 hydraulic double action cylinders of approx. 10 ton for each cylinder. Hydraulic power pack: maximum speed of 0.5 m/min, adjustable.

Side- and back-walls: Constructed from 3-mm. Sendzimir steel plating with reinforcements. An additional double T-profile will be placed over the loading side to protect against damage caused by the loading equipment.

Dripping water collection and pumping facility: Shall be provided

b. Fermenter Unit

Fermentation shall take place in the thermophilic temperature range, i.e. at approx. 55°C. The fermenter shall be provided with a suitable paddle type agitator for mixing the contents of the fermenter. On the top of the tank a dome type gas extraction system shall be provided with
adequate safety valves, inspection manhole and interconnection to the membrane gasholder. The fermenter tank will also be equipped with a grit removal system and a heating device to maintain thermophilic conditions. Waste heat from the gas engine shall be used to heat the contents of the fermenter.

After digestion, the substrate shall be pumped into a sludge dewatering unit using screw pumps where the digested substrate shall be separated into a solid (sludge) and a liquid (centrate) phase. The centrate from the screw press shall be taken into a digestate storage tank with an integrated membrane biogas holder.

Proper access in form of safety rails, ladders and platform shall be provided around all instruments, valves and flanges to ensure proper operations and maintenance.

All electrical drives shall be designed to meet hazardous area classification for flammable gas and vapors as per IS5572 and all its latest amendments.

The technical specifications are as follows:

- Design Flow (m3/day): 40 m3/day
- Hydraulic Retention Time (days): minimum 20
- Freeboard: 0.50 m
- Sand and grit disposal Device: Required
- Heating system: Required to heat contents up to 55 deg Celsius
- Gas tightness: minimum 3 mbar
- Temperature: maximum 55 0C
- Mixers: Required
- Mixer type speed: Slow speed Stainless steel hollow shaft paddle type

**a. Heat system for Fermenter Tank:**

A shell & tube type heat exchangers before the Fermenter Tank or alternatively an inner heating device within the fermenter to heat the contents of the tank shall be provided. In case a heat exchanger is used, the content from the buffer tank shall be allowed in tube side whereas hot water (with 90 0C inlet temperature) generated from Waste Heat Recovery System of Biogas Genset shall be allowed in shell side to heat the substrate up to 55 0C.

**b. Sludge Dewatering System**

Sludge dewatering system shall include feed pumps, dewatering unit, filter press feed pumps, polymer dosing system (as per dewatering unit manufacturer’s recommendation) and a filter press.

Digestate from the fermenter tank, shall be separated into a solid (sludge) and a liquid (centrate/filtrate) phases in the dewatering unit. The dewatered sludge shall be mixed with structural material and then transported to In-Vessel Composting Drums area.
The Centrate/filtrate shall be taken into the digestate tank. A part of centrate/filtrate will be recycled to fermenter unit. Remaining part of centrate/filtrate shall be further dewatered in the filter press to recover all possible solids. The recovered solids will also be fed into composting drums, while the filtrate from the filter press shall be transferred to an effluent treatment plant based on membrane bio-reactor cum reverse osmosis technology. The treated effluent shall be used in the plant for washings, flushing, gardening, land fill, composting and all other such plant operations.

c. Dewatering Feed Pumps:

Dewatering Feed Pumps shall be of positive displacement type eccentric screw pumps suitable for handling digestate having 12 – 25% solids consistency. Each pump shall be provided with base frame, helical gear motor, variable frequency drive, temperature control unit for the stator and pressure indicator.

The technical specifications are as follows:

No. of Pumps: 2 Nos. (1 Working + 1 Standby)
Capacity (m³/hr.): 8.0
Discharge Pressure (Kg/cm²): Suitable
Type: Positive displacement type eccentric screw pump
Medium: Digestate from Fermenters having 12 – 25% solids consistency
Operating Temperature: 55 °C

Material of Construction

Casing: Cast Iron
Suction Housing: DN 200 PN16
Discharge Housing: DN 200 PN16
Drive Shaft: 1.4301
Rotor: 1.2436, hardened at least 62 – 64 HRC
Stator: NBR, self-aligned
Cardon Joint: Steel / VA, commensurate diameter to safely prevent joint from getting entwined, with needle bearings lime time lubricated, completely sealed with NBE sleeve
Shaft Sealing: Mechanical face seal, LWD materials (DIN 24960) SSP-T, with integrated oil quench
Base Frame: Mild steel

d. Dewatering unit:

The Dewatering unit shall be housed on an elevated platform to collect sludge directly from the bottom of the unit. Dewatering unit shall be a continuously operating unit with outlet solid concentration more than 30%.

The technical specifications are as follows:

No. of Units: 2 Nos. (1 Working + 1 Standby)
Capacity (m³/hr.): 8 m³/hr.
Medium: Digestate having 12 – 25% solids consistency
Operating Temperature: 55 0C

Material of Construction
Body & Contact parts: SS 304
Base Frame: Mild Steel Epoxy Painted

e. Filter press feed Pumps

Filter press feed pumps shall be of positive displacement type eccentric screw pumps suitable for handling centrate from screw press having 1-3% solids consistency. The pumps shall take suction from the digestate tank. Each pump shall be provided with base frame, helical gear motor, variable frequency drive, temperature control unit for the stator and pressure indicator etc.

The technical specifications are as follows:
No. of Pumps: 2 Nos. (1 Working + 1 Standby)
Capacity (m3/h): 4 m3/hr.
Discharge Pressure (Kg/cm2): Suitable
Type: Positive displacement type eccentric screw pump
Medium: Centrate/Filtrate from dewatering unit having 1-3% solids consistency
Operating Temperature: 40 – 50 0C

Material of Construction
Casing: Cast Iron
Suction Housing: DN 200 PN16
Discharge Housing: DN 200 PN16
Drive Shaft: 1.4301
Rotor: 1.2436, hardened at least 62 – 64 HRC
Stator: NBR, self-aligned
Cardon Joint: Steel / VA, commensurate diameter to safely prevent joint from getting entwined, with needle bearings lime time lubricated, completely sealed with NBE sleeve
Shaft Sealing: Mechanical face seal, LWD materials (DIN 24960) SSP-T, with integrated oil quench
Base Frame: Mild steel

f. Filter Press

The Filter Press is solid liquid separating equipment working on the principle of filtration under pressure feeding. It consists of a series of recessed plates fitted on mild steel structures and arranged parallel with the filter medium provided in between the plates. When the mother liquor consisting of solids and liquid is fed to the chambers formed between the plates and the filter medium, the solids are trapped inside and the liquid is drained out.
The Filter Press shall consist of Body Structure, Hydraulic Cylinder, Hydraulic Power Pack, Inlet & Outlet Nozzles, Drip Collection Tray, Recessed Plates and Filter Cloths etc.

The technical specifications are as follows:

No. of Units: 1 No. (Working)
Capacity (m³/day): 20
Operating hours (hrs.): 6
Medium: Centrate/Filtrate from dewatering unit having 1-3% solids consistency
Operating Temperature: 40 – 50 °C
Operating Pressure: 5 bar

Material of Construction
Body Structure: Mild Steel – Fabricated and Epoxy Painted
Hydraulic Cylinder: Mild Steel – Epoxy Painted
Hydraulic Piston: Mild Steel – Chrome Plated
Inlet & Outlet Nozzles: SS 304
Recessed Plates: PP
Filter Clothes: PP

G. Digestate tank:

A digestate tank shall be provided to hold the centrate/filtrate from the dewatering unit. It can either be an integrated digestate tank with a membrane type biogas holder, or alternatively two separate units, 1 No. of digestate tank for holding the centrate/filtrate and another membrane based tank for holding the biogas can also be provided. The integrated digestate tank shall have sloping floor and L-Section ring fitted to the edge for fastening of membrane type biogas holder dome on the top of the wall. It shall be equipped with a submersible mixer, access manhole in wall, puddle pipe inserts in wall, GI access ladder with peripheral walkway and all such approach utilities to ensure proper access is available for operations and maintenance of the complete unit, piping, instrumentation and valves. It shall be constructed in reinforced cement concrete of grade M30 or higher. Floor, and wall shall be applied with 3 layers of special acid resistant anticorrosive coating.

Alternatively, Glass-Fused-To-Steel Bolted Tanks or Fusion Bonded Epoxy Coated Steel Bolted Tanks can also be provided.

The technical specifications are as follows:

Design Flow (m³/day): 40.0
Hydraulic Retention Time for centrate (days): 1.0
Freeboard: 0.5 m
Medium: Centrate/Filtrate from dewatering unit having 1 - 3% solids consistency
Temperature: 45 – 55 °C max.
Minimum Storage time of Biogas (hrs.): minimum 12 hrs.
Membrane Material: Polyester fabrics, PVC coated on both sides, 2 layers minimum

**h. Mixer in Digestate tank:**

Submersible or side entry mixers shall be provided at the circumference of digestate tank for efficient mixing of the contents.

The technical specifications are as follows:

- No. of Mixer: Adequate for complete mixing,
- MOC: Corrosion resistant tungsten carbide blades with Stainless steel shaft
- RPM: Slow speed
- Medium: Centrate/Filtrate from dewatering unit having 1 - 3% solids consistency
- Temperature: 55 0C

**i. Biogas Holder Dome:**

Double membrane, hemispherical, biogas holder dome shall be provided at the top of the digestate tank for storage of biogas. Alternatively a stand-alone bullet or sphere can also be provided. In case of an integrated tank, the outer and inner membranes shall be clamped to the L-Section ring fitted to the edge of tank for fastening of biogas holder dome on the top of the wall in such a way that they are leak-proof and do not tear out. The outer shell will protect against climatic conditions. This membrane will absorb all external loads such as wind, rain, hail and climatic conditions. The actual gas storage shall be inside and thus protected against atmospheric conditions. The inner shell will store biogas. This gas chamber will be located between the inner membrane and the centrate. The pressure within the support air space will spread to the biogas via the inner membrane. The inner membrane will float between the outer membrane and the brace system in an adjustable height, depending on the filling level. The overpressure valve will limit the pressure in the gas chamber.

The technical specifications are as follows:

- Minimum Storage time of Biogas (hrs.): minimum 12 hrs.
- Membrane Material: Polyester fabrics, PVC coated on both sides, 2 layers minimum

**j. In-Vessel Composting Drums**

The dewatered sludge from the dewatering unit as well as filter press machine shall be fed to In-Vessel Composting Drums where decomposition shall takes place in an accelerated manner due to continuous rotation of the enclosed drums. Structural material in the form of wood chips/ dry leaves/coarse screenings of compost shall be mixed with dewatered sludge to increase the porosity.
The in-vessel composting shall offer a very high degree of control over the compost process in order to produce relatively stable organic end products in duration of 4 – 5 days. The resulting compost shall be stable and odor less. The in-vessel composting unit shall be in the form of drums rotating at about 5 to 10 RPH. It shall consist of the following parts:

1. Heavy duty mounting frames
2. Geared drives
3. Carbon steel walls
4. Wear bars for durability
5. Negative ventilation system for process and odor control
6. Feed and discharge gate
7. Individual feed & discharge conveyers

The technical specifications are as follows:

Medium: Dewatered sludge from sludge dewatering system having 25 – 30% solids consistency
Quantum (m3/day): .............. 40.0
Structural Material: .............. As required
No. of Units: ...................... minimum 2 Nos.
Type: ............................. Rotating drum type
Diameter of each Unit (m) ...... minimum 3.00
Length of each Unit (m) ........ minimum 18.00 m
Operating Temperature (deg Celsius): ................. 50 – 60 0C

k. Storage, Screening and Bagging of Compost

After in-vessel composting, the compost material shall be stored for a minimum period of 14 days in a shed made of self-supported roofing system for maturation. The matured compost material shall be screened using star screen and bagged with the help of a bagging machine for further sale. Large sized fraction can be granulated and mixed with the smaller grain size product or alternatively used as structure material to provide porosity to the composting medium.

The compost shed shall also have provision to store 15 days of bagged compost.

l. Star Screen

The star screen shall sieve the fine grains out of the input material. The star screen shall have provision for a minimum of 2 Nos. of screening size, i.e. between 10- 30 mm and less than 10 mm. Both these fractions shall be separated from the matured compost. A grinder or granulator shall be provided to grind the more than 10-30 mm fraction and blend it as per requirement. The more than 30 mm fraction shall be mostly structural material and can be recycled back.

A trough conveyor shall be used to feed the star screen with an even flow. The sieving process begins on the star screen where the stars are rotating in one direction and loosens the material. Because of the shape of the stars, and its high speed, the material is loosened, and pulled apart, in an aggressive manner. The finer grain i.e. less than 10 mm is collected in a bunker, and the 10-30 mm larger grain is collected in a separate bunker. The more than 30 mm grains shall be the
overflow and taken into a separate overflow bunker for recycle as structure material or use as RDF.

The feeding hopper, conveyor and star screen shall be integrated together.

**Input Material:**
- Matured Compost
- **Bulk Weight (kg/m³):** Approx. 400–500
- **Throughput Rate (m³/d):** 40 minimum
- **Screen 1st Stage (mm):** 0-10
- **Screen 2nd Stage (mm):** 10-30

### m. Granulator

**Input material:** Woody fraction from compost
- **Quantity:** 1 No.
- **Size of input:** <30 mm
- **Density of material:** 350 kg/m³
- **Size of output:** 10 mm, small percentage on oversize possible
- **Throughput (TPH):** 2.0 TPH
- **Rotor diameter (mm):** Minimum 650 mm
- **Rotational speed (rpm):** Minimum 450 rpm

### n. Biogas Genset based Power Plant

The fermentation of organic residues in an anaerobic atmosphere in the Bio-methanation tank shall generate biogas, 50% – 70% of which shall be methane. The biogas shall be stored in integrated double membrane type gas holder dome, anchored on the top of the digestate tank. This biogas shall be passed to a biological desulphurization Plant (for removal of H₂S) followed by moisture removal system and then fed to Gas Engines for generation of electricity.

Electricity thus generated shall be utilized to run the entire processing facility including various auxiliaries of the genset. The sorting and organic separation units will be operated on a 6-hr./day-shift basis, while the fermenter and composting shall be operated on a 24-hr./day basis.

Separate gas engines/ micro turbines shall be provided to meet continuous as well as intermittent (shift) power requirement. In case there is any excess electricity, the same can be exported to the state electricity grid by the operator.

A part of thermal energy (waste heat) generated shall be used for heating the contents of fermenter tank.

### o. Biogas cleaning system

The biogas produced in an anaerobic atmosphere in bio-methanation system shall be processed to make it useful for power generation by removal of moisture and H₂S. Biological desulphurization unit shall be provided to remove H₂S content.

The technical specifications are as follows:

- **Biogas Flow (m³/h):** minimum 130.0
Input Temperature: ..................40 – 50 0C
H2S Output Concentration:........As per gas engine manufacturer’s recommendation.
Output moisture level: ............As per gas engine manufacturer’s recommendations

**p. Biogas Genset**

Biogas Genset comprising of Biogas Engine with all accessories including control panel with HMI shall be provided. The entire system shall be designed and programmed such that each unit shall be able to operate on 30%, 50%, 75% and 100% loads, automatically, depending on flow as well as least calorific value (LCV) of biogas. Micro turbines can also be used in place of gas engines.

The technical specifications are as follows:

Biogas Flow (m3/day): ............3000
Number of units:.................... Adequate and separate to meet continuous and intermittent power requirement.

**q. Biogas Flaring System**

An automatic Biogas Flaring System comprising Main Flare Burner, Pilot Burner with Pilot Line, Ignition System, Gas Train with Accessories and PLC based Automation System shall be provided for automatic flaring of biogas in the event of breakdown / maintenance of Biogas Gensets.

The technical specifications are as follows:

Biogas Flow (m3/h):............... minimum 200.0

**r. Conveyors for the wet Line treatment**

Table 8.2 for conveyors (minimum sizes) to be installed for the wet line

<table>
<thead>
<tr>
<th>Sno.</th>
<th>From</th>
<th>To</th>
<th>Type</th>
<th>TPH</th>
<th>Density (kg/m³)</th>
<th>Min. width/dia (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lamella screen –under fraction in the MRF Section</td>
<td>Wet feed hopper</td>
<td>Trough conveyor</td>
<td>2</td>
<td>400</td>
<td>1000</td>
</tr>
<tr>
<td>2</td>
<td>Wet feed hopper bunker</td>
<td>Organic extrusion press</td>
<td>Screw</td>
<td>6.5</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>3</td>
<td>Wet feed hopper</td>
<td>By pass bunker</td>
<td>Screw</td>
<td>6.5</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>4</td>
<td>Organic extrusion press</td>
<td>Buffer tank</td>
<td>Screw</td>
<td>6.5</td>
<td>650</td>
<td>500</td>
</tr>
</tbody>
</table>
s. Effluent Treatment Plant

Filtrate from Filter Press, leachate from landfill area, plant drains, washings and sullage from Buildings shall be treated into an effluent treatment plant based on membrane bio-reactor (MBR) cum reverse osmosis technology, and recycled within the plant area for various operation, maintenance, washing, flushing, fire water and gardening/irrigation requirements.

**Design Parameters:** Design flow: 100 m³/d

**Table 8.3 Raw Effluent Quality:**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameters</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td></td>
<td>6.5 to 8.5</td>
</tr>
<tr>
<td>2</td>
<td>Biochemical Oxygen Demand (BOD₅)</td>
<td>mg/l</td>
<td>2000</td>
</tr>
<tr>
<td>3</td>
<td>Chemical Oxygen Demand (COD)</td>
<td>mg/l</td>
<td>4200</td>
</tr>
<tr>
<td>4</td>
<td>Total Suspended Solids (TSS)</td>
<td>mg/l</td>
<td>20000</td>
</tr>
<tr>
<td>5</td>
<td>Total dissolved solids</td>
<td>mg/l</td>
<td>5000 - 10000</td>
</tr>
</tbody>
</table>

**Table 8.4 Treated Effluent Quality:**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameters</th>
<th>UOM</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td></td>
<td>5.5 to 9.0</td>
</tr>
<tr>
<td>2</td>
<td>Biochemical Oxygen Demand (BOD₅)</td>
<td>mg/l</td>
<td>≤ 10</td>
</tr>
<tr>
<td>3</td>
<td>Chemical Oxygen Demand (COD)</td>
<td>mg/l</td>
<td>≤ 100</td>
</tr>
<tr>
<td>4</td>
<td>Total Suspended Solids (TSS)</td>
<td>mg/l</td>
<td>≤ 10</td>
</tr>
<tr>
<td>5</td>
<td>Total dissolved solids (TDS)</td>
<td>mg/l</td>
<td>≤ 2100</td>
</tr>
</tbody>
</table>
MBR shall have submerged hollow fiber/flat sheet membranes and designed for gross flux less than 10 LMH and SDI less than 3. Sludge generated shall be recycled to the Bio-methanation Plant. Reverse osmosis skid shall consist of micron filter, reverse osmosis membrane system, high-pressure pump, and control panel, complete with all accessories. The complete operation shall be PLC controlled.

Treated effluent shall be used in-house to meet the flushing, washing, fire fighting and gardening requirements.
CHAPTER 9.0

Material Recovery Facility and Auxiliary Utilities
9.0 MATERIAL RECOVERY FACILITY

9.1 GENERAL

The Material recovery facility (MRF) has been planned to sort and recover recyclables / useful products from the Non-Biodegradable waste fraction in Municipal Solid Waste.

Generally, the recyclables found in Municipal Solid Waste are wooden pieces, paper, cardboard, textiles, rags, straw, hay, glass, rubber, leather pieces, polythene bags, plastic goods, metals (ferrous & non-ferrous), tetra packs, dry leaf, Aluminum foils, ceramics, and aluminum can etc. which can be processed and reused in different forms.

Therefore, in order to recycle aforesaid components, these components need to be recovered from both the Mixed Non-Biodegradable waste component as well as the segregated non-biodegradable fraction of Municipal Solid Waste. In order to recover these components, the various devices like feed hopper with bag opener, screens, manual sorting station with a conveyor belt and chutes, magnetic separators, shredders, baler press and a container storage yard have been provided.

Once the various components recyclable of waste are separated, these could be recycled or sold out for recycling.

The technologies mentioned above target the separation of different components of Municipal Solid Waste are listed as under:

<table>
<thead>
<tr>
<th>Technologies</th>
<th>Material / Activity Targeted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed hopper, drum feeder with bag opener</td>
<td>Feeding the waste at a controlled rate, along with opening the bags</td>
</tr>
<tr>
<td>Screens (60-80 mm)</td>
<td>Large – Film plastics, large paper pieces cardboard, etc. Midsized- Recyclables, organics, misc. Fine- metal pieces, organics misc.</td>
</tr>
<tr>
<td>Hand picking on a manual belt conveyor housing in a sorting station</td>
<td>Recyclables, plastic cans/bottles, rubber articles, glass, non-ferrous cans, tetra packs, thermocoal, residual RDF</td>
</tr>
<tr>
<td>Magnetic Separators</td>
<td>Ferrous metal components and associates material</td>
</tr>
<tr>
<td>Shredder</td>
<td>Shredding of large sized objects</td>
</tr>
<tr>
<td>Baler press</td>
<td>Baling of recycled material into standard sized bales for ease of storage and transport</td>
</tr>
</tbody>
</table>
9.2 Material Recovery Facility for Dry Recyclables Waste

Mixed dry waste will be collected in open trucks / compactors and delivered at the Material Recovery Facility. Also, a small portion of dry waste will be collected in separate plastic bags (pink, orange, green, black and white) and delivered at the MSW facility. All such dry waste shall be taken to the sorting area, which shall be housed in an enclosed shed, the shed shall be covered and have adequate height with proper arrangement for lighting and ventilation. All equipment along with the tipping floor shall be housed inside the shed.

The main function of the Material Recovery Centre is to recover maximum possible recyclables from the dry waste, such that they can be directly reused. Recyclable and sorted items shall be baled and wrapped for reuse as per the vendor’s requirement. Remaining waste left after sorting and recovering recyclables shall be shredded and/or compacted as refuse derived fuel (RDF) and residual material, which cannot be converted into RDF will be taken to the landfill.

Any e-waste (comprising electronic waste items like computers, television sets, printers, cartridges, refrigerators, phone, compact discs, etc.) coming into the facility shall be sorted at the tipping floor and taken to the e-waste storage shed. The shed shall be designed to store the material for a minimum of 15 days. It shall have a RCC tipping floor, 150 mm above plinth level and 2 sidewalls of minimum 3 m height to enable proper stacking of the e-waste material. Recyclables, which can be recovered from the e-waste, shall be recycled and other components shall be suitably sold to various recycling vendors.

The following minimum fractions shall be sorted from the dry recyclable waste:

1. Paper
2. Cardboard
3. Light thin micron plastic
4. Non-recyclable plastic with metal sheeting (chips, kurkure packets, foil plastic)
5. HDPE, thick micron plastic
6. Plastic items
7. Thermocoal, Styrofoam cups, packaging material
8. Tetrapacks
9. Glass into 3 fractions (green, brown & white glass)
10. Coconut shells
11. Metal items
12. Tyres, rubber parts
13. Textile, rags, cloth
14. Batteries, tube lights, biomedical waste from households, if any

Main units in this section are as follows,

a. Tipping Floor – Dry Waste

The dry waste, delivered in bags as well as in open trucks/compactors shall be brought in the plant and tipped on a Dry Tipping Floor. Separate sections / partitions shall be provided to store dry waste delivered in colored bags and in open trucks/compactors. The dry tipping floor shall be designed to store 3 days of material. The tipping floor shall have a RCC flooring 150 mm above plinth level and 2 sidewalls of minimum 3
m height to enable proper stacking of bags/ material. On the backside of the tipping floor, compartments shall be made to manually sort the different colored bags and stack them in the designated compartment. Drains, floor flushing connection and ventilation shall be provided around tipping floor area.

At the tipping floor the waste shall be visually inspected and any bulky or non-suitable material will be removed. Different colored bags will be sorted and stored color wise in the compartments. Greens bags shall be separated manually and taken to the wet tipping floor area. The waste coming in loose manner in open trucks/ compacters shall be picked using bobcats/ wheel loader and directly taken to the moving floor bunker.

b. Dry Feed Hopper 1 with Bag Opener

The pre-sorted bags as well as dry waste from the Dry Tipping Floor shall be loaded via a skid stir loader / wheel loader into a dry feed hopper 1. The feed hopper shall have a chain belt and bag opener drum arrangement at one end, to open the bags and feeding the contents onto the conveyor belt leading to the lamella screen followed by the manual sorting station.

As a specific color bag contains similar kind of dry waste, the operator can then schedule the level of sorting to be carried out in the manual sorting station. Green bags shall not be loaded in the feed hopper, but taken to the wet waste treatment section.

The purpose of the feed hopper is to provide an adequate storage volume and automatically feed the bags on the sorting line, such that the sorting staff gets a consistent and uniform feed onto the sorting belt for at least a period of 30 to 45 minutes, followed by 10 minutes of rest and so on.

Kinds of Objects in different colored bags

Orange – Mixed plastic like PET-bottles, PE foils, etc.
White – Mixed recyclables – Coated foils, tetra packs, HDPE, Shoes, cloth, thermocol, etc.
Pink – Paper, newspaper, cartridge, tetra-pack
Green – Wet biodegradable organic waste, garden cut, coconuts
Black – Metal (Fe, Non Fe), glass (colored, white)

c. Lamella Screen

The dry waste shall be fed into a Lamella Screen. The Lamella Screen provides the first level of coarse screening and shall have a screen deck of 80 mm opening size. Additionally decks with 20 mm, 60 mm and 140 mm opening size shall also be kept as spare, which can be used in case larger / or smaller sized material is required to be screened.

The purpose of the Lamella Screen is to screen the less than 80 mm dry fractions. The underflow fraction, which is less than 80 mm in size, shall be taken to the wet waste processing line. The overflow fraction, which is more than 80 mm in size, shall be taken further to the Manual Sorting Station.

A separate Dry feed hopper -2, system shall be provided, after the lamella screen to directly feed metal and glass waste on the manual sorting line.
d. Manual Sorting Station
The Manual Sorting Station shall be an elevated flat bed conveyor with hand picking stations and chute system on both sides of the belt. Compartments of standard sizes shall be provided under the chutes to collect the dropped material.
The complete station shall be housed in an enclosed room within the shed with proper ventilation and lighting system. The air ventilation system shall be equipped with proper ducts, filters, cooling system to blow cool and clean air from the top of the room and provide adequate air changes per hour. Suction pipes/ducts shall be provided at the bottom level of the room to suck the spent air out of the room.

The conveyor belt shall be provided with a start, stop and speed control option at one location and a stop option near each work point to stop the conveyor in case of any emergency.

The dry waste and picked-up material shall be separated on the first floor and dropped in separate compartments of specified sizes on the ground floor. The compartment shall store the separated material. The residual material on the conveyor belt, which is not hand picked, shall be taken into the last compartment.

The compartments shall have doors on the front and backside, with an option to transfer the material directly on a baler feed conveyor.

e. Baler with Wrapping Unit
Individual sorted material shall be baled using efficient baler press into pallets. The pallets shall be wrapped in a wrapping machine using thin plastic films and stored inside containers, from where these can be transported in trailers to the recycling vendors.

f. Shredder
A shredder unit shall be provided to shred the recyclable material, wood, rubber, thermocoal, styrofoam, cloth etc. any such material as required to meet the recycling requirement in the plant. Green cuts from market shall also be shredded prior to being sent for composting.

g. Container Storage System
The baled, wrapped and compacted items shall be stored in 20 feet colored container storage yard so that there is no offensive odor in the plant.

The number of containers shall be planned based on a storage requirement of 15 days for the following items,

1. RDF
2. Plastic, PET bottles, HDPE, Coated foils
3. Paper, cardboard, tetra packs
4. Metal – Fe, Non Fe
5. Glass – 3 fractions of green, brown & white
6. Cloth, Textile
7. Rubber
8. Thermocol / Styrofoam
9. Miscellaneous
Sufficient space shall be planned in the layout for the movement and turning of 20 feet trailer trucks and crane access while loading and unloading of the containers. The purpose of the container storage system is to transport the material to recycling vendors in an enclosed manner, without causing any problem of spillage or un-aesthetic sight during travel on the roads of Goa City as well as efficient dispatch of sufficient quantum of the above-mentioned material at a given time. Containers shall also provide weather and rain protection to the recyclable material. A container storage yard shall be provided to house adequate numbers of 20 feet containers to store 15 days of sorted material. Minimum 10 m free space, with roads all around shall be provided for easy movement of forklifts and trailer trucks. High mast-flood lighting provision shall be made for ease of nighttime operation. Crane of suitable capacity shall be rented by the operator to load and un-load the containers on trailer trucks as and when required to transfer material from the MSW facility to the vendor’s place.

**Non bio-Degradable waste generation**

The non biodegradable waste projection in Panaji for year 2040 indicates that a total of 12.64 TPD of non bio-degradable garbage shall be generated on daily basis. Details of the same is refered in the table 9.1 below

<table>
<thead>
<tr>
<th>Waste fraction</th>
<th>Segregated Non-biodegradable waste</th>
<th>Composition of Mixed Non-biodegradable waste</th>
<th>Non Recyclable</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Items</td>
<td>TPD</td>
<td>TPD</td>
<td>TPD</td>
<td></td>
</tr>
<tr>
<td>1 Paper</td>
<td>1.14</td>
<td>2.35</td>
<td>3.49</td>
<td></td>
</tr>
<tr>
<td>2 Recyclable plastic</td>
<td>1.22</td>
<td>2.5</td>
<td>3.72</td>
<td></td>
</tr>
<tr>
<td>3 Glass (mixed color, brown, green, white)</td>
<td>0.19</td>
<td>0.39</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>4 Metal (Fe/Non Fe)</td>
<td>0.19</td>
<td>0.39</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>5 Styrofoam/ thermocol</td>
<td>0.10</td>
<td>0.23</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>6 RDF (Mixed with non recyclable plastic)</td>
<td>1.0</td>
<td>1.96</td>
<td>2.96</td>
<td></td>
</tr>
<tr>
<td>7 Total</td>
<td>3.8</td>
<td>7.84</td>
<td>3.36</td>
<td>15</td>
</tr>
</tbody>
</table>

On the basis of proposed collection system and practical consequences of segregation and collection efficiency on the nonbio-degradable waste generation, a 15TPD capacity MRF facility is proposed to meet the waste quantity requirements for the design year of 2040.

### 9.3 Details of the MRF Treatment units

- **Dry waste Feed Hopper-1 with Bag Opener**
The sorted bags of different colors as well as dry waste from tipping floor shall be fed into a dry waste feed hopper -1, a steep chain belt hopper. This chain belt shall have an inclination of 30°. Material on top will roll back, because of this steep angle and through friction of the sidewalls. A bag opener drum shall be placed at one end of the hopper to open the bags and release the contents into a feed conveyor of the lamella screen.

**Chain belt bunker conveyor with metering drum**

- **Capacity:** .......................2.85 TPH (minimum)
- **Belt width:** .......................2000 mm (minimum)
- **Belt length:** .......................Suitable
- **Inclination:** .......................30 degrees (maximum)
- **Capacity of feed hopper:** ....10 m³
- **Height of sidewalls:** ..........1300 mm (maximum)
- **Drive:** .........................Suitable with mechanical brake
- **Speed Control:** ......................Adjustable, Variable
- **Drum:** ..........................800 mm diameter (minimum)
- **Type:** ..............................Kick-back bag opening type with knifes
- **Drive:** ..............................Suitable with mechanical brake
- **Speed of drum:** ......................Adjustable, Variable
- **Height adjustable provision:** ......To be provided

### Material of construction

Metering drum: .........................Carbon Steel with Hardox 450 knifes

### b. Lamella Screen

The lamella screen is provided to separate several types of material that are smaller in size and difficult to hand pick effectively in the manual sorting station.

The lamella screen shall consist of two layers. A set of cascades improves its efficiency and capacity. The top layer shall be a finger screen. This guides the voluminous material over the complete screen. Big pieces or film shall pass over all finger decks in succession. The smaller and midsize material work their way through the finger screen onto the lower positioned plates. These specially designed plates screen out the product in the desired accurate dimension. The plates shall be mounted in a tiled cascade to improve the capacity and turn the material. In this way the lamella screen sorts more effectively and makes cleaning and maintenance less necessary than alternative screening methods.

The technical specifications are as follows:
After the lamella screen, a separate suitable dry waste feed hopper -2 system shall also be provided for direct feeding of metal and glass waste into the manual sorting line. Specifications for this unit shall be as per the specifications of the dry feed hopper 1.

c. Manual Sorting Station

The dry waste from the lamella screen shall be conveyed to manual sorting station to hand pick the various recyclable fractions. The sorting station shall be in the form of elevated cabins located at both sides of a sorting conveyor to remove valuable items like glass, metals, paper, cloth, rubber, wood pieces, plastic, etc. by hand picking. The recyclables shall be picked and put into the transfer boxes via a chute system below the conveyor belt, by the sorting personnel. Each chute, shall open into a compartment of specified size for storing a particular type of recyclable. The compartments shall have doors on front and backsides. The backside door shall have a flap system, so that the store material can be loaded by a skid stir loader on a feed conveyor leading to the baler press.

The manual sorting station shall be enclosed in a separate building under the shed, with proper lighting and ventilation provision. Air discharge ducts shall be provided on the ceiling and air suction ducts shall be provided at a height of not more than 500 mm from the floor to suck out the spent air. Fresh air shall be filtered, dehumidified, cooled and blown from the air discharge chutes on the ceiling, so as to maintain comfortable working temperature and odorless environment for the operators.

The conveyor belt shall have an option to vary the speed of the conveyor at one end of the room and an emergency stop button near every workstation.

A permanent magnetic separator shall be provided at the end of the sorting belt to automatically pick ferrous-based metal items. The picked items shall be dropped in a chute below the metal separator in a metal container to collect the separated metal pieces.

The manual sorting conveyor belt shall terminate into a compartment for storage of any residual material, which is not hand picked on the conveyor belt. A chain type conveyor belt shall be provided along the complete length of the sorting station to convey the sorted material into the baler press.

d. Disposal Chutes:
• The disposal chutes shall consist of a framework made of shaped tubes that is clad with sheet steel inside and outside.
• The disposals chutes a shall be positioned on the finished platform floors and fixed to prevent them from being moved (screw/bolt or welded fixing).
• The heights of the disposal chutes shall be adapted to the conveyor belt so that the disposal chutes are level with the top edge of the conveyor belt side claddin

e. Equipment for each hand-picking work station:
• A rounded wooden corner strip shall be attached at every standing position along the sorting belt. These are for the comfort of the sorting staff.
• In addition, Emergency Stop buttons shall be provided at every standing position as well as an Emergency Stop cord above head height along the whole length of the sorting conveyor belt.
• There shall be necessary general room lighting, forced lighting and ventilation air ducts at each handpicking stations.

The technical specifications of the manual sorting station is as follows:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input material</td>
<td>Dry waste from lamella screen</td>
</tr>
<tr>
<td>Bulk weight (kg/m³)</td>
<td>Approx. 75 - 300</td>
</tr>
<tr>
<td>Throughput Rate (ton/hr.)</td>
<td>minimum 2.85</td>
</tr>
<tr>
<td>No. of workstations</td>
<td>minimum 12 No’s with 2 chutes on either side</td>
</tr>
<tr>
<td>Dimension of each workstation (W X L) (m)</td>
<td>minimum 2.0 x 2.0 m</td>
</tr>
<tr>
<td>Dimension of each chute (m) (L X W X H)</td>
<td>minimum 0.8 x 0.5 x 1.5 m</td>
</tr>
<tr>
<td>Height of platform (m)</td>
<td>minimum 2.0 above FGL</td>
</tr>
<tr>
<td>Height of conveyor above the platform (m)</td>
<td>maximum 1.2 m</td>
</tr>
<tr>
<td>Width of the conveyor (m)</td>
<td>minimum 1.0 m</td>
</tr>
<tr>
<td>Height of room including false ceiling for ventilation duct (m)</td>
<td>maximum 4.0 m</td>
</tr>
</tbody>
</table>

f. Iron Separator
At the end of the manual sorting belt, a permanent magnet type magnetic separator shall be placed over the conveyor for removal of ferromagnetic materials. The separator shall be so installed to drop the collected metal pieces directly into the drop boxes below, from where the same can be stored in the container yard for later resale/reuse to a metal vendor. The magnetic separator shall be placed outside the manual sorting room to ensure operators are not exposed to magnetic fields. An easy to see safety notice (regarding electromagnetic fields) for the location where the separators are set up shall be provided. It should ensure that staff is not exposed to magnetic fields that are too strong.

The iron separator shall remove ferromagnetic materials that are contained in the flow of materials. In order to optimize the separator’s performance the device shall be designed with a pole shoe extension.

The permanent magnet shall create strong magnetic filed. A conveyer belt shall run over magnet and pick up ferrous material. As the belt moves away from magnetic filed, material shall dislodge
and fall into a chute. The belt of magnetic separator shall be manufactured to a reinforced design (at least 15 mm thick) with supports made of rubber or non-magnetic metal. The alignment of the belt shall be provided by fixed rollers on the side of the magnet.

The transfer chute shall be manufactured of antimagnetic material. This chute shall transport the metal scrap to the collection container. Especially this chute shall be designed in a way to prevent material blockages due to hook up of e.g. metal wires or conglomerates of metals and other parts.

The end section of the conveyors must be made in stainless steel.

The device shall be provided with support structures, which are height-adjustable to ensure the height of the devise can be adjusted over the conveyor belt.

The technical specifications are as follows:

- **Input material:** Dry Waste over the conveyor belt
- **Quantity (kg/day):** 50
- **Bulk Weight (kg/m³):** Approx. 100 - 400
- **Throughput Rate (Ton/hr.):** minimum 2.85
- **Type of magnet:** Permanent magnet
- **Belt Width (mm):** minimum 1000
- **Orientation:** In-line to feeding Conveyor
- **Direction of metal extraction:** In direction of feeding Conveyor
- **Separation Efficiency (%):** minimum 85 % of incoming Fe

- **Magnetic Field (center):**
  - At a distance of 300 mm to the belt(Gauss): minimum 800
- **Magnetic Field (side):**
  - At a distance of 300 mm to the belt(Gauss): minimum 350

**g. Baler with feed conveyor and Wrapping Unit**

A horizontal automatic baler press shall be provided along with a tilting device and bale-wrapping device.

Channel automatic baler

Recyclables handpicked in manual sorting station and collected in the compartment storage area shall be taken to the horizontal automatic baler press, via a chain type feed conveyor.

The Baler must be equipped with an automatic draw cable, bale length measuring device, fully automatic strapping unit, automatically adjustable baler plate and an extension hopper along with the complete hydraulic system and control panel. The start, stop and emergency stop signal of the baler shall be integrated with the plant main control station.

For the baling of plastics, an automatically controllable pressure reduction must be provided. Wire-roll holders and wire un-coilers must be provided in an appropriate number.
corresponding to the number of tying wires. The baler also shall include an automatic cutting edge stamper, a belt charging hopper closed at the top with a safety curtain and a large-digit digital display for the bale length measurement and a comprehensive fault indicator in conjunction with the electronic controller. In addition, a bale chute from the opening edge of the baler channel to the surrounding level must be provided. It must be manufactured from sturdy sheet steel sections. The baler must be supplied complete with substructure, charging hopper, bale chute and wire roll stands. It should have option to vary the pressure as per the baling material and also the balelength.

The materials to be baled include:

a. Paper, card board, tetra packs
b. Flat plastics, foils, coated plastics
c. Plastic containers
d. Other light fractions from waste sorting
e. Cloth & textile
f. RDF fraction

The technical specifications are as follows:

Input material: Recyclables and RDF from Manual Sorting Station
Quantity (ton/day): Maximum 12
Bulk weight(kg/m³): Approx. 20 – 200
Throughput Rate (ton/hr.): Minimum 2.0
Bale press force (ton): Minimum 35.0
Bale Pressure: Adjustable
Bale Length (mm): Minimum 700, Adjustable
Bale size (mm x mm): 700 x 700,

Wrapping Unit:

The bales produced by baler press shall be wrapped in plastic foil and then stored in container storage yard for clean and aesthetic environment. The robust bale wrapper is placed at the end of channel baler. The bales, from baler outlet shall be send to the wrapping unit via conveyor. The machine shall have unique roller system with two independently driven rollers that ensure a smooth and consistent bale rotation. A “rotate after wrap” feature allows multi-positioning of wrapped square bales. This size shall be matching with the size of the Bale produced by Baler Machine.

The turntable shall rotate and the film shall lead through the pre-stretcher unit to the bale. On each rotation of the table, the oscillation rollers shall carry the bale, which are driven via a center gearbox, which rotates an exact turn turning the bale as well. This principle brings the right overlap of film on the bale, which guarantees a tight close bale. At the end of the cycle the bale shall be taken off and the machine is ready to be loaded again with the next bale.

The wrapping unit shall have a hydraulic cut and tie system, which shall automatically cut the film at the end of the wrapping cycle and hold the film for the next bale. In case of a film break or film is finished, machine stops. So the film can be fixed again and the bale will be wrapped properly.
No bale will leave the machine without the adjusted amount of film. An automatic electronic control panel shall be provided for local operation.

The technical specifications are as follows:

Input material: Bales from Baler outlet
Throughput Rate(ton/hr.): minimum 2.0
Theoretical Throughput (bales/hr.): minimum 10.0
Bulk weight(kg/m³): app. 250 - 350
Size of the bale mm (H X W): 700 x 700 to 1100 x 1100

Length of the bale (L) mm: 700 – 1700, variable
Weight of the bale (Kg): 250 to 900
Film Width (mm): 750

h. Shredder

A single shaft, low speed shredders shall be provided having a high throughput rate, a well thought-out construction and reliable operation.

Shredder shall have following features:

- Sturdy construction,
- High throughput rates for very reliable, easy to use
- Easy maintenance and wide range of possibilities for use

The shredder shall be provided with its own feed hopper and a conveyor belt. The feed hopper shall have a height of not more than 1 m for easy feeding via bobcats/wheel loaders. The shredder shall be used to shred the following items as applicable,

- Plastic
- Plastic bottles
- Cloth
- Thermocoal sheets
- Cut tyre pieces (Whole tyres shall be manually cut to 200 x 200 mm size before feeding)
- Wood, branches
- Vegetable green waste prior to composting

The technical specifications are as follows:

Bulk Weight(kg/m³): Approx. 150 – 200
Throughput Rate (ton/hr.): Minimum. 3
Hopper Opening (mm): 800 x 1000
Hopper Volume(m³): 5.0
Size of input (mm): 50 to 300 mm
Feeding method: Continuous with conveyor belt
Size of output material (mm): maximum 30, small percentage of Over-size possible
Anti vibration pads: To be provided

**Material of construction:**

Blades: Hardox
Housing: Alloy steel

i. Conveyors

The waste shall be conveyed from one processing unit to another with the help of conveyors. Conveyor type and capacity shall be provided as per the following minimum sizes provided in the table below,

9.2 Table for conveyor sizing (Minimum sizing):

<table>
<thead>
<tr>
<th></th>
<th>From</th>
<th>To</th>
<th>Type of conveyor</th>
<th>Feed Input</th>
<th>Density of material</th>
<th>Width/Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dry Line</td>
<td>Dry feed hopper bunker with bag opener</td>
<td>Lamella screen</td>
<td>Trough conveyor</td>
<td>3</td>
<td>200</td>
</tr>
<tr>
<td>2</td>
<td>Lamella Screen-</td>
<td>Manual sorting station</td>
<td>Sorting conveyor (Slide Roller Belt)</td>
<td>2.5</td>
<td>200</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td>over fraction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Secondary in feed</td>
<td>Sorting Conveyor</td>
<td>Trough conveyor</td>
<td>1</td>
<td>750</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td>Glass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Secondary In feed</td>
<td>Shredder</td>
<td>Chain Belt Conveyor</td>
<td>3.5</td>
<td>250</td>
<td>1200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Shredder</td>
<td>Container</td>
<td>Chain Belt Conveyor</td>
<td>3.5</td>
<td>350</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Sorted Recyclables compartments</td>
<td>Baler</td>
<td>Chain Belt Conveyor</td>
<td>3.5</td>
<td>100</td>
<td>1200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Baler</td>
<td>Wrapping unit</td>
<td>Roller Conveyor</td>
<td>3.5</td>
<td>250</td>
<td>850</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Wrapping unit</td>
<td>Output</td>
<td>Roller Conveyor</td>
<td>3.5</td>
<td>250</td>
<td>850</td>
</tr>
</tbody>
</table>

j. Conveyor specifications
s. Trough conveyors

The trough conveyor shall be designed for transporting middleweight to heavy material. When heavy material is transported, extra impact plates shall be placed in the in-feed section of the conveyor.

The conveyor shall consist of a driven- and a tail section. Between these two sections the conveyor shall be built from sectional modules. The modules shall be laser cut and constructed of strong 5 mm sheet metal.

At the in-feed, the conveyor shall be provided with 4 mm thick side plates. These side plates shall be equipped with hatches for cleaning. The left – and right side frames shall be connected with each other with idler sets and steel supports plating. At all in-feed positions of the conveyors there shall be chutes to guide the material away from the side of the belt. These are constructed in 2 mm sheet metal.

A motor and gearbox shall drive the conveyor belt. It shall be mounted directly on the drive drum shaft.

**Driven section:**

The side plates of the drive section shall be made of 5 mm steel sheet metal.

The drive drum shall be of minimum Ø 250 mm in diameter. This drive drum shall be covered with 8 mm rubber, ETR70 or equivalent, to improve traction of the belt. A scraper, with HDPE wear resistant scraper blade, shall be placed beneath the drive drum.

**Tail section:**

The side plates of the tail section frame shall be made out of 5 mm steel sheet metal. For safety reasons, the tail section shall be totally closed. The top is closed with a cover.

The tail drum shall be of minimum Ø 250 mm in diameter. To clean the tail section a cleaning hatch shall be placed on both sides of the steel side frame. The tail drum shall be placed in take-up bearing unit with stretcher frames to easily stretch the rubber belt accordingly. A plough scraper, with wear resistant HDPE scraper blade, shall be placed right before the tail roller to clean material away from the inside of the belt.

**Conveyor belt and rollers:**

The rubber surface shall slide over steel trough rollers with a diameter of minimum Ø 89 mm. 3 trough rollers will shape the trough form. For the 650 mm wide or less than 650 mm wide conveyor, 2 x Ø 89 mm trough rollers can also be used.

In the return path of the conveyor return rollers shall be provided. These rollers shall have a diameter of Ø 89 mm and a wall thickness of 3 mm. The roller shall be with rubber donuts (No rubber donuts are required when using cleats or chevron), and minimal outer diameter of Ø 133 mm. This is to prevent sticking of material on the rollers and to align the return
rollers. The conveyor shall be stretched on the right tension with the 2 take-up bearings with stretcher frames in the tail section. The standard conveyor belt shall have a top-layer of minimal 3 mm. It has minimal 2 internal layers and an under-layer of minimal 1,5 mm. The belt shall be wear resistant. It shall have a minimum breaking strength of 250 N/mm²

**Maintenance:**

Access points shall be provided to the closed conveyors for ease of cleaning and maintenance.

To exchange the rubber belt for a new fully sealed one, the rear drum section should be fully removable to replace the belt. In case the belt must be vulcanized, this should be done in the middle section of a conveyor. The motor shall be shaft mounted.

**Specifications:**

- **Power:** Electric motor with gear box
- **Support:** The conveyor shall be supported on a steel frame
- **Bottom Covers:** included, Galvanized steel or UV resistant plastic
- **Frame:** Mild Steel Epoxy painted
- **Idler sets:** Mild Steel Epoxy painted
- **Idler rollers:** Mild Steel, Ø89, galvanized
- **Return rollers:** Mild Steel, Ø89, galvanized, provided with rubber donut rings
- **Drive drum:** Convex, Mild Steel Ø250mm, or bigger depending on length, width and inclination
- **Drum Coating:** Grey aluminum – RAL9007 covered with 8mm rubber ETR70
- **Tail drum:** Convex, Mild Steel Ø250mm, or bigger
- **Drum Coating:** Grey aluminum – RAL9007
- **Conveyor belt:** Minimal EP400/3 3+1,5Y or equivalent
- **Plough scraper:** provided
- **Drive drum scraper:** provided

**b. Side roller belt conveyors**

The rubber surface shall slides over a steel roller with a minimum diameter of Ø89 mm in the middle. At both sides, the rubber belt shall slide over a sheet metal plate. These sheet metal plates are bent, which shapes a trough form. The transported material shall lie in the middle of the conveyor, and will not flow under the side sealing. Because the rubber belt slides over the sheet metal of the complete conveyor length, less material flows under the side sealing than by traditional trough and roller conveyors.

The side plating where the rubber belt slides on, shall be closed completely to the top of the side guiding. This is to prevent material to drop off the belt. At the drive side of the conveyor a labyrinth-seal shall be provided. This means that the sealed side guiding follows the belt all the way to the drive drum. The drum shall lie within the belt and the side guiding shall be formed just like the drum. The belt itself thus seals the conveyor. Wrapping materials shall not wrap around the shaft of the driven drum.
The construction of the conveyor shall be completely modular and laser cut. That means that it shall be built from sections of several lengths. Adding or subtracting sections could alter the length in time. The material of the frame shall have 5mm thick. The frame shall be with a fixed pattern of holes where side guiding could be placed.

This is also possible for chutes on the side guiding or bottom connections.

**Driven section:**

The side plates of the drive section shall be made of 5 mm steel sheet metal, laser cut. The drive drum shall be of minimum Ø250 mm. This drive drum shall be covered with 8mm rubber, ETR70 or equivalent, to improve traction of the belt. A scraper, with HDPE wear resistant scraper blade, shall be placed beneath the drive drum.

**Tail section:**

The side plates of the tail section frame shall be made out of 5 mm steel sheet metal, laser cut. For safety reasons, the tail section shall be totally closed. The top shall be closed with a cover. The tail drum shall be of minimum Ø250 mm in diameter.

To clean the tail section a cleaning hatch shall be placed on both sides of the steel side frame. The tail drum shall be placed in take-up bearing units with stretcher frames to easily stretch the rubber belt accordingly. A plough scraper, with HDPE wear resistant scraper blade, shall be placed right before the tail roller to clean material away from the inside of the belt.

**Specifications:**

- **Power:** Electric motor with gear box
- **Support:** The conveyor shall be supported on a steel frame
- **Bottom Covers:** included, Galvanized steel or UV resistant plastic
- **Frame:** Mild Steel Epoxy painted
- **Idler sets:** Mild Steel Epoxy painted
- **Idler rollers:** Mild Steel, Ø89, galvanized
- **Return rollers:** Mild Steel, Ø89, galvanized, provided with rubber donut rings
- **Drive drum:** Convex, Mild Steel Ø250mm, or bigger depending on length, width and inclination
- **Drum Coating:** Grey aluminum – RAL9007 covered with 8mm rubber ETR70
- **Tail drum:** Convex, Mild Steel Ø250mm, or bigger
- **Drum Coating:** Grey aluminum – RAL9007
- **Conveyor belt:** Minimal EP400/3 3+1,5Y or equivalent
- **Plough scraper:** provided
- **Drive drum scraper:** provided
The conveyor shall consist of a drive- and a tail-section. Between these 2 sections the conveyor shall be built from sectional modules. The modules shall be laser cut and constructed of strong 5mm sheet metal. At the infeed the conveyor shall be provided with 3 mm thick side plates. These side plates are equipped with hatches for cleaning. The left –and right side frames shall be connected with each other with steel supports plating. The steel cleats, the rubber belt, support and transport chain shall be integrated in one system. The rubber belt shall be supported with steel square profiles. At both ends of these steel square profiles, special plates shall be welded which are bolted to the chains. Together with the sidewalls it shall work as a Labyrinth seal.

The rubber belt shall be placed between the steel cleats and the steel square profiles. The steel cleats shall be fastened to the profiles. At all infeed positions of the conveyors, chutes shall be provided to guide the material away from the side of the belt. These shall be constructed of 3 mm steel. A high-end quality drive motor shall drive the conveyor belt. It shall be mounted directly on the drive drum shaft.

A very high structural strength chain, minimum 2 chains, each 112,000 N shall be provided, resulting in a break load of 25 Tons total. The pitch of the chain shall be 100mm, which implies that there shall be 10 rollers per m per chain. This will result in less wear and tear per roll and smoother running of the belt. The rollers shall be of 70mm in diameter and run on wear resistant exchangeable manganese plates that are mounted on the frame. Top alignment is done in upward curves.

The chain sprockets shall have 10 teeth to guarantee smooth running. The chain tensioning is equipped with a spring to prevent tension peaks on the chain and also makes the adjustment less frequent.

All bearings shall be self-adjusting to prevent misalignment of the bearings.

On an up going chain conveyor, the motor shall have a brake to prevent running backwards. The 5 mm strong base frame shall be modular, so it can be extended when necessary. The side guiding’s shall be bolted on top of the base frame, so for maintenance, the side guiding’s can be taken off and the chain is made available.

**Specifications:**

- Chain type: DIN8168 hollow pin chain MC112, galvanized
- Chain roller diameter (minimum): 70 mm
- Wear resistant slide plates: The chain slides over S355/ equivalent flat steel
- Belt: Rubber, EP 250/2 3+1,5 / equivalent- with steel carriers 30 mm high border, flex is vulcanized on both sides of the rubber belt.
- Speed of belt: 0.2 m/min, 50 Hz
- Cover plates: 1.5 mm steel plates are mounted under the conveyor for safety till 2400 mm high.
The conveyor shall consist of a driven- and a tail section. Between these two sections, the conveyor shall be built from sectional modules. The modules shall be laser cut and constructed of strong 5mm sheet metal.

The 5mm strong base frame shall be modular, so that it can be extended when necessary. The sidewalls shall be bolted on top of the base frame, so for maintenance, the side guiding’s can be taken off and makes the chain available.

The left and right side frames shall be connected with each other with steel supports plating. The steel cleats, the rubber belt, support and transport chain shall be integrated in one system. The rubber belt shall be supported with steel square profiles. At both ends of these steel square profiles special plates shall be welded which are bolted to the chains. Together with the sidewalls it shall work as a Labyrinth seal.

The rubber belt shall be placed between the steel cleats and the steel square profiles. The steel cleats shall be fastened to the profiles. A high-end quality drive motor shall drive the conveyor belt. It shall be mounted directly on the drive drum shaft. A very high structural strength chain, minimum 2 chains, each 112,000 N shall be provided, resulting in a break load of 25 Tons total.

The pitch of the chain shall be 100mm, which implies that there shall be 10 rollers per m per chain. This will result in less wear and tear per roll and smoother running of the belt. The rollers shall be of 70mm in diameter and run on wear resistant exchangeable manganese plates that are mounted on the frame. Top alignment is done in upward curves. The chain sprockets shall have 10 teeth to guarantee smooth running. The chain tensioning shall be equipped with a spring to prevent tension peaks on the chain and also makes the adjustment less frequent. All bearings shall be self-adjusting to prevent misalignment of the bearings. On an up going chain conveyor, the motor shall have a brake to prevent running backwards.

The steel frames, supports shall be hot-dipped galvanized to ensure protection against corrosion.

Specifications:

- Chain type: DIN8168 hollow pin chain MC112, galvanized
- Chain roller diameter (minimum): 70 mm
- Wear resistant slide plates: The chain slides over S355/ equivalent flat steel
- Belt: Rubber, EP 250/2 3+1,5 / equivalent - with steel carriers 30 mm high border, flex is vulcanized on both sides of the rubber belt.
- Speed of belt: 0.2 m/min, 50 Hz
- Cover plates: 1.5 mm steel plates are mounted under the conveyor for safety till 2400 mm high.

### Screw Conveyor

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116
Screw conveyors shall be designed with or without shafts. Unless otherwise stated in the technical specifications, the decision is left to the bidder. Depending on the assembly situation, the trough is to be designed in parts to allow later replacement.

The following applies in general to screws with U-shaped troughs:

The trough must have a minimum wall thickness of 4 mm and be equipped internally with a replaceable cladding made of wear-resistant steel (at least HBW 400) at least 4 mm thick (alternatively: 8 mm HDPE). The end panels of the trough shall be made of steel plate at least 10 mm thick. In so far as the screw must be designed as sealed according to the technical specifications, the U-shaped trough shall be closed off with cover plates of dust- and weather-proof construction.

The screw's bearings may only be designed as externally located roller bearings. The screw core shall be made from a suitably rigid tube of a minimum grade of material of SS304. The weld on end journals shall also to be made in at least this grade of steel. The screw flight shall be made of wear-resistant steel (at least HBW 400) at least 10 mm thick. With core-less screws, the screw threads shall be made from flat steel with a minimum cross-section of 60 x 20 mm and of a minimum grade of steel of SS304. With core-less screws that have bearings on only one side, lengthwise anti-wear strips made of wear-resistant steel (min. HBW 400) shall be fitted in the screw trough. The screw pitch and annular gap shall be specified by the supplier.

The drive shall be provided, as required, by means of a shaft-mounted geared motor or with a chain drive and geared motor.

The screw trough or screw tube shall be equipped with the intakes and outlets required according to the installation plan. A standardised round flange or square flange shall be fitted to every intake and outlet. Where required, suitable expansion joints are to be supplied.

9.4 Details of the other associated miscellaneous units

Other Miscellaneous Common Facilities

The other common facilities as planned for the functioning of the ISWM facility are as follows,

1. Sheds for the following areas
   1. Material Recovery Centre
   2. Composting Shed along with bag storage area
   3. Construction debris storage shed
   4. E-Waste storage shed

2. Building for the following units,
   1. Administration building
   2. Resource centre
   3. Facility Centre
4. MCC cum Central control room
5. Sludge dewatering building
6. Biogas Genset building
7. HT Substation cum metering room
8. Drivers rest room
9. Work shop and spares room
10. Security cabin
11. Weigh bridge control station

3. Other infrastructure works,
   1. Internal roads, plant drains and storm water drains
   2. Parking terminal for trucks and visitors vehicles
   3. Container storage yard
   4. Truck washing area
   5. Non-useable area fencing with gates at suitable location
   6. In-Plant landscaping
   7. Fire fighting system
   8. Bore well system
   9. Underground water storage tank with pumps, Fire water tank with pumps
   10. Elevated service reservoir
   11. Flushing water system with hydro-pneumatic pumps and lockable valves at every 30 m

4. Mobile equipment’s,
   1. Wheel Loaders – 1 No.
   2. Skid Stir loader – 2 Nos.
   3. Fork lifts – 2 Nos.
   5. General site vehicle – 2 Nos.
   6. Open Trucks – 2 nos.

a. Specifications for shed
   **Self-Supported Roofing System**

Sheds of suitable size as mentioned in the general arrangement drawings, and as per specs in Volume -2, shall be provided to accommodate all the units, equipment and accessories as required for the process operation. It shall be an energy-efficient, arch-shaped structure without trusses, purlins or ancillary supports based on the new-age self-supported roofing technology.

Panel, fabricated from of high quality, high grade, pre-coated Galvalume (steel) sheets shall be used for roofing without trusses, purlins or ancillary supports. Its arch-shaped profile shall be so designed as to make the Panel structurally strong to withstand all required loads.

It shall have the following features:
Onsite fabrication & installation.
Free from holes, nuts, bolts, overlap or sealants.
Zero maintenance.
Resistant to damage and corrosion.
100% leak proof.
Free from bird nuisance.
Strong aesthetic appeal.

The Shed should be so designed as to ensure easy installation / operation of equipments, free movement of vehicles and effective handling of materials inside. Columns (RCC/Steel), Roads, Pathways, Stairs, Platforms, Cabins, Containers etc. should be planned and provided accordingly. It shall be covered at all sides as per the general arrangement drawings, and Collapsible Gates / Shutters shall be provided at suitable locations for entry / exit of vehicles. It shall be provided with Gutters (RCC / FRP) at both sides with Rain Water Pipes at suitable intervals, Skylights for natural lighting, Turbo ventilators for ventilation and Hangers for installation of electrical fixtures. An elevated Control Station made of Glass and consisting of Viewing Gallery, PLC/SCADA Cubicles etc. shall be provided in the Shed at a suitable location from where watching, monitoring and controlling all the major Units / Equipment’s in the particular shed can be done.

b. Buildings
Buildings shall be RCC framed structures with brick masonry and designed as per relevant IS Codes, building byelaws and recommendations of equipment manufacturers.

c. Infrastructure Work
The Scope of Work under Infrastructure shall consist of the following Units / Works: specifications shall be as mentioned below,

a. Internal roads and storm water drains
b. Plant drains, flushing water connections
c. Truck and Vechile parking area
d. Fencing of non-useable plot area
e. Bore well, elevated service reservoir and water distribution network
f. In-plant garden requirement and landscaping. Prior approval for gardening and landscaping shall be taken by the GSIDC’s engineer-in-charge.
g. Fire fighting system

d. Roads & Pathways
Suitable Internal bituminous roads & paved pathways for easy movement of transport vehicles, operation & maintenance, loading and unloading of materials and as required for approach to all Units / Equipment’s shall be provided.

e. Storm Water Drains
Storm Water Drains shall be provided, on one or both sides of the Roads with sufficient numbers of Cross Drainage works, all along the Periphery Roads / Compound Wall. Based on contour levels,
adequate number of disposal points shall be provided into the quarry pits at the ultimate boundaries of the plot for discharge of rains / storm water during monsoon.

f. Truck and Vehicle Parking Area

A Truck Terminal, sufficient to park 30 Nos. of Trucks at a time, shall be provided at the backside of the Facility. It shall consist of a Drivers rest room; Truck parking lots, Truck washing platform with drain all around. The truck washing system shall include pressurized jet washing equipment, for cleaning the trucks before the leave the facility. Treated effluent shall be used for this purpose.

A Vehicle Parking Area, sufficient to park 15 Nos. of cars and 30 Nos. of motorcycles at a time shall be provided near entrance of the facility and in the vicinity of the Administration Building. Heavy duty, interlocking, colored paver blocks shall be provided in the Parking Area.

g. Fencing with Gates

The non-useable area of the plot shall be fenced as per the approved layout. Entry gates will be provided at 2 locations, out of which one shall be used for disposal of construction debris. The same has been marked on the “Indicative Layout” and specifications enclosed with the tender document as per Volume 2- General specifications

h. Raw water Tanks and Water Distribution Network

The incoming water connection at the plant battery limits as well as the bore well shall be terminated in an underground tank, from where it shall be pumped into an elevated service reservoir (ESR). Raw water from the ESR shall be supplied to all buildings for human consumption, bathing, use in the canteen etc. purpose.

i. Treated effluent

All other water requirements (other than human consumption) in the facility like flushing, floor/equipment/truck/container washing, gardening, buffer zone maintenance, fire water requirement etc. shall be met by the treated recycled effluent. The treated effluent shall be stored in a permeate tank from where it will be pumped using hydro pneumatic pumps connected to a close loop flushing line. Tapings for flushing water connection, with lockable valves shall be provided at every 30 m. Further flushing water line will be painted with proper color coding and proper signage “Water not suitable for drinking” at adequate locations.

j. Firewater

An underground firewater tank shall be provided for storing firewater. This tank shall have provisions for taking water from the permeate storage tank via the treated effluent pumps as well as the raw water and bore well water line. The tank shall be always kept in a fully filled condition. Firewater pumps shall be provided to pump water into the fire water line with suitable hydrant connections as per the firewater specifications.

k. Plantation / Gardening / Landscaping

Plantation/Gardening Landscaping within the plant useable area shall be provided as per the “Landscaping Scheme”, designed in consultation with landscaping professionals.

A Water Distribution Network consisting of Gardening Water Sump, Pumps and Piping etc. shall be
provided for watering trees, flower plots and other grass covered landscape.

A drip irrigation system shall be provided for the buffer green belt area. Treated effluent shall be used for the meeting all gardening/irrigation requirement. Adequate number of irrigation hydrants shall be suitably located so that all the “Greenbelt Area” can be watered.

I. Fire fighting system

A separate fire-water tank of adequate capacity shall be provided at the battery limit of the facility. The firewater tank shall always be in a fully filled up condition and will have suitable type, capacity and number of firewater pumps installed in a separate firewater pump house. The fire fighting system comprising firewater tank, pumps, etc. shall be designed as per fire fighting guidelines and specifications mentioned under the general specification. Fire water pipe lines of adequate size shall be provided covering the entire useable plant area, with proper water tapping’s and fire water hydrants/hoses to ensure complete working area is properly accessed with fire water in case on any emergency. Further, each building will have adequate fire hydrants and sand buckets.

9.5 Control and Automation philosophy for plant operation

General

The complete plant shall be designed for automatic operation through a Programmable Logic Control (PLC) and Supervisory Control and Data Acquisition (SCADA).

This shall be achieved by individual equipment PLCs, digital controllers with human machine interface (HMI). These individual PLCs or digital controllers shall be integrated with main PLC and SCADA for centralized control and monitoring.

The main PLC will be located in central control room.

The plant shall have provision for operations in following modes –

1. Automatic – Auto operation through PLC/digital controller.
3. Local – Local operation through local control panel located near equipment.

It is essential that the all PLC’s and digital controllers shall communicate to central PLC and SCADA through Modbus protocol. For communication, a cable can be used, depending upon its signal carrying distance, however if cabling distance between two systems is more than its signal carrying capacity or 50 meters (whichever is less), fiber optic cables shall be used.

Remote monitoring

The SCADA shall be equipped with provision of remote monitoring to enable the plant monitoring from any remote location.

Emergency and Isolation of equipment

Emergency push buttons shall be provided in the proximity of each equipment for emergency stop of the equipment. The automation system shall generate audio-visual alarms in case any of the emergency push buttons are activated. These emergency push buttons will also be used for
isolation of various equipment during maintenance mode.

**Audio Visual Alarms**

Alarms shall be audio, visual in nature and shall be provided for normal service conditions and emergency or equipment trip condition.

These alarms shall be initiated at equipment, local control panel and central control room.

**9.4.1 Brief Description of Operation and Control of Equipment**

**a. Dry Waste Processing Line**

**Process sequence**

Dry waste feed Hopper with conveyor -> Metering drum/Bag opener -> Conveyor (dry waste feed hopper to Lamella screen) -> Lamella screen -> Manual sorting Conveyor -> Conveyor (glass feed hopper to Manual sorting conveyor) -> Magnetic separator -> Conveyor (Manual sorting station to Baler) -> Baler -> Bale wrapper

1. **Dry waste feed hopper with conveyor**

The color wise sorted bags as well as dry waste from open trucks / compactors will be put in dry waste feed hopper, which conveys the bags to lamella screen via metering drum/bag opener.

The dry waste feed hopper shall have 3 (three) numbers of ultrasonic level sensors. These level sensors will be mounted at start, middle and end of the hopper. Considering cumulative input from 3 numbers of level sensors the automation system shall generate an audio-visual alarm in case of dry waste feed hopper is full or empty.

If hopper is full; further waste bags shall not be loaded in it.

If hopper is empty then the bag opener, conveyor, lamella screen, manual sorting conveyor shall stop after a pre-set time, and this pre-set time shall be editable in HMI of automation system for dry waste processing line.

A conveyor carries the dry waste from feed hopper to the lamella screen.

This conveyor shall have variable speed; the control to change the speed shall be provided in HMI. Also the speed of conveyor shall reduce to a preset speed (editable in HMI), a switch shall also be provided for varying the speed of the conveyor in manual sorting line which will alter the speed if it is difficult to carry out sorting activity.

The conveyor shall also have an overload sensing arrangement. If hopper is overload/trip then automation system shall generate an audio-visual alarm. Further the conveyor, lamella screen, manual sorting conveyor shall stop after a pre-set time; this pre-set time shall be editable in HMI of automation system for dry waste processing line.
2. **Metering drum/Bag opener**

Bag opener shall stop its operation automatically if the feed hopper is empty.

Metering drum/Bag opener shall have overload sensing arrangement.

If bag opener is at fault or not working downstream units (conveyors, lamella screen) shall stop after a pre-set time, this pre-set time shall be editable in HMI of automation system for dry waste processing line.

3. **Conveyor (dry waste feed hopper to Lamella screen)**

This conveyor will carry loose dry waste from bag opener to lamella screen.

The conveyor shall have sway switch, if activated automation system shall generate an audio-visual alarm. Also Conveyor shall stop immediately.

Conveyor shall have overload sensing arrangement. If conveyor is overload or not working then automation system shall generate an audio-visual alarm.

Further all units on the downstream side (bag opener, lamella screen, manual sorting conveyor, magnetic separator) shall stop automatically after a pre-set time; this pre-set time shall be editable in HMI of automation system for dry waste processing line.

4. **Lamella screen**

Lamella screen will sort larger sized fraction, which will lead to the manual-sorting conveyor, and smaller sized fraction that will be fed to the wet feed hopper bunker.

Lamella screen shall have overload sensing arrangement. If Lamella screen is overload or not working, then automation system shall generate an audio-visual alarm. Further all units upstream as well as downstream of the screen (upstream units – feed hopper, bag opener and conveyor, downstream units - manual sorting conveyor, magnetic separator) shall stop automatically after a pre-set time; this pre-set time shall be editable in HMI of automation system for dry waste processing line.

5. **Conveyor (glass feed hopper to Manual sorting conveyor)**

A separate conveyor will carry glass waste to the manual sorting line. The selection of this conveyor shall be done manually in HMI. Option shall be provided in the HMI, to keep the manual-sorting belt “on” in case this conveyor is “on” and the dry waste feed hopper , bag opener or lamella screen are switched off.

Conveyor shall have overload sensing arrangement. If conveyor is overload or not working then automation system shall generate an audio-visual alarm. Further in case this feed conveyor and also the dry waste feed conveyor units are “off”, manual sorting conveyor shall stop automatically after a pre-set time; this pre-set time shall be editable in HMI of automation system for dry waste processing line.

6. **Manual sorting conveyor**

Manual sorting conveyor shall have variable speed; the same shall vary automatically as per speed fed in HMI.
The conveyor shall have sway switch, if activated automation system shall generate an audio-visual alarm. Also conveyor shall stop immediately.

Conveyor shall have overload sensing arrangement. If conveyor is overload or not working then automation system shall generate an audio-visual alarm. Further all upstream and downstream units (Upstream units – Feed hopper, bag opener and Lamella screen downstream units – magnetic separator) shall stop automatically after a pre-set time; this pre-set time shall be editable in HMI of automation system for dry waste processing line.

At every sorting station a Lockable emergency stop push button and emergency stop cord above head height shall be provided, when activated the entire system shall be stop immediately. This is to ensure safety of the operators.

7. Iron separator
Iron separator conveyor shall be interlocked with the manual sorting conveyor such that iron separator conveyor shall start and stop with manual sorting conveyor.

Conveyor shall have overload sensing arrangement. If conveyor is overload or not working then automation system shall generate an audio-visual alarm.

8. Conveyor (Manual sorting station to Baler)
Manually sorted material from compartments will be loaded on this conveyor by means of skid stir loader. Operation of this conveyor will be independent to the manual sorting station.

The selection to On/Off this conveyor shall be from HMI of automation system for dry waste processing line. When switched on baler shall start its operation automatically and when switched off baler shall stop its operation automatically after a preset time; this pre-set time shall be editable in HMI of automation system for dry waste processing line.

9. Baler
The hopper of baler shall have level sensing arrangement. The automation system shall generate an audio-visual alarm in case of hopper is full or empty.

If hopper is empty then Baler shall stop its operation, which in turn will switch off the feed conveyor. The baler will compact the waste for ease of transportation. Baler shall have overload sensing arrangement. If baler is overload or not working then automation system shall generate an audio-visual alarm.

10. Bale wrapper
Bale wrapper will be used to wrap the bale with plastic film to avoid spillage of waste during transportation. Bale wrapping will be manual and standalone operation.

b. Wet waste processing line

Process sequence
Wet tipping floor -> Wet feed hopper -> Bag opener -> Screw Conveyor (Bag opener to Organic extrusion press) -> Organic extrusion press/Organic extrusion press by-pass -> Screw Conveyor
(Wet fraction) -> Screw Conveyor (Organic extrusion press by-pass) -> Buffer tank -> Screw Conveyor (Buffer tank to Fermenter)

1. **Wet tipping floor**
Wet waste in bags as well as in open trucks / compactors will be dumped in wet tipping floor. The bags will be then moved to wet feed hopper by means of skid stir loader.

2. **Wet feed hopper**
Hopper will store wet waste bags as well as waste in open trucks / compactors to feed it to bag opener.

The hopper shall have level sensing arrangement; it shall have 3 numbers of ultrasonic level sensors. These level sensors will be mounted at start, middle and end of the hopper. Considering cumulative input from 3 numbers of level sensors the automation system shall generate an audio-visual alarm in case of dry waste feed hopper is full or empty. If hopper is full; further waste bags shall not be loaded in it. The automation system shall generate an audio-visual alarm in case of hopper is full or empty. If hopper is full; further wet waste bags shall not be loaded in hopper.

If hopper is empty then downstream units (bag opener, conveyors and Organic extrusion press) shall stop after a pre-set time; this pre-set time shall be editable in HMI of automation system for dry waste processing line.

3. **Metering drum/Bag opener**
Bag opener shall stop its operation automatically if wet feed hopper is empty.

Metering drum/Bag opener shall have variable speed; the same shall vary automatically as per speed fed in HMI. Metering drum/Bag opener shall have overload sensing arrangement. If bag opener is at fault or not working then all downstream equipment shall stop after a pre-set time, this pre-set time shall be editable in HMI.

4. **Screw Conveyor to Organic extrusion press**
This screw conveyor will carry wet waste from Bag opener to feed hopper of Organic extrusion press/by-pass. An additional arrangement shall be made in screw conveyor using a flap opening to by-pass Organic extrusion press and divert the content on secondary screw Conveyor. The secondary screw conveyor shall carry wet waste to storage bunker. The opening of flap shall be operated manually.

Conveyor shall have overload sensing arrangement. If conveyor is overload or not working then automation system shall generate an audio-visual alarm. Further Bag opener shall stop automatically. Also screw conveyor (wet fraction) and screw conveyor (buffer tank to Fermenter) shall stop after a pre-set time; this pre-set time shall be editable in HMI.

5. **Organic extrusion press**
Organic extrusion press hopper will store wet waste to feed it to Organic extrusion press.
The hopper shall have ultrasonic level sensing arrangement. The automation system shall generate an audio-visual alarm in case of hopper is full or empty. If hopper is full, wet waste shall not loaded in hopper by stopping all upstream units.

If hopper is empty then organic extrusion press shall stop after a pre-set time, this pre-set time shall be editable in HMI of automation system for dry waste processing line.

The Organic extrusion press shall have necessary control system to ensure that all necessary feedbacks required from press are communicated to its PLC. On the basis of these feedbacks PLC shall take necessary action and control the operations of press.

If Organic extrusion press is not working then automation system shall generate an audio-visual alarm. Further all upstream and downstream units (Upstream units – wet in-feed hopper, bag opener, Screw Conveyor (Bag opener to Organic extrusion press), downstream units – screw conveyor (wet fraction)), shall stop automatically after a pre-set time; this pre-set time shall be editable in HMI of automation system for dry waste processing line.

6. Screw Conveyor (Wet fraction)

This screw conveyor will carry wet fraction from Organic extrusion press to Buffer tank.

Conveyor shall have overload sensing arrangement. If conveyor is overload or not working then automation system shall generate an audio-visual alarm. Further upstream units shall stop automatically.

7. Buffer tank and Screw Conveyor

Wet fraction from Organic extrusion press will be collected in buffer tank to feed it to the fermenter tank.

The buffer tank shall have level sensing arrangement. The automation system shall generate an audio-visual alarm in case of Buffer Tank is full or empty. If buffer tank is full then upstream units shall stop automatically. A screw conveyor will carry wet fraction from Buffer tank to Digester.

If buffer tank is empty then Screw Conveyor (Buffer tank to fermenter) shall stop after a pre-set time; this pre-set time shall be editable in HMI of automation system for wet waste processing line.

The screw conveyor shall have overload sensing arrangement. If conveyor is overload or not working then automation system shall generate an audio-visual alarm.

c. Bio-methanation system

1. Process sequence

Fermenter - > Sludge dewatering - > H₂S removal system - > Digestate tank - > Gas flaring system

2. Fermenter tank

The fermenter shall have level transmitter, temperature transmitter, and pressure transmitter and pH analyzer.
Level Transmitter – In case of high level the in-feed screw conveyor shall stop. In case of low-level sludge withdrawal pump shall stop.

Temperature Transmitter – It shall automatically control the flow rate of hot water pump through VFD, so as to maintain set temperature within fermenter. Hot water pumps shall pump water from hot water tank and shall be controlled via level transmitter. The hot water circuit shall have temperature indicator for inlet and outlet temperature.

Pressure Transmitter – It shall measure the gas pressure within fermenter and automatically divert the biogas either to H₂S removal system when pressure is normal or to the flare system in case of high pressure.

pH Analyzer – It shall measure and display the pH of the contents inside the fermenter. Alarms shall be generated in case of high or low pH, the set points for high and low pH shall be editable in HMI.

Fermenter agitator shall have overload sensing arrangement. If agitator is overload then automation system shall generate an audio-visual alarm.

The sludge dewatering pumps shall be operated based on level in fermenter.

3. Digestate Tank cum integrated gas holder

The digested tank shall have the following instruments,

Level transmitter (for liquid) – In case of high level an alarm shall be generated. In case of low level an alarm shall be generated and submersible mixers in digested tank shall stop. Also the recirculation pump and filter press feed pump shall stop.

Level transmitter (for gas membrane) – The volume of gas shall be calculated based on readings of level.

Pressure transmitter (for gas membrane) – A pressure transmitter shall be provided to measure the biogas pressure in gas dome. The blower shall be interlocked with pressure in gas dome. The set points to switch on and off the blower shall be editable in HMI.

Pressure transmitter (for gas inlet line) – A pressure transmitter shall be provided to measure the biogas pressure at gas inlet line. In case of high pressure automatic valve to flare shall open. The set point of high pressure shall be editable in HMI.

4. biogas Flaring system –

The flaring system shall have auto ignition system supported by LPG based pilot flame. Flaring system shall be automatic; it shall get activated when gas is release for flaring. If gas is released and flaring system fails to activate an audiovisual alarm shall be generated by automation system. This feature shall be controlled using a temperature monitoring system on flare stack.
5. Biogas Engine

It is envisaged to have separate PLC and HMI for Gas engine. The Gas engine PLC shall have ability to transfer system status data to Main PLC through Ethernet based Modbus protocol. The gas engine PLC shall have necessary interface with digestate tank instrumentation to ensure proper operation. All necessary automation as per standard manufacturer’s recommendation shall be provided.

d. Composting

Process sequence
Compost feed hopper -> conveyor (compost feed hopper to in-vessel composing drum) -> in-vessel composing drum -> conveyor (in-vessel composing drum to composing shed)

1. Compost feed hopper
   • Material for compost will be fed to hopper manually.
   • The hopper shall have level sensing arrangement the automation system shall generate an audio-visual alarm in case of dry waste feed hopper is full or empty. If hopper is full; further material shall not be loaded in it.

2. Conveyors feed as well as outlet
   This conveyor will carry wet waste from compost feed hopper to in-vessel composting drum. Conveyor shall have overload sensing arrangement. If conveyor is overload or not working then automation system shall generate an audio-visual alarm. The conveyor shall also have sway switch, if activated automation system shall generate an audio-visual alarm. Also Conveyor shall stop immediately.

3. In-vessel composting drum

Temperature Transmitter

The in-vessel composting drums shall have temperature transmitter for indication on HMI/SCADA.

Drum drive

Drum drive shall have overload sensing arrangement. If drum drive is overload then automation system shall generate an audio-visual alarm.

Blower drive

Blower drive shall have overload sensing arrangement. If blower drive is overload then automation system shall generate an audio-visual alarm.

4. Compost Screening

Feed hopper with conveyor

Material for compost will be fed to hopper manually by wheel loader / skid stir loader.
The hopper shall have level sensing arrangement the automation system shall generate an audio-visual alarm in case of dry waste feed hopper is full or empty. If hopper is full; further material shall not be loaded in it.

Conveyor shall have overload sensing arrangement. If conveyor is overload or not working then automation system shall generate an audio-visual alarm. The conveyor shall also have sway switch, if activated automation system shall generate an audio-visual alarm. Also Conveyor shall stop immediately.

5. Star Screen
Star screen will separate material above 10mm. Star screen shall have overload sensing arrangement. If screen is overload or not working then automation system shall generate an audio-visual alarm.

6. Weigh bridge
Weigh bridge computer shall have communication link with main PLC/SCADA. The data fed in weighbridge computer shall be made available on appropriate protocol to allow SCADA to generate reports.
Chapter 10.0

Design of Sanitary Landfill Facility
10.0 DESIGN OF SANITARY LANDFILL FACILITY

Sanitary Landfilling of non-biodegradable, non-recyclables, reject component of municipal solid waste is mandatory as per the MSW rules 2000. Therefore it is proposed to set up an integrated sanitary landfill facility for final disposal of the residual rejects from the ISWM facility.

In order to design the sanitary landfill facility, the base year for garbage generation has been taken as year 2013 and design year has been considered as 2040.

Base Year : 2013
Design Year : 2040
Operative Life of the Landfill - 25 Years

10.1 Waste to be handled

A detailed inventory survey & waste projections indicated that approximately 100 tons in the year 2040 of municipal solid waste will be generated daily in the corporation area.

Based on the various treatment sections, the various reject residue generated from the ISWM facility is listed in table 10.1 below, based on which the landfill has been designed.

Construction debris shall be diverted to the existing quarry pits after sorting of metal, wooden frames, panels, and other recyclable material.

Table 10.1: Quantum of residue/reject from the facility to the landfill

<table>
<thead>
<tr>
<th>Waste fractions</th>
<th>Quantum (TPD)</th>
<th>Residual Reject % to landfill</th>
<th>Total Rejects to landfill (TPD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Recyclable waste</td>
<td>19.0</td>
<td>20%</td>
<td>3.8</td>
</tr>
<tr>
<td>3 Bio-degradable waste</td>
<td>37.0</td>
<td>15%</td>
<td>5.6</td>
</tr>
<tr>
<td>4 Construction debris</td>
<td>33.0</td>
<td>0%</td>
<td>0</td>
</tr>
<tr>
<td>5 Mulched tree waste</td>
<td>11.0</td>
<td>0%</td>
<td>0</td>
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<tr>
<td><strong>Total (TPD)</strong></td>
<td><strong>100</strong></td>
<td></td>
<td><strong>9.4</strong></td>
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</tbody>
</table>

say 10 TPD

10.2 Estimation of Landfill Capacity, Landfill Height, Landfill Area

Method of Calculation

1. Current Waste Generation per Year = W (ton per Year)
2. Estimated rate of increase (or decrease) = X (percent)
   of waste generation per year (Use rate of population growth where waste generation growth rate estimates are not available)
3. Proposed Life of Landfill (in years) = n (years)
4. Waste Generation after n years
   \[ W \left( \frac{1+\frac{n}{100}}{100} \right)^n \text{ (tons per year)} \]

5. Total waste generation in n years (T) in tons
   \[ T = \frac{1}{2} \left[ W \left( \frac{1+\frac{n}{100}}{100} \right)^n \right] n \text{ (tons)} \]

6. Total volume of waste inn years (Vw) (on the assumption of 0.85 t/Cu.m density of waste)
   \[ V_w = \frac{T \text{ (cum)}}{0.85} \]

7. Total Volume of daily cover inn years (Vdc) (on the basis of 15 cm soil cover on top and sides for lift height of 1.5 m to 2 m)
   \[ V_{dc} = 0.1 V_w \text{ (Cum)} \]

8. Total Volume required for components of liner system and of cover system (on the assumption of 1.5 m thick liner system (including leachate collection layer) and 1.0 m thick cover system (including gas collection layer)
   \[ V_c = kV_w \text{ (Cum)} \]
   (k = 0.25 for 10 m high landfill, 0.125 for 20 m high landfill and 0.08 for 30 m high landfill. This is valid for landfills where width of landfill is significantly larger than height)

9. Volume likely to become available within 10 years due to settlement/biodegradation of Waste
   \[ V_s = mV_w \]

10. First estimate of landfill Capacity (Cf)
    \[ C_f = V_w + V_a + V_c - V_s \text{ (cum)} \]

11. Likely shape of landfill in plans and section (To be based on topography of area, depth to ground water table and other factors)

12. First Estimate of Landfill Height and Area
    (a) Restricted Area Available
       Area required for infrastructural facilities = 0.15 Ar
       Area available for landfilling = 0.85 Ar
       Average landfill height required (first estimate) above base level
       \[ H_i = \frac{C_f}{0.9 A_f} \text{ (Sq.m)} \] (Valid for area type landfill)
    
    (b) No limitation on Area
    Possible maximum average landfill Height (first estimate)
    \[ H_i \text{ (typically between 10 to 20 m, rarely above 30m)} \]
\[ A_i = \frac{C_i}{H_i} (\text{Sq.m})(\text{valid for area type landfill}) \]

Total Area required for landfilling separations (including infrastructural facilities) (first estimate)

\[ A_i = 1.15 A_i, \]

**BASIC DATA AND CALCULATION**

<table>
<thead>
<tr>
<th>No.</th>
<th>Input Waste (Inerts) (TPD)</th>
<th>Proposed Life of Landfill (in n years) (years)</th>
<th>No. of days per year (days)</th>
<th>Current Waste Generation per Year, W (TPY)</th>
<th>Estimated rate of increase (or decrease) (x) (%)</th>
<th>Waste Generation after n years, ( W_n = W \times \frac{(1+x)/100)^n}{100} ) (T/yr)</th>
<th>Total waste generation in n years, ( W_T ) (Tons)</th>
<th>Density of waste (T/m³)</th>
<th>Total Volume of waste in n years, ( V_w ) (m³)</th>
<th>K factor for liner</th>
<th>Total Volume of daily cover in n years, ( V_{dc} ) (m³)</th>
<th>k factor for liner</th>
<th>Total Volume of daily cover in n years, ( V_{dc} ) (m³)</th>
<th>Total Volume required for components of liner system and of cover system including leachate collection layer and including gas collection layer = ( V_c = k \times V_w ) (m³)</th>
<th>Volume likely to become available within n years due to settlement/biodegradation of Waste ( V_s = m \times V_w ) (m³)</th>
<th>First estimate of landfill Capacity, ( C_i = V_w + V_d + V_c - V_s ) (m³)</th>
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<tbody>
<tr>
<td>1</td>
<td>2.8</td>
<td>25</td>
<td>365</td>
<td>1022.0</td>
<td>5%</td>
<td>3460.85</td>
<td>56035.7</td>
<td>0.85</td>
<td>65924.3</td>
<td>0.25</td>
<td>6592.4</td>
<td>As per Manual k = 0.25 for 10 m ht, 0.125 for 20 m ht &amp; 0.08 for 30 m ht</td>
<td>16481.1</td>
<td>3296</td>
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</table>

Area Calculations

- Estimated waste volume, \( C_i \) = 85702 m³
- Ht of dump (h), provided = 10 m
Slope of the dump (1:3) | 3 m, typical as per manual
---|---
Bottom dimension, W, assumed | 88 m
Bottom dimension, L, assumed | 176 m
Bottom area (A) | 15488 m²
Top dimension | 28 M
Top area (a) | 3248 M²
Check volume of landfill | 86095 m³, OK
Area required for landfill | 15488 m²
Area required for infrastructure | 2323 m²
TOTAL AREA required | 17811 m²

The area for landfill shall be allocated in the acquired land.

Before starting implementation, topographic survey has to be conducted to arrive at the exact quantities of cutting & filling and giving proper shape to landfill/quarry, which will be used for the development of landfill facility.

**LANDFILL SECTION AND PLAN**

Landfill Section and Plan is evaluated on the basis of:

(i) 3:1 side slope for the above-ground portion of the landfill.
(ii) 2:1 side slope for the below-ground portion of the landfill.
(iii) Material balance for daily cover, liner and final cover material through excavation at site.
(iv) Extra space around the waste filling area for infrastructural facilities.

**LANDFILL PHASES**

(i) Active Life of the Landfill :: 25 years
(ii) Duration of one phase :: 5 years
(iii) Number of Phases :: 5 (each phase extends from base to final cover)

**LINER AND LEACHATE COLLECTION SYSTEM**

a. Liner System for inert Waste

The liner system will comprise of the following layers below the waste:

(i) 0.30 m thick leachate drainage layer comprising of sand (coarse sand) or gravel (stone dust with no fines)
(ii) 2.2 mm non woven geo textile protective layer (Buckling of membrane)
(iii) 1.50 mm thick HDPE geomembrane
(iv) 6.0 mm Geo clay liner (Clay Liners)
(v) 1.0 m thick amended soil
Note: Earlier clay liner was being used. Now Geo-Clay liner have been introduced reducing the thickness of liner

b. Leachate Evaluation
Average total precipitation : 3200 mm/year
Only one yearly cell is operative every year
Plan area of operating cell : 180000 sq. m/25 = 7200 m²
Assuming 80% precipitation in 4 months (monsoon period), peak leachate quantity (thumb rule basis):

\[ \text{(3200/1000)*7200*0.8/4/30 = 154 Cum/day} \]

While majority of this rainfall will be diverted to storm water drains, 30% shall also come as leachate = 46 m³/d

c. Leachate Collection Pipes
Dia. of HOPE pipes (perforated) : 315 mm main
 : 200 mm distribution

d. Leachate Holding Tank : 4.00 m dia. 6 m deep

COVER SYSTEM DESIGN

Cover System
The cover system will comprise of the following layer above the waste.

(i) 0.45 m thick gas collection layer comprising of gravel (stone dust with no fines)
(ii) 0.6 m thick barrier layer (sandy silt+ 5% bentonite)
(iii) 0.3 m thick surface layer of local top soil for vegetative growth

b. Passive Gas Vents
Passive gas vents 1 m high (above ground surface) will be provided at a spacing of 75m x 75m.

10.3 Monitoring Facilities
The soil, air and water in the area shall be continuously monitored for no contamination. Both sampling methods and non-sampling methods are adopted and monitored as per the monitoring plan for timely action to be taken before water contamination and leakage of gases into the soil. The facility is provided with a minimum four monitoring wells for soil water and gas measurements.

The monitoring requires lab testing and acquisition of all the instruments for such small quantity of waste will be un-economical. Therefore some tests could be conducted by common lab, whereas major tests like water quality monitoring viz-a-viz for metals used to be conducted through authorized laboratory.

Apart from the above, regular inspection and monitoring of important components of the landfill shall be done as per the schedule given below:
**Final Top Cover:** Once in a year and after each substantial rainfall it should be checked for any erosion, landslides, movement of soil, slope, etc.

**Vegetation:** Four times in a year a check should be made for existence of dead plants/trees. Any plant/tree found dead shall be removed immediately.

**Final Grade:** Twice a year should be checked for pending/logging of water. If any abnormalities found, slope should be corrected by putting soil

**Surface drains:** Four times a year and after each substantial rain should be checked for any blockages. Leaves, debris or any other accumulation found in the drain shall be removed immediately.

**Gas Monitoring:** As required in the Management Plan it should be checked for strong presence of odor. The gas monitoring equipment’s (compressor, pipes, flaring stand, etc) should be checked to ensure their workability as they might become inoperable due to high gas generation.

**Groundwater Monitoring:** As per the Action Plan. A regular inspection shall be done to check for any failures in the monitoring system.

**Leachate Management:** As required by the plan

**10.4 Determination of Equipment Requirements**

The landfill facility shall have minimum operating equipment for the construction stages and no earth moving machinery is planned as the work shall be done by engaging suitable contracting agency.

For the operations of daily cover the following nominal equipment shall be provided:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front-end loader/JCB</td>
<td>1 No</td>
</tr>
<tr>
<td>Diesel Generator</td>
<td>1 No</td>
</tr>
<tr>
<td>Vibro Compactor</td>
<td>1 No</td>
</tr>
<tr>
<td>Safety Equipments</td>
<td>1 Lot</td>
</tr>
<tr>
<td>Fire Fighting Equipment</td>
<td>1 Lot</td>
</tr>
</tbody>
</table>

**10.5 Design Life**

The landfill design life relates to active period, closure period and post closure period. The active period is the period in which actual filling takes place. In this case, this will be 25 years. The closure and post-closure period for which a landfill will be monitored and maintained shall be 25 years after the active period, which is not part of the scope of this project.
10.6 Construction and Operational Practice of Sanitary Landfill

The Construction and Operation of a landfill consists of the following steps:

1. Site Development
2. Phase Development
3. Phase Operation
4. Phase Closure
5. Landfill Closure: Not considered under the scope of this project

Site Development

The following construction activities are undertaken during site development:

1. Construction of perimeter fence and entrance gate
2. Construction of main access road near the entrance gate with parking area
3. Construction of main access road along the perimeter of the site and well as construction of arterial load to tipping area of the first phase.
4. Acquisition and installation of weighbridges
5. Construction of weighbridge room/office, administrative office and site vehicle cleaning area
6. Installation of direction signs, site lighting, fire fighting facilities, communication facilities
7. Construction of water supply and Waste water/sewage disposal system
8. Construction of main leachate pipe, tank and treatment facility
9. Installation of environmental monitoring facilities
10. Construction of gas collection pipe and treatment facility

Site Procedures

It is important to formalize and document the record keeping procedures as well as waste acceptance procedures to be followed at the landfill site.

Record Keeping

Records will be kept on a daily, weekly and monthly basis. In addition a site manual will be kept at the site office giving all site investigation, design and construction details - these are necessary as landfill design may get modified during the operational phase.

Site Manual: The site manual will contain the following information:

a. Data collected during site selection
b. Environmental impact assessment report
c. Site investigation and characterization data
d. Detailed topographical map
e. Design of all landfill components
f. Landfill layout and its phases

g. Construction plans

h. Details of Leachate Management Plan

i. Details of Gas Management Plan

j. Environmental Monitoring Programme

k. Closure and Post - Closure Plan

l. All permissions/Licenses from concerned authorities.

Site Report: The daily, weekly and monthly reports will comprise of the following:

a. Weighbridge data (daily inflow and outflow for each vehicle)
b. Waste inspection data (daily)
c. Materials, stores etc. (daily)
d. Bills / Accounts (daily)
e. Visitorrecord(daily)
f. Complaints record from nearby areas (daily)
g. Topographic survey at operating phase (daily I weekly)
h. Photographic record at operating phase (daily I weekly)
i. Environmental monitoring data (weekly I monthly)
j. Waste filling plan and actual progress i.e. cell construction (daily / weekly) and review
k. (monthly)
l. Leachate generation and gas generation (weekly/ monthly I extreme events)
m. Weather / climatic (extreme events)
n. Accidents etc. (adhoc.)
o. Others

Waste Inspection Procedure

p. Each vehicle carrying the waste must be checked for:

q. Incoming weight (full)
r. Outgoing weight (empty)
s. Availability of relevant documents
t. Visual check at weigh - in (if feasible)
u. Visual inspection after discharge at tipping area (inspection report to be filed for each vehicle). A visual inspection checklist must be framed which should list visual features for identification of unacceptable material. This checklist must be filled for every unloading by a vehicle in tipping area at the working phase in the landfill.

If there is reason to doubt the presence of unacceptable waste, the vehicle will be taken to the waste inspection facility ,the waste down–loaded, inspected visually and sampled (if necessary). Vehicles having non-conforming waste will be held up and matter reported to engineer or manager of the site.

Phase Development
Development of each phase is done in stages. These stages are:

- Clearing the area of all shrubs and vegetation,
- Excavation (if required)
- Stockpiling of excavated material and material imported from borrow area,
- Levelling of base and side slopes of landfill and achieving desirable grades at the base of the landfill,
- Construction of embankment and temporary berms along the perimeter of the phase,
- Construction contemporary surface water drains,
- Installation of monitoring instruments,
- Liner construction
- Leachate collection and removal system.

Phase Operation

At the design stage the phases of a landfill are clearly demarcated. Operation of a phase requires planning and execution of daily activities—daily waste filling plan and demarcation, waste discharge and inspection, waste placement, waste compaction, daily covering of waste, prevention of pollution and fires.

On the completion of a phase and before the start of a new phase, a waste filling plan for daily cells must be evolved. A study of the landfill base contour maps and the final cover levels of the phase allow such a plan to be developed. If a phase is to be operational for 365 days, all 365 cells must be marked in plan and in sectional drawings. These may require revision as a landfill is constructed because waste quantities may vary in an unforeseen manner.

The area and height proposed to be filled every day should be demarcated at the site on a daily or weekly basis using temporary markers or bunds.

Waste Discharge and Inspection

Waste must be discharged by tipping at the working area of a landfill, within the area demarcated for the cell. Every discharged load should be visually inspected by a designated operator. Working area personnel should be trained and competent at waste identification in order that they can recognize waste which may be non-conforming. In the event of reasonable doubt as to the waste acceptability, the operator should inform the waste reception facility and/or the site manager immediately and the consignment should be isolated pending further inspection.

Once waste has been discharged it must be spread in layers and compacted in a well defined manner to ensure that the completed slopes of a daily cell are at the designed gradients.

Waste placement (spreading) can be done by the following methods

- Face tipping Method: Waste is deposited on top of existing surface and spread horizontally by tipping over an advancing face.
- Inclined layering method (onion skin tipping): Similar to (a) but inclined layering (gentle slope) done instead of advancing of face.
- Working upwards: Waste is deposited on the lower surface and pushed upwards.
Waste Compaction

It has become conventional practice to level and compact the waste as soon as it is discharged at the working area. Steel wheeled mobile landfill compactors (cleated I spiked I special wheels) are generally accepted as the best equipment for this purpose. They have largely replaced the small crawler-tracked machines which previously were in general use. These steel wheel compactors have been developed specifically for landfill operations with different patterns of cleated wheels designed to break up and compact waste. For small sites receiving low volumes of waste, a compactor alone may be adequate to spread and compact the waste as well as handle and place cover material. However, a compactor is not designed to be a multi-purpose machine and at busy sites it is more usual to provide a tracked dozer or wheeled bucket loader for spreading followed by a compactor for densification. Compactors help to (a) chop and homogenize the waste; (b) reduce the void fraction of the waste; (c) produce an even and stable surface; and (d) pin down waste to minimize litter and make the site less attractive to birds and vermin.

Landfill compactors are not manufactured in India. However, they are available overseas in a wide range of sizes and operating weights (typically ranging from 12 tons to 30 tons). Apart from size, the differences between machines are the cleat patterns on the wheels and the wheel configuration. The wheel configuration is relevant when determining the number of passes required to achieve the desired amount of compaction.

Daily Cover

The advantages of using daily cover are primarily in preventing windblown litter and odours, deterrence to scavengers, birds and vermin and in improving the site’s visual appearance. It is also advocated as a means of shedding surface water during the filling sequence, thereby assisting in leachate management by reducing infiltration, although its effectiveness in this respect is doubtful.

It is important that site location and waste inputs are taken into account when considering the type and application of daily cover. Soils used as daily cover will give a pleasing uniform appearance from the site boundary. To achieve this, a thickness of about 150 mm is usually adequate and should be adopted. About 300mm needs to be used to avoid paper, etc. being seen from close proximity. This is excessive for other purposes and the visibility of waste through daily cover should not be regarded as the sole criterion of effectiveness.

At sites where daily covered is spread by machines such as dozers etc., a thickness less than 150mm will not be feasible, keeping in view the uneven surface of the waste. At sites where daily cover is spread manually, a thickness of 100 mm can be attempted if soil is used; this thickness should not be less than 150mm if construction debris is used.

Cover material takes up valuable void space for primary wastes and if a 150 mm deep layer is placed over every 2 m layer of waste, about 7.5% of the Void space is lost. The covering of faces and flanks will cause even more loss of void space and most operators estimate that the total loss of void space is between 10% and 20%.

If compacted, daily cover can have a relatively low permeability which results in the partial containment of each layer of waste as a result, leachate becomes perched and difficult to extract. Landfill gas then moves preferentially sideways giving greater potential for migration off-site and both gas and leachate become difficult to extract. Hence daily cover way not be compacted by rollers.
Traditionally soil material has been used for daily cover. Whenever possible daily cover is obtained by planned excavation from within the landfill area and thereby causes no net consumption of space. This will optimize the commercial value of the waste accepted. Where a site is deficient in appropriate resources, daily cover may come through the gate from construction activities. Construction waste is now also used to form screening bunds and for landscaping at the construction site.

Results so far have failed to identify any single material which can be used as a simple substitute for soil materials and all of them have given rise to secondary problems.

**Pollution Prevention During Operation**

Measures are needed to ensure that the landfill operation does not adversely affect local environment within and outside the landfill. Operators may appoint community liaison officers to be available to visit complainants and establish the nature and source of the problem. This is reported to the site manager so that corrective measures can be taken.

**Traffic:** Heavy lorry traffic can give rise to nuisance, damage to road surface and verges and routing problems. The following guidelines are helpful:

- a. Routing to avoid residential areas
- b. Using one-way routes to avoid traffic conflict in narrow roads
- c. Carrying out road improvements, for example, strengthening or widening of roads, improved provision of footpaths, improvement of sight lines, provision of passing places, provision of new roads.
- d. Limiting the number of vehicle movements
- e. Restrictions on traffic movement hours which are staggered with respect to peak traffic hours.

**Noise:** Adverse impacts on the local community from noise may arise from a number of sources including - throughput of vehicles and fixed and mobile plant, for example compactors, generators at the site. Peripheral noise abatement site measures should be adopted.

**Odour:** Offensive odours at landfill sites may emanate from a number of sources, including waste materials, which have decomposed significantly prior to landfilling, leachates and leachate treatment system, and landfill gas. Good landfill practices will greatly reduce general site smell and reduce impact from odours which could lead to complaints from the local community, site users and site staff. Good practice includes: (a) adequate compaction; (b) speedy disposal and burial of malodorous wastes; (c) effective use of appropriate types of daily cover; (d) progressive capping and restoration; (e) effective landfill gas management; (f) effective leachate management and (g) consideration of prevailing wind direction when planning leachate treatment plants, gas flares, and direction of tipping.

**Litter:** Poor litter control both on and off site is particularly offensive to neighbours. Good operational practice should be adhered to in terms of waste discharge, placement, compaction and covering to minimize the occurrence of windblown litter. Measures for controlling litter include:

- a. Consideration of prevailing wind direction and strength when planning the filling direction and
sequence.

b. Strategically placed mobile screen close to the tipping area or on the nearest downwind crest.
c. Temporary banks and bunds immediately adjacent to the tipping area.
d. Permanent catch fences and netting to trap windblown litter
e. Restricting incoming vehicles to only those which are sheeted and secured will reduce litter problems on the highways.

Litter pickers should be employed to collect litter which escapes the preventative measures. Litter screens, fences, nets and perimeter ditches should be maintained free of litter.

**Bird Control:** Birds are attracted to landfill sites in large numbers, particularly where sites receive appreciable amounts of food wastes. Usually only large birds such as eagles, gulls are regarded as a nuisance. Bird control techniques should be carefully planned taking into account the species likely to be affected. Measures which can be used to mitigate bird nuisance include the employment of good landfill practice, working in small active areas and progressive prompt covering of waste, together with the use of bird scaring techniques. Measures involving explosions or distress calls have inherently adverse environmental impacts in terms of noise.

**Vermin and Other Pests:** Landfills have potential to harbor flies and vermin, particularly where the waste contains food materials. Modern landfilling techniques including prompt emplacement, consolidation and covering of wastes in well-defined cells, are effective in the prevention of infestation by rodents and insects. Rats and flies are the main pests which require control. Sites with extensive non-operational land can become infested with rabbits.

Effective measures to deal with rodent infestation include regular visits by pest control contractors or fully trained operatives. The use of insecticides on exposed faces and flanks of the tipping area, by spraying and fogging, is an effective means of exterminating insects.

**Dust:** Dust from landfill operations is mainly a problem during periods of dry weather but can also arise from dusty waste as it is tipped. Dust is generally associated with (a) site preparation and restoration activities; (b) the disposal of waste comprising of fine particles, for example powders; and (c) traffic dust. Dust suppression can be effected by (a) limiting vehicle speed; (b) spraying. Roads with water; and (c) spraying site and powder type waste with water.

**Mud on the Road:** Mud on the public highway is one of the most common causes of public complaint. It is, therefore, in the interests of the landfill operator to provide adequate wheel cleaning facilities to ensure that mud is not carried off site by vehicles.

**Landfill Fire Management**

Fires in waste and landfill sites are not uncommon and it is important for site operators to be aware of the dangers, how to treat fires and to address the problems associated with them. All fires on-site should be treated as a potential emergency and dealt with accordingly.

All sites should have an emergency tipping area set aside from the immediate working area where incoming loads of material known to be on fire or suspected of being so can be deposited, inspected and dealt with.
Waste that is burning on delivery should be doused with water or more preferably covered progressively with adequate supplies of damp soil. Cover followed by cooling and finally removal to its disposal point. It should not normally be allowed to burn itself out as this will give rise to nuisance from smoke and odour and may constitute a health risk. Fire fighting techniques should be appropriate for the waste type.

Fires within the operational area are either surface fires or deep-seated fires: The former usually occur in recently deposited and as yet un-compacted materials adjacent to the current working area, whilst the latter are found at depth in material deposited weeks or months earlier. Site operators should have a plan to deal with each type of fire and have a code of practice for their operators stating exactly how to tackle any outbreak. Regardless of the circumstances, no individual should ever tackle a landfill fire alone. Deep-seated fires require expensive remediation techniques including vertical cut-offs.

Landfill Safety Aspects

Training of employees should include site safety, first aid and the handling of dangerous materials where appropriate. Since landfill sites can pose dangers to both site operator and users, emergency plans should be laid down. Landfill sites should be regarded as potentially hazardous locations and the operator should have a written safety plan for the site.

Safety hazards present at landfill sites may include: (a) moving plant and vehicle; (b) steep slopes; (c) bodies of standing water; (d) contaminated, putrescible, toxic, flammable or infective material and (e) noxious, flammable, toxic or hazardous gas.

All employees and visitors to the site should be made aware of the potential hazards and the safety procedures to be implemented including fire safety.

Phase Closure

After the last set of cells of a phase are placed on the highest lift, an intermediate or final cover is constructed. If another phase is to be placed over the just completed phase, an intermediate cover is provided. However if the just completed phase has reached the final height of the landfill, the final cover system and surface water drainage system is provided.

An intermediate cover is made of locally available soil (preferably low-permeability) and is 45 to 60cm thick. It is compacted with smooth steel drum rollers and provided a suitable gradient (3 to 5%) to encourage surface water to run-off from the cover and thus minimize infiltration. The side slopes of the intermediate cover are compacted by the crawler tracked dozer moving up and down the slope.

Final cover construction and quality control issues are similar to those for liner construction. The layer below the low-permeability layer, referred to as the grading layer or gas venting layer, should be constructed using poorly graded sand. A grain size analysis for every 400 Cu.m of material used is recommended for quality control purposes. The layer should be compacted to above 75% relative density to provide a firm sub-base for the low-permeability layer above. The density should be tested at 30m grid points.

Lying of the topsoil layer should be done as soon as the protective layer construction is finished. Heavy construction equipment should not be allowed on the finished surface. The nutrient and
liming requirements for the topsoil should be assessed from a competent agricultural laboratory. In the absence of a regulatory recommendation I requirement regarding seed mix, a horticulturist or soil scientist should be consulted. A combination of grass and bush type vegetation capable of surviving without irrigation water should be planted. At least five samples of topsoil per hectare (2.4 acres) should be tested for nutrient and liming requirements. Nutrient and seed mix application rates should be supervised on site for quality control purpose.

The final cover is provided a gradient of 3 to 5 percent to assist surface run-off. Lined ditches or channels are constructed on the final cover to intercept and carry surface water off the cover to the storm water basin.

On the cover of each phase, settlement devices are installed for monthly measurement of settlement of the landfill cover. This helps in identifying the quantity of soil required periodically for repair of the landfill cover.

**Landfill Closure**

As each phase is completed and as the final cover level is reached in successive phases, the following interconnectivities are established:

a. The leachate collection system of each phase is sequentially connected (if so designed)

b. The surface water drainage system at the cover of each phase is sequentially connected (if so designed)

c. The temporary surface water drainage system constructed at the base of each completed phase is dismantled.

d. The gas collection system (if provided) of each phase is sequentially connected.

e. Upon completion of all phases a final check is made of the proper functioning of all interconnected systems.

An access road is provided on the landfill cover to enable easy approach for routine inspection of the landfill cover.

**10.7 Post Closure Care**

Post closure care involves the routine inspection of the completed landfill site, maintenance of infrastructure and environmental monitoring. A well defined closure plan shall be formulated for effective implementation. Post closure shall be implemented as a separate contract, and is not included in the current scope of work.

**10.8 Technical Specifications**

The detail technical specifications of the following items have been given in **Annexure 1.7**

1. Preparation of work areal clearing site/ jungle
2. Striping
3. Excavation & filling work
4. Excavation of trenches
5. Borrow areas
6. Cast-in-situ cement concrete
7. Formwork and staging
8. Reinforcement
9. Structural steel work
10. Stone work-random rubble masonry
11. Filling for clay liner and foundation
12. Foundation for embankment
13. Earthen embankment
14. Turfing
15. HOPE liner
16. Clay liner
17. Leachate collection system
18. HDPE liner
19. Sand layer
20. Gravel layer
21. Vertical centrifugal pump
22. Valves
23. Leachate treatment plant
24. Weighbridge
25. Piezometers
26. Electrical works
27. Schedule of Makes
28. Quantity assurance check list
29. List of mandatory spares
Chapter 11.0

Other Operation and Maintenance Aspects
11. OTHER OPERATIONS AND MAINTENANCE ASPECTS

11.1 Management Information System

11.1.1 Objective

To ensure success of municipal solid waste management system, it is required to collect specific and discreet information not only to keep records up-to-date but also, for taking corrective measures as well as proper planning for future. Some of the information is thus required to:

- Have overall idea of existing condition.
- Deficiencies in the existing system.
- Develop corrective measures for the existing system.
- Upgrading the existing system.
- Decision making.
- Planning a better system.
- Making budgetary provisions.

Computerization of data helps people working at all levels for waste management. It helps to build a strong and a reliable information database necessary to facilitate the decision making and monitoring process for management. An Enterprise resource planning (ERP) systems which integrates internal and external information across an entire operation—embracing finance/accounting, manufacturing, sales and service, customer relationship management, shall be employed to operate and maintain the ISWM facility. ERP systems shall automate this activity with an integrated software application. The purpose of ERP is to facilitate the flow of information between all business functions inside the boundaries of the operation and provide correct data and information to the operator to take quick and factual decisions.

The waste management system will essentially comprise the following components:

- Waste Generation
- Waste Collection
- Primary
- Secondary
- Waste Transportation
- Waste Processing and disposal

The general information to be collected, collated and updated from time to time of an existing system is as detailed below:

a. Waste Generation

The waste generation data to be collected and maintained in the database comprised of:

- Average quantity of waste generated per capital/kg/day
- Average quantity of waste produced each day in metric tons. (MT)
- Seasonal variation in daily waste generation
- Total quantity of waste produced annually during last 3 years (MT)
• Breakup of the quantity of waste generated per day in kg or MT
• Household, shops and establishment waste
• Vegetable and food market waste
• Meat, fish and slaughter house waste
• Construction and demolition waste
• Non-infectious hospital waste
• Non-hazardous industrial waste

b. Waste Collection
The collection of data has two components viz. primary and secondary collection. The data to be collected and maintained in the database for each of the two components is as detailed below:

c. Primary Collection
Primary collection is the first and prime activity of solid waste management. For planning and designing effective, sustainable, cost effective and efficient primary collection system, the following information is required for the city;

• Area
• Present and future growth of population
• Population density
• Source of waste generation
• Sanitation workers in local body
• Contract workers
• Voluntary agency workers
• Tools and implements used in primary collection system
• Welfare measures for the wormers
• Personnel protective equipments provided to the workforce
• Mode and frequency of collection from various sources:
• No. of sanitary workers required to report for duty
• No. of sanitary workers actually reported
• No. of sanitary workers absent
• No. of houses actually attended by each sanitary worker
• Amount of waste collected
• Houses left unattended
• No. of street bins emptied and amount of waste transferred to the waste storage depots
• No. of persons required to supervise
• No. of cases where performance found satisfactory
• No. of cases where performance was not upto mark
• Action taken and proposed to be taken
• Complaints received and attended
d. **Secondary Collection:**

The second and vital activity in solid waste management services is the transfer of waste to intermediate storage points. To design an intermediate waste storage point and to ensure a synchronized transportation system the following information is to be established for the city:

- Location
- Area
- Capacity
- Type of transfer system
- Mode of unloading
- Mode of loading
- No. of secondary collection locations per ward
- Type of secondary collection locations in each ward:
  - Dumper Placer container
  - Dustbin
- Amount of waste received from various sources in each ward

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e. **Waste Transportation**

To enable designing a cost effective and efficient transportation system synchronized with primary and secondary collection system, the following information is to be established for the city:

- Percentage of waste treated
- Amount of rejects from plant
- Details of processed waste
- End use of processed waste
- Quantity of waste disposed to landfill after processing
- Amount of waste received for processing
- Characteristics of waste (physical & chemical)
- Amount of waste received for disposal in landfill
- Amount of waste received from processing unit
- Amount of waste disposed off in landfill
- Volume of leachate generated
- Leachate management system
- Response from private sector

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f. **Performance Monitoring Indicators**

There are a number of specific performance measures that can be used to assess the individual functional elements or operating sub-systems of any MSWM systems, there are also measures that help gauge the overall performance of any MSWM system. Some of such measures are as presented in table 11.1 below:
### Table 11.1: Measures to gauge performance of MSWM system

<table>
<thead>
<tr>
<th><strong>Health</strong></th>
<th>Morbidity and mortality rates due to illness related, directly or indirectly with solid waste such as.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Cholera</td>
</tr>
<tr>
<td></td>
<td>- Tetanus</td>
</tr>
<tr>
<td></td>
<td>- Dengue fever</td>
</tr>
<tr>
<td></td>
<td>- Hepatitis, etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Economy</strong></th>
<th>Manpower employed in waste management activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Various stakeholders involved in waste management system (equipment manufacturer, recycling industry, consultants, maintenance department, etc.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Environmental Conditions</strong></th>
<th>Percentage of MSW collected over the total MSW generated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage of MSW properly disposed over SW collected</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Social Condition</strong></th>
<th>Percentage of population provided with waste collection services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annual increase/decrease in number of waste pickers in final disposal</td>
</tr>
<tr>
<td></td>
<td>No. of community health education programs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Solid Waste Generation</strong></th>
<th>Per capita waste generation (kg/person/day)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Recovery</strong></th>
<th>(Tonnage of solid waste recovered per day/tonnage of solid waste generated per day)*100</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Coverage &amp; Access to Urban Sanitation Services</strong></th>
<th>Percentage of urban population served</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage of semi-urban population served</td>
</tr>
<tr>
<td></td>
<td>Ration of urban/semi-urban population served</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Management Operation and Finance</strong></th>
<th>No. of waste management employees/thousand persons served</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average monthly service charge</td>
</tr>
<tr>
<td></td>
<td>Budget of waste management system</td>
</tr>
<tr>
<td></td>
<td>Income generation through tariffs</td>
</tr>
<tr>
<td></td>
<td>Efficiency of collection i.e. value collected divided by value billed multiplied by 100</td>
</tr>
<tr>
<td></td>
<td>Unit cost of waste management service (Rs./ton) i.e. sum of all direct costs, annual costs, indirect costs, financial costs, depreciation divided by tonnage received at final disposal site per years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Other Recommended Indicators</strong></th>
<th>Coverage of street sweeping</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Efficiency of collection equipment i.e. total equipment divided by the no of equipment in operation + backup equipment + maintenance equipment</td>
</tr>
<tr>
<td></td>
<td>No. of bills paid per month</td>
</tr>
<tr>
<td></td>
<td>No. of bills raised per month</td>
</tr>
</tbody>
</table>

It is important to note that general performance measures have to be compiled at regular intervals and then compared over time to enable SWM managers to monitor and establish.
positive and negative trends in waste management system. For e.g., if at any time it is found that there is variation in revenue collection i.e. it is going down over past few months, it is important for the concerned person of CCP to look into the matter and find way of overcoming this.

11.2 Complaint Handling System

An effective and transparent complaint handling system is a pre-requisite to any successful transformation. It is thus proposed to set-up an efficient, effective, transparent and user-friendly complaint handling system for registering complaints from people regarding removal of solid waste.

Complaint handling is another important component of waste management system. It helps in analysing and improving the level of services provided to the stakeholders.

11.2.1 Essential features of a complaint handling system

A complaint handling system that is efficient and fair includes:

- Acknowledging that your customers have a right to complain
- Openly seeking feedback from your customers
- Having a written policy about handling complaints readily available to citizens

The essential features of complaint handling system are as described below:

**Fairness:** Complaint handling should be fair to all parties, and must allow everyone’s views to be heard and taken into account in a balanced way.

**Effectiveness:** Availability of adequate resources is vital to handle complaints efficiently and effectively, Complaints received should be dealt with quickly and courteously. The people involved in responding to complaints will communicate the complaints to the field staff and will have the authority and ability to decide remedies and to put them into effect.

**Accessibility:** The complaint handling system should be accessible to all customers, and help the lodge their complaints. Information about how to make a complaint will be readily available and simple to understand or in other words it will be a user-friendly system. Toll free numbers, e-mail address etc will be provided for registering complaints. These numbers will also be available on all the vehicles, bins placed at public places, at all waste storage locations and will be displayed at all prominent public places.

**Accountability:** The system will record the complaints received and the outcomes achieved. All the recurring and systemic problems that become known through the complaint handling system will be identified and rectified.

The operation of complaint handling system will be reviewed regularly to make sure that effective outcomes are achieved for customers.
11.2.2 General Rules for Handling Complaints

The general rules/ etiquettes for handling complaints include:

- Listen to the complaint and get all details
- Repeat the message to confirm your understanding
- Tell the customer what will be done and when
- Handle complaints quickly
- Follow-up to be sure the complaint is redressed
- Confirm the complaint has received a satisfactory response and thank the customer
- Inform public of services, your responsibilities and theirs.

11.2.3 Complaint handling system for Panaji

Three dedicated telephone lines will be put in place for receiving customer calls and complaints. The system will be operational all times of day round the year. The system will have provision wherein the operator punches in all details of the complainant whenever a complaint is received. The complaint will be forwarded to the required field staff, which will ensure that it is addressed. Once the necessary action has been taken on the complaint, it can be disposed off and a note will be sent to the complainant stating details of action taken.

A record of all the complaints lodged will be maintained to prepare a database, which will help in establishing:

- Complainant’s name
- Location
- Nature of complaint
- Time of complaint
- Response time
- Feedback from complainant

The most important feature, which will help in upgrading the complaint handling system will be the feedback received from people.

11.3 Environment, Health and Safety Aspects

Improper management of solid waste gives rise to problems of health, sanitation and environmental degradation. Several diseases like dysentery, cholera, plague, typhoid, infective hepatitis, etc. are transmitted through the breeding of rodents and vector insects on the MSW. The workers engaged in SWM services are exposed to high health risks and frequently suffer from respiratory tract infections and also gastro-intestinal problems.

The rag pickers who move from street to street, bin to bin and go to dump yards to retrieve recyclable waste are most vulnerable to diseases on account of their direct contact with contaminated waste. They too are found to suffer from intestinal and respiratory infections, skin
disorders and eye infection. They also suffer from injuries at open dumps, which can cause tetanus and serum hepatitis.

Unscientific disposal of waste also contaminates soil and ground water resources with heavy metal and other contaminants through leachate and pose a serious problem of environmental deterioration and health risk. It is therefore essential that at all stages solid waste is handled carefully and health risks are minimised. Certain practices which shall be followed include:

- Waste is covered at all stages of management cycle
- Waste stored at the source of generation is collected daily before it starts decaying and emanates foul smell.
- Workers are adequately trained in waste handling and protecting themselves from the health risks involved in their occupation
- Workers are given protective clothing and shoes and persuaded or requested to use them
- Waste is not burnt on the street/open space or at any place as it causes pollution
- Landfill sites are properly managed and monitored to prevent ground water pollution.

It is proposed that all CCP waste handlers should be given annual medical examination and free medical treatment if it is felt that the illness is occupation-related.

11.4 Project Benefits Assessment

11.4.1 Social Cost-benefit Assessment

The proposed plan for Municipal Solid Waste Management in Panaji city is based on 4R principal (Reduce, Reuse, Recycle and Recover). The plan is developed in lines with the requirements of MSW Rules 2000 and ensures well-being of the society at large.

The MSW management plan proposes up-gradation of the existing infrastructure and development of new infrastructure as per the current status of MSW management facilities in Panaji city, In the proposed plan, infrastructure provision has been done to ensure that collection, transportation, Treatment and disposal of MSW in Panaji is done properly. The proposed approach will have positive and negative environmental, social and economic benefits to MSW workers and the overall society.

The benefits and adverse impacts from the proposed MSW management plan are summarized below in table 11.2:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Benefit Description</th>
<th>Comments</th>
<th>Quantitative Impacts (wherever possible) &amp; Underlying Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Improved working conditions</td>
<td>Provision of wheelbarrow with covered containers &amp; brakes</td>
<td>Workers will be given infrastructure for waste collection and handling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
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<td></td>
</tr>
</tbody>
</table>
| 2. | Improved workers morale | Provision of PPEs  
- No manual handling of waste proposed  
- Workers will be given appropriate competence training|
|   |   | as per the design  
- Workers will be given appropriate competence training|
|   |   |   |
| 3. | Improved health & safety | Ability to perform activities as desired  
- Improved efficiency  
- Workers will be given appropriate training on waste handling  
- Infrastructure facilities maintained as per the proposed design.|
|   |   |   |
| 4. | Employment opportunities | PPP proposed for MSW management  
- New infrastructure facilities (MRF, Compost Plant and Sanitary landfill) proposed  
- PPP model is successful  
- Infrastructure facilities are run efficiently|
|   |   |   |
| 5. | Reforms driven economic sustainability | Grants are being provided on the condition that CCP would undertake suitable reforms in Management Accounting and other areas so as to maintain sustainability of the project in the long run  
- Reforms Implemented|
|   |   |   |
| Benefits to the Society |   |   |
| 6. | Easy access to MSW infrastructure facilities | Door-to-door collection facility in all the localities in covered vehicles  
- Door-to-door waste collection from all households|
| 1. | Clean and Hygienic conditions resulting reduction in number of infectious and other diseases such as bronchitis, hepatitis, diarrheal, parasitic infection and pulmonary diseases | 100% door-to-door collection of waste proposed  
- MSW handling in covered containers  
- Daily cleaning of roads and secondary waste storage depots  
- Waste transportation in covered vehicles  
- Provided MSW collection from all households|
### 8. Environmental Improvement

- No dumping of waste on ground
- Covered waste handling, so no foul odour at collection points
- No open burning of waste
- Recycling of waste
- Composting of biodegradable waste
- Development of Engineered Sanitary Landfill

### 9. Improved quality of life

- Improved surroundings
- Clean environment
- Access to infrastructure

### 10. Improved awareness and civic sense in people

- Training and awareness of people for MSW management

### Adverse Impacts

<table>
<thead>
<tr>
<th>1.</th>
<th>Environmental impacts during construction of new infrastructural facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dust pollution during construction</td>
</tr>
<tr>
<td></td>
<td>Air pollution from vehicles</td>
</tr>
<tr>
<td></td>
<td>Water pollution due to construction activities</td>
</tr>
<tr>
<td></td>
<td>Noise from material transportation vehicles</td>
</tr>
</tbody>
</table>

- Adverse impacts from construction activities will be minimized by due care

<table>
<thead>
<tr>
<th>2.</th>
<th>Reduced green cover</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Construction of landfill site and compost plant on a large piece of land</td>
</tr>
</tbody>
</table>

- Alternate green cover will be developed as per the norms to compensate for the loss

<table>
<thead>
<tr>
<th>1.</th>
<th>Labour Redundancy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PPP proposed for most of the MSW services</td>
</tr>
<tr>
<td></td>
<td>Under-utilization of labour presently employed with CCP</td>
</tr>
</tbody>
</table>

- Number of redundant employees with CCP will reduce overtime as the employees get retired
- New employees to be appointed only as per the requirement

<table>
<thead>
<tr>
<th>2.</th>
<th>Possible unplanned development around integrated waste management facility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Integrated Solid Waste Management Facility will have necessary infrastructure in place</td>
</tr>
<tr>
<td></td>
<td>Integrated Solid Waste Management Facility will generate employment</td>
</tr>
</tbody>
</table>

- Land use around the project site to be well defined
- Plan for temporary and permanent workers engaged in project site to be developed

The negative and positive impacts summarized above indicate that positive impacts can be maintained and enhanced and negative impacts can be minimized with a properly planned approach. To achieve the broader objective of well-being of the society, the above aspects need to be inculcated in the project implementation plan and its long-term operation and maintenance.
The actual benefits to the society can only be realized after a period of successful implementation of the proposed plan.

11.5 Outcome of the Project

The present method of waste handling does not effectively address the problems associated with garbage disposal. The existing number of composting units is insufficient. Also finding areas in Panaji city for setting up of new de-centralized compost units is a difficult proposition due to the fact that in Panaji city, land is scarce commodity and not available for setting up the required MSW facilities. The Present sorting centre for non-biodegradable waste (dry waste) is not sufficient enough and not efficient because of being completely manual in operation. Crude disposal of Construction & demolition waste is happening without any facility for disposal and resource recovery. Most of the vehicles involved in the waste transportation have surpassed their economic life. Crude dumping of waste is happening at various locations in the outskirts of the city due to the absence of a centralised Engineered MSW treatment facility. Therefore in order to safeguard the population from health hazards, maintain a clean and hygienic environment it is extremely essential to implement the proposed MSW facility. Development and implementation of this integrated MSW management plan is based on the 4R Environmental Protection Rules (Reduce, recycle, Reuse, and Recover). The proposed project has the following outcomes.

- MSW management in the Panaji city as per MSW Rules 2000
- Segregation of waste at the source.
- Waste covered at all stages of handling – during storage at source, primary collection, as well as transportation.
- No manual handling of waste in transferring of waste from containers to transportation vehicles.
- Provision of the proper Personal Protective Equipments (PPEs) to the workers.
- Recycling of biodegradable waste through biomethanation, composting and non-biodegradable via a fully automatic MRF facility, generating profits from this venture
- Landfilling only of waste which is inert and non-biodegradable, thus reduced landfill cost and land requirement.
- Healthy and safe environment for the people.
- Information, education and communication across the stakeholders to create awareness within community and MSW workers.
- Promotion of PPP to bring efficiency in the system and reduce burden on CP.

These steps will lead to greater cleanliness of the city and overall improvement of environmental hygiene. It would reduce disease and improve health of citizens. It will also make the system in compliance with the legal requirement of MSW Rules 2000.
Chapter 12.0

Environmental Impact Assessment
Chapter 12.0 ENVIRONMENTAL IMPACT ASSESSMENT

Environmental Impact Assessment (EIA) is the process by which we measure anticipated effects on the environment of a proposed development or project. If the likely effects are unacceptable, design measures or other steps can be taken to reduce/minimize the impacts.

12.1 Need for the EIA

An ISWM Facility development, apart from providing the desired benefits of processing, treatment and disposal of SW in a scientific manner, can also lead to adverse impacts on various facets of the environment. It is imperative to study the likely positive or negative Impacts resulting from construction and operation of the planned project on various aspects of environment, so that necessary actions can be taken to minimize negative impacts and enhance positive impacts. This chapter presents assessment of likely impacts from construction and operation of this project and based on this assessment a suitable Environmental Management Plan (EMP), to ameliorate the adverse impacts and enhance the positive impacts. The various steps involved in conducting an Environmental Study are summarized below:

a. Scoping: An exhaustive list of all likely impacts drawing information from as many sources as possible is prepared. The next step is to select a manageable number of attributes, which are likely to be affected as a result of the proposed project.

b. Baseline Study: Before the start of the project, it is essential to ascertain the baseline level of appropriate environmental parameters, which could be significantly affected by the implementation of the project.

c. Impact Prediction: is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of the construction and operation of the proposed project. An attempt has been made to forecast future environmental conditions quantitatively to the extent possible.

d. Environmental Management / Mitigation Plan (EMP): The approach for formulation of an Environmental Management Plan (EMP) is to maximize the positive environmental impacts and minimize the negative ones.

12.2 Brief Description of the Project

The purpose of this project is to develop an integrated solid Waste Management Facility for managing solid waste of the project town. With increasing population & urbanization, there is an urgent requirement to develop ISWM facility for proper waste management.

12.2.1 Project Site

For the effective management of the Municipal waste being generated from Panaji City. The City Corporation has earmarked a site located at Baiguinim village in Tiswadi taluka with an area of 171312 sq.m (Approx. 17 ha). In the aforesaid site, an Integrated Solid Waste Management Facility (ISWM) will be located including a material recovery facility (MRF), compost plant, brick making unit,
sanitary landfill, bio-medical waste incinerator and ancillary facilities with provisions for overall management of municipal solid waste.

12.2.2 Project Components
The SWM system components are waste segregation at source, primary collection, secondary storage, transportation & then further treatment and disposal in scientific manner.

For disposal process an ISWM facility has been proposed which includes Biomethanation and invessel Compost Plant for the processing of Bio-degradable waste, Material Recovery Facility (MRF) for the processing of non-biodegradable/recyclable waste, Sanitary Landfill facility for the final disposal of the inert waste and the rejects from the above mentioned processing facilities. The project includes design phase, construction phase & operation & maintenance phase.

12.2.3 Environmental Impact Assessment (EIA) Legislation
The Ministry of Environment and Forests (MoEF), Government of India has under the Environmental (Protection) Act 1986 promulgated an Environmental Impact Assessment Notification on 27 January 1994 making environmental clearance mandatory for expansion or modernization of any activity or for setting up news projects listed in Schedule I of the notification. Till 1994, EIA clearance was the administrative requirement for big projects undertaken by the Government or public sector undertakings. The EIA Notification dated 14th September, 2006 supersedes the earlier EIA Notification, 1994 and subsequent amendments thereto.

In supersession of the EIA Notification, 1994 all projects and activities are broadly categorized into two categories – Category A and Category B, based on the spatial extent of potential Impacts and potential Impacts on human health and natural and manmade resources.

All projects or activities included as Category ‘A’ in the Schedule, including expansion and modernization of existing projects or activities and change in product mix, shall require prior environmental clearance from the Central Government in the Ministry of Environment and Forests (MoEF) on the recommendations of an Expert Appraisal Committee (EAC) to be constituted by the Central Government for the purposes of this notification. All projects or activities included as Category ‘B’ in the Schedule, including expansion and modernization of existing projects or activities with addition of capacity beyond the limits specified for the concerned sector, that is, projects or activities which cross the threshold limits given in the Schedule, after expansion or modernization or change in product mix in an existing manufacturing unit included in Schedule beyond the specified range, but excluding those which fulfil the General Conditions (GC) stipulated in the Schedule, will require prior environmental clearance from the State/Union territory Environment Impact Assessment Authority (SEIAA).
The SEIAA shall base its decision on the recommendations of a State or Union territory level Expert Appraisal Committee (SEAC) as to be constituted for in this notification. In the absence of a duly constituted SEIAA or SEAC, a Category 'B' project shall be treated as a Category 'A' project. The environmental clearance process for new projects will complete in maximum of four stages. In first stage, Screening shall be done only for Category 'B' projects and activities. Further, Scoping, Public Consultation and Appraisal shall be done in sequential manner.

The public hearing at, or in close proximity to, the site(s) in all cases shall be conducted by the State Pollution Control Board (SPCB) or the Union territory Pollution Control Committee (UTPCC) concerned in the specified manner and forward the proceeding to the regulatory authority concerned within 45 (forty five) of a request to the effect from the applicant.

Clearance application shall be made in Form I and they shall be considered by the concerned Expert Appraisal Committee or State Level Expert Appraisal Committee within sixty days, who will decide on the due diligence necessary including preparation of EIA and public consultations and the application shall be appraised accordingly for grant of environmental clearance.

In the environmental clearance process, the documents to be submitted to MoEF are project report, public hearing report, site clearance for site specific projects, no objection certificate from State Pollution Control Board (SPCB), environmental appraisal questionnaire, EIA/EMP report, risk analysis for projects involving hazardous substance and resettlement plans, if more than 1000 people are likely to be displaced.

According to EIA notification, an legislation, primarily the 1994 MOEF Environmental Impact Assessment Notification, the AIDP may or may not require an Environmental Impact Assessment (EIA) or other type of environmental review. The necessary criteria for some type of environmental analysis would be met if the AIDP were to support construction of new or expansion of existing industrial facilities.

12.2.3.1 Overview of the Applicable Legislation

A) THE ENVIRONMENT (PROTECTION) ACT, 1986

- The Environment(Protection)Act,1986
- The Environment(Protection)Act,1986
- The Bio-Medical Wastes (Management and Handling) Rules,1998
- The Noise Pollution (Regulation and Control) Rules,2000
- The Municipal Solid Wastes (Management and Handling) Rules,2000
- The Batteries (Management and Handling) Rules,2001

B) AIR

- The Air (Prevention and Control of Pollution) Act,1981
- The Air (Prevention and Control of Pollution) Rules,1982
C) WATER

- The Water (Prevention and Control of Pollution) Act, 1974
- The Water (Prevention and Control of Pollution) Rules, 1975
- The Water (Prevention and Control of Pollution) Cess Act, 1977
- The Water (Prevention and Control of Pollution) Cess Rules, 1978

12.2.3.2 Details on the Applicable Legislation:

A) Environment protection Act, 1986

The Environmental Protection Act is comprehensive umbrella legislation and has conferred powers on the Central Government to take all necessary measures for protecting the quality of environment. This Act provides power to the Central Government to take all such measures as it deems necessary for the purpose of protecting and improving the quality of the environment and preventing and abating environmental pollution. The central Government also has to laydown standards for emission or discharge of environmental pollutants from various sources having regard to the quality or composition of the emission or discharge of environmental pollutants from such sources.

B) Water (Prevention and control of Pollution) ACT, 1974

The Water Act provides for the prevention and control of water pollution and for maintaining or for restoring the quality of water in all its sources. The Act provides for executive and territorial functions for Central and State Pollution Control Boards. Following are a number of key specific obligations under this Act:

- Obtain "Consent to Establish", before taking any steps to establish any Operation, industry, or process or any treatment and disposal system which is likely to discharge effluents.
- Obtain "Consent to Operate", before commencing operations of any industry, or any treatment and disposal system which is likely to discharge effluents.
- Provide the Pollution Control Board (PCB) with any information which is sought for preventing or controlling pollution of water regarding the construction, installation, operation or the treatment and disposal systems of an industrial establishment.
- Provide access to the PCB, or any officer empowered by it, for taking samples of water or effluents from the industrial establishment for the purpose of analysis.
- Allow entry to the PCB or any person empowered by it, at any time, for the purpose of performing any of the entrusted functions; or for inspecting in order to ascertain that the provisions of the Act are being complied with;
- Not to discharge, knowingly, of any effluent into the stream, sewer or on land, of quality which is not conforming to the standards prescribed by the PCB.
- Furnish information to the PCB and other designated agencies, of any accidental or unforeseen event, in which effluents not conforming to the prescribed standards are being discharged, or likely to be discharged into a stream or sewer or on land; and
- Comply with the conditions as prescribed in the "Consent to Establish" or "Consent to Operate" for discharge of effluents into a stream or sewer or on land without treatment.
C) Water Cess Act,1977, Modified 1992

This act provides for the levy and collection of a Cess on water consumed by persons carrying on certain industries (16 categories) and by local authorities, with a view to augment the resources of the Central Board and the State Boards for the prevention and control of water pollution constituted under the Water (Prevention and Control of Pollution) Act,1974.

D) The Air Act,1981

This 1981 Air Act provides for the" prevention, control and abatement of air pollution". This Act defines an air pollutant as "any solid, liquid or gaseous substance present in the atmosphere in such concentration as may be ordent to be injurious to human beings or other living creatures or plants or property or environment". The provisions of the Air Actinclude:

- Allocation to state governments the power to declare air pollution control areas after consultation with the State Board. By this, it may control or even prohibit burning certain materials in those specific areas.;and
- A requirement that operators obtain "Consent to Operate" before commencing operations of any industry, or any treatment and emission system. The Act and its implementing regulations contain emissions standards specific to particular industries.


These Rules were enacted under the EPA to ensure safe and environmentally responsible storage, handling and disposal of hazardous waste generated by the industrial sector. The 2000 amendment defines hazardous waste as waste that is generated by processes defined in Schedule 1 of the Rules or which may be found in the environment at concentrations above limits that are also defined in Schedule1. The industrial facilities to which these Rules apply must:

- Identify all the hazardous wastes that they generate with the applicable quantities and nature;
- Ensure proper collection, reception, treatment, storage and disposal of hazardous wastes by the owner himself or through and operator of the facility for specified hazardous wastes;
- Obtain"grant of authorization" for handling hazardous wastes from PCB;
- Maintain records of hazardous wastes handling, at the site, in the prescribed form;
- Submit "Annual Returns" to the PCB regarding disposal of hazardous wastes in the prescribed form; and
- Report to the PCB any accident at site, or during transportation, while handling hazardous wastes, in the prescribed form.

F) Municipal Solid Waste Management Rules,2000

As a second initiative, the Ministry of Environment and Forests (MoEF),Gol, published "Municipal Solid Waste (Management and Handling) Rules 2000" (MSW Rules 2000). These rules were developed in conformance with Sections 3, 6 and 25 of the Environment Protection Act,1986 and aim at standardization and enforcement of SWM practices in the urban sector. They dictate that, "Every municipal authority shall, within the territorial area of the municipality, be
responsible for the implementation of the provisions of these rules and infrastructure development for collection, storage segregation, transportation, processing and disposal of municipal solid wastes”.

The Jawaharlal Nehru National Urban Renewal Mission (JnNURM) is a notable initiative undertaken by GoI. JnNURM provides funding for urban infrastructure development in 63 cities and towns of the country. This mission was initiated in 2006 and is stated to continue until 2011.

The primary objective of this scheme is to improve the urban infrastructure in town and sand cities in a planned manner and to promote public-private partnership (PPP) in infrastructure development. This scheme was introduced in the year 2005-06 and will continue for seven years. This scheme is applicable to all cities/towns as per 2001 census, except the cities/towns covered under the JNNURM. One of the components of this scheme is to renew the old sewerage and solid waste disposal systems in inner (old) areas.

The Twelfth Finance Commission (TFC) under Department of Expenditure, GoI, has recommended measures to augment the Consolidated Funds of the States to supplement resources of the Rural Local Bodies (RLBs) (Panchayats) and Urban Local Bodies (ULBs) (Municipalities). These funds are allocated to the RLBs and ULBs, based on the recommendations made by the State Finance Commissions (SFCs). In addition, in accordance with the recommendations made by the TFC, sum of Rs.20,000 crores and Rs.5,000 crores has been allocated for RLBS and ULBs, respectively, for the period 2005-10.


The Bio Medical Waste (Management and Handling) Rules, are framed by gov't. Of India under the Environment (Protection) Act1986. They were first notified in July, 1998, and amended in June 2000. These rules are applicable to all persons who generate, collect, receive, store, transport, treat, dispose or handle Bio-medical waste in any form.

With a view to control the indiscriminate disposal of hospital waste/bio medical waste, the Management Rules, 1998 has also constituted advisory committee, appellate authority in exercise of powers conferred under Bio Medical Rules.

Bio-medical waste shall be treated and disposed of in accordance with Schedule I, and in compliance with the standards prescribed in Schedule V of the rules. Schedule V laysout the standards for treatment and disposal of biomedical wastes. It laysout standards for incinerators, autoclaves, standards for treating liquid waste, microwaving and deep burial of wastes.

As defined in these rules, 'Bio-medical' waste means any waste generated during diagnosis, treatment or immunization of human beings or animals. A person who has control over hospital, nursing home, clinic, dispensary, veterinary institution, animal house, vide the amendment rules dated 2nd June 2000, responsibility has been laid on local municipal authorities for providing suitable common disposal/incineration site for Bio-medical waste generated in the area under their jurisdiction. However, this provision is without prejudice to the rules pertaining to the responsibility of the Occupier, which means that it is the responsibility of the Occupier to make his/her own arrangement for disposal of Bio-medical waste engendered by his/her institution, till such time the local municipal authorities make an arrangement for providing common disposal site.
12.3 Base Line Environmental Status
As apart of the environmental assessment study, following information was collected to establish the baseline status of project area.

12.3.1 Site
Panaji, also known as Panjim, is located on the banks of the Mandovi estuary and the Arabian Sea. It is an important part of the North Goa District. According to the local dialect, Panaji is popularly known as 'the land that does not flood'. The geographical co-ordinates are 15.25°N Latitude and 73.50°E Longitude.

Panaji city is bound by Mondovi river in the north, a hill in the south and criss cross creeks in the east and west, it creates a picturesque setting to the city. The city of Panaji encompasses an area of 8.2 sq.kms (approx.) (CCPlimits) (Source: CCP, Panaj1). For the purpose of Solid Waste Management, the city of Panaji is divided into 12 zones.

12.3.2 Soil Characteristics
Most of the Goa has laterite and lateritic clayey-loamy soil. This soil is red in colour and enriched with ferric aluminium oxides. The soil near the river banks and in inland areas is mostly alluvial and loamy in character. Overall, the soil is good for vegetation.

12.3.3 Climate
Panaji features a tropical monsoon climate. The climate in Panajii is hot in summer and equable in winter. During summers (from March to May) the temperature reaches up to 32-330 C in winters (from December to February) it is usually between 29°C and 20°C. The monsoon period is from June to September with heavy rainfall and gusty winds. The annual average rainfall is 2932mm (115.5inches).

12.3.4 Surface Water
Panaji city is bound by Mondovi river in the north. Considering that Panaji is situated at the bank of Mandovi, surface water quality was tested by Goa State Pollution Control Board. The report of the water analysis is indicated below, in table 12.1:

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Parameters</th>
<th>July-10</th>
<th>Oct-10</th>
<th>Jan-11</th>
<th>April -11</th>
<th>July-11</th>
<th>Oct-11</th>
<th>Jan 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Temperature °C</td>
<td>26°C</td>
<td>29°C</td>
<td>28°C</td>
<td>32°C</td>
<td>22°C</td>
<td>33°C</td>
<td>27°C</td>
</tr>
<tr>
<td>2</td>
<td>pH</td>
<td>6.1</td>
<td>6.12</td>
<td>6.28</td>
<td>6.38</td>
<td>5.56</td>
<td>6.65</td>
<td>6.68</td>
</tr>
<tr>
<td>3</td>
<td>Conductivity</td>
<td>41.0 ms/cm</td>
<td>60.0 ms/cm</td>
<td>53.4 ms/cm</td>
<td>55.1 ms/cm</td>
<td>289.9 µs/cm</td>
<td>25.57 ms/cm</td>
<td>49.9 ms/cm</td>
</tr>
<tr>
<td>4</td>
<td>Nitrate Nitrogen mg/l</td>
<td>0.63</td>
<td>0.56</td>
<td>0.19</td>
<td>0.70</td>
<td>0.08</td>
<td>0.10</td>
<td>0.547</td>
</tr>
<tr>
<td>5</td>
<td>Dissolved Oxygen mg/l</td>
<td>4.55</td>
<td>6.5</td>
<td>7.1</td>
<td>4.56</td>
<td>6.4</td>
<td>5.86</td>
<td>6.51</td>
</tr>
<tr>
<td>6</td>
<td>BOD mg/l</td>
<td>2.80</td>
<td>1.0</td>
<td>1.1</td>
<td>1.64</td>
<td>1.1</td>
<td>2.27</td>
<td>0.99</td>
</tr>
<tr>
<td>7</td>
<td>Fecal Coli form MPN/100 ml</td>
<td>12.0</td>
<td>4.0</td>
<td>4.0</td>
<td>11.0</td>
<td>7.0</td>
<td>14.0</td>
<td>--</td>
</tr>
<tr>
<td>8</td>
<td>Total Coli form MPN/100 ml</td>
<td>150.0</td>
<td>150.0</td>
<td>110.0</td>
<td>154.0</td>
<td>200.0</td>
<td>200.0</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>Nitrite Nitrogen mg/l</td>
<td>BDL</td>
<td>BDL</td>
<td>BDL</td>
<td>BDL</td>
<td>0.03</td>
<td>BDL</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Source: GSPCB
12.3.6 AIR QUALITY

The air quality monitoring was conducted by Goa SPCB in year 2008-2009. The results of air quality monitoring carried out at locations nearest to Panaji are given below:

<table>
<thead>
<tr>
<th>Month</th>
<th>502 No. of Obs</th>
<th>Arith Mean</th>
<th>NOx No. of Obs</th>
<th>Arith Mean</th>
<th>RSPM No. of Obs</th>
<th>Arith Mean</th>
<th>SPM No. of Obs</th>
<th>Arith Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr-08</td>
<td>54</td>
<td>2.0</td>
<td>54</td>
<td>10.55</td>
<td>27</td>
<td>44.1</td>
<td>27</td>
<td>69.1</td>
</tr>
<tr>
<td>May-08</td>
<td>48</td>
<td>2.0</td>
<td>48</td>
<td>9.2</td>
<td>24</td>
<td>32.8</td>
<td>24</td>
<td>73.5</td>
</tr>
<tr>
<td>Jun-08</td>
<td>54</td>
<td>2.96</td>
<td>54</td>
<td>8.7</td>
<td>27</td>
<td>27.8</td>
<td>27</td>
<td>60.7</td>
</tr>
<tr>
<td>Jul-08</td>
<td>53</td>
<td>3.49</td>
<td>53</td>
<td>7.3</td>
<td>27</td>
<td>22.7</td>
<td>27</td>
<td>47.4</td>
</tr>
<tr>
<td>Aug-08</td>
<td>46</td>
<td>2.95</td>
<td>46</td>
<td>6.2</td>
<td>23</td>
<td>28.4</td>
<td>23</td>
<td>57.3</td>
</tr>
<tr>
<td>Sep-08</td>
<td>48</td>
<td>2.29</td>
<td>48</td>
<td>7.9</td>
<td>24</td>
<td>28.2</td>
<td>24</td>
<td>49.0</td>
</tr>
<tr>
<td>Oct-08</td>
<td>54</td>
<td>2.0</td>
<td>54</td>
<td>13.6</td>
<td>27</td>
<td>56.4</td>
<td>27</td>
<td>93.7</td>
</tr>
<tr>
<td>Nov-08</td>
<td>48</td>
<td>2.2</td>
<td>48</td>
<td>17.77</td>
<td>24</td>
<td>70.1</td>
<td>24</td>
<td>115.08</td>
</tr>
<tr>
<td>Dec-08</td>
<td>60</td>
<td>2.38</td>
<td>60</td>
<td>16.73</td>
<td>30</td>
<td>101.7</td>
<td>30</td>
<td>180.2</td>
</tr>
<tr>
<td>Jan-09</td>
<td>43</td>
<td>3.93</td>
<td>43</td>
<td>18.81</td>
<td>23</td>
<td>92.1</td>
<td>23</td>
<td>174.4</td>
</tr>
<tr>
<td>Feb-09</td>
<td>46</td>
<td>2.69</td>
<td>46</td>
<td>20.34</td>
<td>23</td>
<td>72.39</td>
<td>23</td>
<td>132.3</td>
</tr>
<tr>
<td>Mar-09</td>
<td>53</td>
<td>1.83</td>
<td>54</td>
<td>13.77</td>
<td>27</td>
<td>67.4</td>
<td>27</td>
<td>130.5</td>
</tr>
</tbody>
</table>

Source: GSPCB

12.3.7 Ground Water Quality

At present the ground water is being exploited at some places of Panaji through tube wells. However, the ground water level is quite low. It is about 16.0 m below ground level.

12.4 Environmental impacts of the project

12.4.1 Identification Of Environmental Impacts Due To Project Activities

The environmental impacts associated with development ISWM facility have been identified comprehensively by assessing each project activity individually with respect to existing baseline status of the project site. The entire project cycle has been divided onto four phases-

- Pre-construction Phase which includes site preparation aspects
- Construction Phase which includes construction and installation of various components of ISWM facility as per the design specifications
- Operation Phase including transportation of waste, its storage & further processing
- Closure and Post-Closure Phase including laying of cover liner and monitoring of Sanitary Landfill.

As indicated above, each phase has been divided into major activities having direct and/or insinuclent, positive and/or negative and short and/or long-term impacts on the surrounding environment. The possible impacts have been predicted based on the nature and magnitude of each activity and based on the existing environmental settings of the area.
(A) Impacts During Pre-Construction Phase

The pre-construction stage is the project planning stage which has strong bearing on success of the project. The present environmental status of the site needs to be analyzed thoroughly in order to have planning as per the site requirements. Most of the environmental impacts can be mitigated at this stage by careful planning and design. This stage involves preparation of site prior to starting construction activity.

The negative impacts resulting from activities of this stage can result in long-term impacts of the project.

(B) Impacts During Construction Phase

Almost all major construction projects pose hazards to environmental resources during the project’s construction phase. All activities carried out in this phase need to be identified individually as impacts associate with various construction activities vary depending upon the technique and resources required for construction. The activities identified for the project are—

- Workers working and staying on site for carrying out construction activity
- Site Clearing, excavation, backfilling and Grading
- Transportation of construction material and equipments
- Construction of Embankment
- Laying of Liner system at the bottom of the pond and sides of embankment
- Installation of the Drainage System
- Construction and installation of other support infrastructure facilities such as leachate collection drains, laboratory, washing area, road, etc.
- Development of green belt

(C) Impacts During Operation Phase

For this project, most of the potential impacts have to be taken care off at the planning and construction phase to minimize negative impacts during the operation of the activity. However, based on experience of similar projects world over the probability of occurrence of negative impacts even after due attention and care during planning and design cannot be negated.

For prediction of impacts during the operational phase of the project, following major activities have been identified—

- Transportation and unloading of waste on site
- Storage of waste at compostplant, waste processing units & MRF
- Storage of waste in landfill pond
- Operation of the compost plant, Waste processing units & MRF
- Operation of DG set
(D) Impacts During Closure And Post-Closure Phase

After the landfill site is full with waste as per the design specifications, the site has to be closed with the top cover to ensure that there is non-negative impact on the surrounding environment due to its existence. This stage primarily includes two activities—
- Installation of top cover liner system
- Monitoring of the secured landfill facility

Regular monitoring of the landfill site would ensure that the impact is identified at a nearly stage of its occurrence and is mitigated accordingly. Table 13.4 outlines the impacts associated with each activity/sub-activity comprehensively.

12.5 Environmental Impact Analysis And Development Of Environment Management Plan

The impacts have been identified with respect to various components of the environment, including:

1. Air Environment
2. Noise Environment
3. Land Environment
4. Water Environment
5. Socio-economic Environment

For each activity/sub-activity, its interaction with different elements of the environment has been identified and analyzed to establish significance of the environmental impact.

Table 12.3: Environment impact analysis

<table>
<thead>
<tr>
<th>S.No.</th>
<th>ACTIVITY</th>
<th>IMPACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>A PRE-CONSTRUCTION STAGE</td>
<td></td>
<td>Clearing of vegetation</td>
</tr>
<tr>
<td>1 Site Preparation</td>
<td>Dust pollution due to levelling and filling activity at project site</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alteration in drainage pattern due to site</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Development of temporary road for construction</td>
<td></td>
</tr>
<tr>
<td>B CONSTRUCTION</td>
<td></td>
<td>Dust generation due to excavation and filling of earth for site development</td>
</tr>
<tr>
<td>1 Excavation, backfilling and Grading</td>
<td></td>
<td>Noise generation during excavation</td>
</tr>
<tr>
<td>2 Transportation of construction material and equipments</td>
<td>Air pollution from exhaust of vehicles transporting materials</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Noise pollution due to movement and operation of heavy construction equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Traffic congestion due to intensive vehicular movement</td>
<td></td>
</tr>
<tr>
<td>S.No.</td>
<td>ACTIVITY</td>
<td>IMPACT</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>C</td>
<td>OPERATION</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Transportation and unloading of waste on site</td>
<td>Air pollution due to movement of trucks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traffic congestion due to movement of hazardous waste carrying trucks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil and water contamination due to washing of vehicles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil and water contamination due to spillage of waste</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Personnel injury during transportation and handling of waste</td>
</tr>
<tr>
<td>2</td>
<td>Incineration of Waste in biomedical waste processing unit</td>
<td>Air Pollution from incinerator due to its failure to meet air quality standards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Noise generation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air pollution due to flaring of gas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fire Hazard</td>
</tr>
<tr>
<td>3</td>
<td>Storage of waste in compost plant, MRF, Waste Processing Units &amp;</td>
<td>Odour due to sustained storage of waste over longer periods in temporary storage area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contamination of storm water due to contact with waste</td>
</tr>
</tbody>
</table>
Table: 12.4 below present the mitigation measures to be taken for controlling/eliminating each of the identified impacts.

TABLE: 12.4. Mitigation Measures For Environmental Impacts

<table>
<thead>
<tr>
<th>A</th>
<th>PRE-CONSTRUCTION STAGE</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Site Preparation</td>
<td>Dust generation due to construction activity for closure</td>
</tr>
<tr>
<td></td>
<td>Clearing of vegetation</td>
<td>Noise generation due to movement of material transportation vehicles for closure</td>
</tr>
<tr>
<td></td>
<td>Dust pollution due to leveling of project area</td>
<td>Traffic congestion due to movement of transportation vehicles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rainwater seepage into the landfill pond due to leakage in top cover</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Change in landuse pattern</td>
</tr>
<tr>
<td>2</td>
<td>Monitoring of the landfill Facility</td>
<td>Groundwater and soil contamination due to leakage in liner system over time</td>
</tr>
</tbody>
</table>

The site has been provided with 30m wide green cover on all four sides of the site boundary. Apart from this additional green area has been provided in and around the administrative and residential blocks. Once the landfill area is filled with waste, the top surface of the sanitary landfill will also be covered with grass.

Mist sprays shall be provided at appropriate places for preventing dust pollution during handling and stockpiling of loose earth.
### Detailed Project Report – Volume 1  Solid waste management in Panaji, Goa

<table>
<thead>
<tr>
<th>Alteration in drainage pattern due to site development activities</th>
<th>Due provision of storm water drains has been done to divert storm water and channelize towards its normal course of movement. This way effort has been made to minimize alteration in normal course of drainage.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of temporary roads</td>
<td>Initially a temporary road shall be constructed to provide access to the site to provide connectivity.</td>
</tr>
</tbody>
</table>

### B  CONSTRUCTION

<table>
<thead>
<tr>
<th>1</th>
<th>Excavation, backfilling and Grading</th>
<th>Dust generation due to excavation and filling of earth for site development</th>
<th>Mist sprays shall be provided at appropriate places for preventing dust pollution during handling and stockpiling of loose earth.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise generation during excavation</td>
<td>The proposed facility is away from the habitation area. However, no construction activity will be allowed during the night time. The workers on site shall be provided with requisite PPEs to prevent/minimize continuous exposure to the high noise levels.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2</th>
<th>Transportation of construction material and equipments</th>
<th>Air pollution from exhaust of vehicles transporting materials</th>
<th>The vehicles transporting waste shall follow a strict maintenance schedule and shall comply with required performance norms.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise pollution due to movement and operation of heavy construction equipment</td>
<td>The workers on site shall be provided with requisite PPEs to prevent/minimize continuous exposure to the high noise levels. Habitation nearest to the site is 500m away and hence would not be affected with this noise pollution.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic congestion due to intensive vehicular movement</td>
<td>The material shall be received on site required as per the construction schedule and shall not be stocked unnecessarily. The material transportation on-site shall be during the early hours of the day to avoid day traffic.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>Construction of Embankment</strong></td>
<td>Dust generation due to transfer of soil</td>
<td>The stockpiling of soil on site shall be done in such a manner that its transfer distance for construction of embankment or filling of quarry is minimized. Mist sprays shall be provided at appropriate places for preventing dust pollution during handling of soil. At the embankment proper water treatment would be given for soil compaction. Any transfer of soil from outside the site will be in closed trucks.</td>
</tr>
<tr>
<td>Noise pollution from the operation of construction equipment</td>
<td>Workers would be provided with requisite PPEs. Construction equipment shall be under regular maintenance to prevent unnecessary high noise levels.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil erosion due to alteration in surface drainage of the area</td>
<td>Lined intercepting drains are provided to check any soil erosion due to alteration in drainage pattern.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in topography of the area</td>
<td>Changes in the land topography have been done keeping in view the space requirements for ISWM facility. Effort has been made to minimize alteration of the existing topography for the remaining part of the site.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><strong>Laying of Liner system at the bottom of the pond and side of embankment</strong> (including layer of clay, sand, geotextile, HOPE, geonet)</td>
<td>Dust generation</td>
<td>Mist sprays shall be provided at appropriate places for preventing dust pollution in the surrounding areas; workers shall be provided with requisite PPEs such as nose mask, face mask and boots.</td>
</tr>
<tr>
<td>Noise generation due to operation of construction machinery</td>
<td>All vehicles and equipment used in construction shall be fitted with exhaust silencers; During routine servicing operations, the effectiveness of exhaust silencers shall be checked and if found to be defective shall be replaced; workers shall be provided with requisite PPEs such as ear plugs and ear muffs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><strong>Installation of the Drainage System</strong></td>
<td>Dust generation</td>
<td>Mist sprays shall be provided at appropriate places for preventing dust pollution in the surrounding areas; workers shall be provided with requisite PPEs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Any localized water logging shall be pumped out and thrown in the nearby areas.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td><strong>Construction and installation of compost plant, MRF facility, incinerator for biomedical waste management, brick making unit, etc and other ancillary facilities such as administration building, staff quarters, etc.</strong></td>
<td><strong>Dust generation</strong></td>
<td>Mist sprays shall be provided at appropriate places for preventing dust pollution in the surrounding areas; workers shall be provided with requisite PPEs</td>
</tr>
<tr>
<td><strong>Noise generation due to operation of construction machinery</strong></td>
<td>All vehicles and equipment used in construction shall be fitted with exhaust silencers; During routine servicing operations, the effectiveness of exhaust silencers shall be checked and if found to be defective shall be replaced; workers shall be provided with requisite PPEs</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water use for construction activity</strong></td>
<td>Groundwater shall be used for undertaking construction activity. Workers shall be trained not to waste water and economies water usage during construction.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 7 | **Workers working and staying on site for carrying out construction activity** | **Sewage generation from temporary labor sheds** | The sewage system for construction laborers' camp shall be designed, built and operated so that no soil or water pollution takes place. Compliance with the relevant legislation shall be strictly followed. Garbage bins shall be provided in the camps and regularly emptied and the garbage shall be disposed off/stored in an environmentally safe manner. |
| **Creation of construction related jobs for local people** | |
| **Safety Hazard to workers from accidents during construction and transportation** | The plants and equipment used in construction shall strictly conform to the MoEF/CPCB noise standards and air emission standards; Workers shall be trained for safe practices of construction and operation; Workers shall be trained in first aid; emergency response procedure shall be followed in case of any accident |

<p>| C | <strong>OPERATION</strong> |
| 1 | <strong>Transportation and unloading of waste on site</strong> | <strong>Air pollution due to movement of trucks</strong> | Trucks shall be routine checked as per the strict maintenance schedule and emissions from their exhaust to be monitored regularly to ensure compliance with the pollution norms. |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic congestion due to movement of waste carrying trucks</td>
<td>The existing narrow roads have to be eased and all weathered roads have to be provided to prevent traffic congestion. Straight approach roads to be provided to the site; the vehicles shall move on identified routes; size and type of vehicles, days and timing of collection vehicles movement shall be specified so that staggered transportation plan is formulated and conflict with general public movement is minimized.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Incineration of waste in biomedical waste processing unit</td>
<td>Air Pollution from incinerator due to its failure to meet air quality standards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Noise generation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air pollution due to flaring of gas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air Pollution while transporting ash to sanitary landfill</td>
</tr>
<tr>
<td>3</td>
<td>Storage of waste in Compost Plant, MRF, Waste Processing Unit &amp; Sanitary landfill</td>
<td>Odour due to sustained storage of waste over longer periods in temporary storage area</td>
</tr>
<tr>
<td></td>
<td>Contamination of storm water due to contact with Waste</td>
<td>The sanitary landfill shall have the provision for selectively diverting majority of the rainwater from unused areas of the Landfill to the storm water drain and prevent its unnecessary contamination. Only part area of Landfill shall be exposed at a time for direct rainfall thus minimizing storm water contamination.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>Groundwater and soil contamination due to leachate leakage through the liner</td>
<td>Monitoring shall be regularly done to ensure that any kind of leachate leakage into the groundwater and soil is detected timely. Once leakage is detected, its root cause shall be identified and immediately the point of leakage shall be plugged.</td>
</tr>
<tr>
<td></td>
<td>Improved waste management in the region thus resulting in better environment</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Leachate collection in the leachate collection sump</td>
<td>Groundwater and soil contamination due to leakage in leachate collection system</td>
</tr>
<tr>
<td></td>
<td>Water logging hazard due to blockage in storm water and leachate collection system</td>
<td>Regular flushing of storm water and leachate collection system shall be done to ensure that there are no blockages in the pipes. Apart from this flushing shall be done after every heavy rain to remove blockages, if any.</td>
</tr>
<tr>
<td>5</td>
<td>Operation of the machineries set up for ISWM facilities</td>
<td>Noise due to operation</td>
</tr>
<tr>
<td>Operation of DG set</td>
<td>Noise due to operation of DG set</td>
<td>DG set shall be provided with adequate acoustic enclosure to ensure that noise level is well within specified norms; persons working near DG set shall be provided with requisite PPEs such as ear plugs and ear muffs</td>
</tr>
<tr>
<td>Air pollution due to its failure to meet air quality standards</td>
<td>Strict maintenance schedule shall be followed and regular stack monitoring shall be done to ensure that emissions from DG set exhaust are within the specified norms</td>
<td></td>
</tr>
</tbody>
</table>

**D CLOSURE AND POST-CLOSURE**

| 1 | Installation of cover liner system. | Dust generation due to construction activity for closure | Mist sprays shall be provided at appropriate places for preventing dust pollution in the surrounding areas; workers shall be provided with requisite PPEs |
| Noise generation due to movement of construction equipment for closure | The plants and equipment used in construction shall strictly conform to the MoEF/CPCB noise standards and air emission standards; regular maintenance schedule shall be strictly adhered to ensure good working condition of equipments; workers shall be provided with requisite PPEs |
| Traffic congestion due to movement of transportation vehicles | The vehicles shall move on identified routes; size and type of vehicles, days and timing of material transportation vehicles shall be specified so that staggered transportation plan is formulated and conflict with general public movement is minimized |
| Rainwater seepage into the landfill pond due to leakage in top cover | Monitoring of leachate collection system is a continuous process. In case leachate generation increases due to seepage of rainwater, it shall come into notice immediately; when such instances are noted, the root cause analysis of increase in leachate generation shall be done and any leakage in top cover shall tie patched up immediately |
| Change in land use pattern | The site after closure shall be developed as open green area. The site shall serve as open area for the surrounding habitation. |
| 2 | Monitoring of the Secured Landfill Facility | Groundwater and soil contamination due to leakage in liner system overtime | Adequate monitoring system shall be installed for post-closure monitoring of the Sanitary Landfill. Proper monitoring system shall be put in place to ensure timely detection of groundwater and soil contamination, if any. Once contamination is identified, proper remedial action shall be taken to plug the leakage and carry out groundwater and soil remediation. |
CHAPTER 13.0

Capital and Operating Cost of the Proposed Scheme
13.0 COST OF THE PROPOSED SCHEME

The total capital cost of the project scheme is estimated at Rs 89.35 cores. After adding for 3% contingency and 5% project management charges the total project cost is estimated as 96.63 cores.

The implementation of the scheme is scheduled to be completed in one year after award of contract after which the commercial production of the ISWM facility and use landfill facilities will commence. The scheme for collection, storage and transportation of wastes shall be implemented along side construction of the main facility.

Details of the cost of the proposed scheme are given in Table 13.1:

1.0 Capital Cost

Table 13.1: Breakup of the Cost of the Proposed Scheme as per JNNURM Guidelines

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particulars</th>
<th>Price (INR Lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Collection, Storage &amp; Transportation System</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Primary Waste Collection and Storage</td>
<td>57.91</td>
</tr>
<tr>
<td>1.2</td>
<td>Transportation Infrastructure</td>
<td>185.57</td>
</tr>
<tr>
<td></td>
<td>Ref. p g No.63 of Vol. 1 of 1 (DPR) Sub Total...1</td>
<td>243.48</td>
</tr>
<tr>
<td>2.0</td>
<td>Integrated MSW Processing Facility</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Civil Works</td>
<td>1398.39</td>
</tr>
<tr>
<td>2.2</td>
<td>Development of Landfill Cells</td>
<td>226.2</td>
</tr>
<tr>
<td>2.3</td>
<td>Mechanical, Electrical &amp; Instrumentation Works</td>
<td>6404.11</td>
</tr>
<tr>
<td>2.4</td>
<td>Electrical &amp; Instrumentation Works</td>
<td>414.97</td>
</tr>
<tr>
<td></td>
<td>Ref. Pg No.1 of Vol. 2 of 1 (Detailed Estimate)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sub Total...2</td>
<td>8,443.67</td>
</tr>
<tr>
<td>3.0</td>
<td>Total...1+2</td>
<td>8,687.15</td>
</tr>
<tr>
<td>4.0</td>
<td>Contingencies @ 3% on &quot;3&quot;</td>
<td>3.00%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>260.61</td>
</tr>
<tr>
<td>5.0</td>
<td>Grand Total with Contingencies...3+4</td>
<td>8947.76</td>
</tr>
</tbody>
</table>
Details of the operation & maintenance cost of the proposed scheme are given in section 2.0:

### 2.0 Operations & Maintenance Cost

#### Table 13.2: Electricity

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Equipment</th>
<th>Motor Rating Installed (kW)</th>
<th>No. of Drives</th>
<th>BkW</th>
<th>Running Time (hr.)</th>
<th>Power Consumed (kW.hr/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Recycling center + OREX feeding area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Moving Floor Bunker</td>
<td>5.00</td>
<td>1</td>
<td>0</td>
<td>3.20</td>
<td>4.00</td>
</tr>
<tr>
<td>2</td>
<td>Drum Feeder</td>
<td>5.00</td>
<td>2</td>
<td>0</td>
<td>3.20</td>
<td>4.00</td>
</tr>
<tr>
<td>3</td>
<td>Belt Conveyor for feeding to Organic Extrusion Press</td>
<td>2.20</td>
<td>1</td>
<td>0</td>
<td>1.41</td>
<td>6.00</td>
</tr>
<tr>
<td>4</td>
<td>In-feed Hopper for feeding to Organic Extrusion Press</td>
<td>5.50</td>
<td>1</td>
<td>0</td>
<td>3.52</td>
<td>2.00</td>
</tr>
<tr>
<td>5</td>
<td>Magnetic separator conveyor</td>
<td>2.00</td>
<td>1</td>
<td>0</td>
<td>1.28</td>
<td>0.50</td>
</tr>
<tr>
<td>6</td>
<td>Manual sorting station conveyor</td>
<td>5.50</td>
<td>1</td>
<td>0</td>
<td>3.52</td>
<td>6.00</td>
</tr>
<tr>
<td>7</td>
<td>Organic Extrusion Press</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Hydraulic Power Pack</td>
<td>75.00</td>
<td>3</td>
<td>0</td>
<td>48.00</td>
<td>6.00</td>
</tr>
<tr>
<td>9</td>
<td>Discharge Gate</td>
<td>3.70</td>
<td>1</td>
<td>0</td>
<td>2.37</td>
<td>6.00</td>
</tr>
<tr>
<td>10</td>
<td>Baler press</td>
<td>20.00</td>
<td>2</td>
<td>0</td>
<td>12.80</td>
<td>1.00</td>
</tr>
<tr>
<td>11</td>
<td>Styropactor</td>
<td>25.00</td>
<td>1</td>
<td>0</td>
<td>16.00</td>
<td>1.00</td>
</tr>
<tr>
<td>12</td>
<td>Wood grinder</td>
<td>25.00</td>
<td>1</td>
<td>0</td>
<td>16.00</td>
<td>2.00</td>
</tr>
<tr>
<td>13</td>
<td>Magnetic separator conveyor</td>
<td>25.00</td>
<td>1</td>
<td>0</td>
<td>16.00</td>
<td>6.00</td>
</tr>
<tr>
<td>14</td>
<td>RDF shredder</td>
<td>20.00</td>
<td>2</td>
<td>0</td>
<td>12.80</td>
<td>1.00</td>
</tr>
<tr>
<td>15</td>
<td>Wet Fraction Processing Line</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Screw Conveyor for Wet Fraction from Organic Extrusion Press</td>
<td>2.20</td>
<td>1</td>
<td>0</td>
<td>1.41</td>
<td>6.00</td>
</tr>
<tr>
<td>17</td>
<td>Fermenter Tank Feed Pumps</td>
<td>5.50</td>
<td>1</td>
<td>1</td>
<td>2.19</td>
<td>6.00</td>
</tr>
<tr>
<td>18</td>
<td>Mixer in Fermenter Tank</td>
<td>15.00</td>
<td>1</td>
<td>0</td>
<td>9.60</td>
<td>6.00</td>
</tr>
<tr>
<td>19</td>
<td>Submersible Mixers in Post Fermenter Tank</td>
<td>7.50</td>
<td>2</td>
<td>0</td>
<td>4.80</td>
<td>24.00</td>
</tr>
<tr>
<td>20</td>
<td>Air blower for double membrane gas dome</td>
<td>2.20</td>
<td>1</td>
<td>0</td>
<td>1.41</td>
<td>24.00</td>
</tr>
<tr>
<td>21</td>
<td>Sludge Dewatering System</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Decanter Centrifuge Feed Pumps</td>
<td>5.50</td>
<td>2</td>
<td>1</td>
<td>2.04</td>
<td>6.00</td>
</tr>
<tr>
<td>23</td>
<td>Decanter Centrifuges</td>
<td>30.00</td>
<td>2</td>
<td>0</td>
<td>19.20</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>Back Drive</td>
<td>5.00</td>
<td>2</td>
<td>0</td>
<td>3.20</td>
<td>6.00</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------</td>
<td>------</td>
<td>---</td>
<td>---</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>3</td>
<td>Dewatering Polymer Dosing Pumps for Decanter Centrifuges</td>
<td>1.10</td>
<td>2</td>
<td>1</td>
<td>0.12</td>
<td>6.00</td>
</tr>
<tr>
<td>4</td>
<td>Dewatering Polymer Dosing Pumps for filter press</td>
<td>1.10</td>
<td>1</td>
<td>1</td>
<td>0.12</td>
<td>8.00</td>
</tr>
<tr>
<td>5</td>
<td>Centrate Transfer Pumps (Recirculation to Sink Tanks)</td>
<td>1.10</td>
<td>1</td>
<td>1</td>
<td>0.7</td>
<td>6.00</td>
</tr>
<tr>
<td>6</td>
<td>Centrate Transfer Pumps (Feed to Filter Press)</td>
<td>1.10</td>
<td>1</td>
<td>1</td>
<td>0.7</td>
<td>6.00</td>
</tr>
<tr>
<td>7</td>
<td>Filter Press</td>
<td>5.00</td>
<td>1</td>
<td>1</td>
<td>3.2</td>
<td>6.00</td>
</tr>
<tr>
<td>8</td>
<td>Pumps for ETP</td>
<td>5.00</td>
<td>1</td>
<td>1</td>
<td>3.20</td>
<td>6.00</td>
</tr>
</tbody>
</table>

**E Composting**

<table>
<thead>
<tr>
<th></th>
<th>Belt Conveyor for In-Vessel Composting Drums (Feed)</th>
<th>2.20</th>
<th>2</th>
<th>0</th>
<th>1.41</th>
<th>6.00</th>
<th>16.90</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Drives for In-Vessel Composting Drums</td>
<td>2.20</td>
<td>8</td>
<td>0</td>
<td>1.41</td>
<td>24.0</td>
<td>270.34</td>
</tr>
<tr>
<td>3</td>
<td>Belt Conveyors from In-Vessel Composting Drums (Discharge)</td>
<td>3.70</td>
<td>1</td>
<td>0</td>
<td>2.37</td>
<td>6.00</td>
<td>14.21</td>
</tr>
<tr>
<td>4</td>
<td>Belt Conveyor from In-Vessel Composting Drums up to Storage &amp; Bagging Area</td>
<td>3.70</td>
<td>1</td>
<td>0</td>
<td>2.37</td>
<td>6.00</td>
<td>14.21</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Drum screen</th>
<th>3.70</th>
<th>2</th>
<th>0</th>
<th>2.37</th>
<th>6.00</th>
<th>28.42</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Flip-Flow screen</td>
<td>3.70</td>
<td>2</td>
<td>0</td>
<td>2.37</td>
<td>7.00</td>
<td>33.15</td>
</tr>
<tr>
<td>7</td>
<td>Star Screen</td>
<td>3.70</td>
<td>1</td>
<td>0</td>
<td>2.37</td>
<td>6.00</td>
<td>14.21</td>
</tr>
<tr>
<td>8</td>
<td>Air Blowers for Bio filter</td>
<td>10.00</td>
<td>1</td>
<td>1</td>
<td>7.50</td>
<td>6.00</td>
<td>45</td>
</tr>
</tbody>
</table>

**F Biogas Genset based Power Plant**

<table>
<thead>
<tr>
<th></th>
<th>H₂S Scrubber System</th>
<th>15.00</th>
<th>1</th>
<th>1</th>
<th>10.00</th>
<th>24.0</th>
<th>240</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H₂S Scrubber Feed Blowers</td>
<td>15.00</td>
<td>1</td>
<td>0</td>
<td>9.60</td>
<td>24.0</td>
<td>230</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Biogas Genset based Power Plant</th>
<th>5.00</th>
<th>1</th>
<th>0</th>
<th>3.20</th>
<th>24.0</th>
<th>77</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interface Panel Loads consisting of Battery Charger, Instrumentation &amp;Control etc.</td>
<td>2.20</td>
<td>1</td>
<td>0</td>
<td>1.41</td>
<td>24.0</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Low Temperature Water Pumps</td>
<td>1.60</td>
<td>4</td>
<td>0</td>
<td>1.02</td>
<td>24.0</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>Module Control Panel consisting of Control Load, Radiator Fans etc.</td>
<td>1.50</td>
<td>2</td>
<td>2</td>
<td>0.96</td>
<td>24.0</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>LT Cooling Tower Pumps</td>
<td>0.75</td>
<td>1</td>
<td>0</td>
<td>0.48</td>
<td>24.0</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>LT Cooling Tower Fans</td>
<td>1.00</td>
<td>1</td>
<td>0</td>
<td>0.64</td>
<td>24.0</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Air Conditioner</td>
<td>1.50</td>
<td>1</td>
<td>0</td>
<td>0.96</td>
<td>24.0</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Engine Cooling Water Make-up Pumps</td>
<td>1.50</td>
<td>1</td>
<td>0</td>
<td>0.96</td>
<td>24.0</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Lube Oil Pumps: Fresh</td>
<td>1.50</td>
<td>1</td>
<td>0</td>
<td>0.96</td>
<td>24.0</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Lube Oil Pumps: Used</td>
<td>1.50</td>
<td>1</td>
<td>0</td>
<td>0.96</td>
<td>24.0</td>
<td>23</td>
</tr>
</tbody>
</table>
### Table 13.3: Diesel

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Head</th>
<th>Qty. No.</th>
<th>Diesel Consumption Liters/hr.</th>
<th>Running Time hr./day</th>
<th>Diesels Consumed Liters</th>
<th>Unit Rate Rs.</th>
<th>Amount Rs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DG Set</td>
<td>1</td>
<td>120</td>
<td>2.00</td>
<td>240</td>
<td>50.00</td>
<td>12,000</td>
</tr>
<tr>
<td>2</td>
<td>Wheel Loader</td>
<td>1</td>
<td>4.00</td>
<td>6.00</td>
<td>24</td>
<td>50.00</td>
<td>1,200</td>
</tr>
<tr>
<td>3</td>
<td>Skid Stir Loader/ Forklift - Recycling Centre</td>
<td>2</td>
<td>2.00</td>
<td>4.00</td>
<td>16</td>
<td>50.00</td>
<td>800</td>
</tr>
<tr>
<td>4</td>
<td>Skid Stir Loader/ Forklift -- Biological Section</td>
<td>1</td>
<td>2.00</td>
<td>4.00</td>
<td>8</td>
<td>50.00</td>
<td>400</td>
</tr>
<tr>
<td>5</td>
<td>Compactor - Landfill section</td>
<td>1</td>
<td>4.00</td>
<td>2.00</td>
<td>8</td>
<td>50.00</td>
<td>400</td>
</tr>
<tr>
<td>6</td>
<td>Tree Mulcher</td>
<td>1</td>
<td>5.00</td>
<td>5.00</td>
<td>25</td>
<td>50.00</td>
<td>1,250</td>
</tr>
<tr>
<td><strong>Total (Rs./day)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>16,050</strong></td>
</tr>
<tr>
<td></td>
<td>(Rs/Ton)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>161</strong></td>
</tr>
</tbody>
</table>
### Table 13.4: Man Power

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Personnel</th>
<th>Nos. per Shift</th>
<th>No. of Shifts per Day</th>
<th>Total Nos. per day</th>
<th>Salary Rs./day</th>
<th>Salary Rs./mth</th>
<th>Total Amount Rs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Plant Manager</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1,000</td>
<td>30,000</td>
<td>30,000</td>
</tr>
<tr>
<td>2</td>
<td>Weigh Bridge Operator</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>400</td>
<td>12,000</td>
<td>12,000</td>
</tr>
<tr>
<td>3</td>
<td>Mechanic/Fitter</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>500</td>
<td>15,000</td>
<td>15,000</td>
</tr>
<tr>
<td>4</td>
<td>Electrician</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>500</td>
<td>15,000</td>
<td>15,000</td>
</tr>
<tr>
<td>5</td>
<td>Plant Operator</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>500</td>
<td>15,000</td>
<td>60,000</td>
</tr>
<tr>
<td>6</td>
<td>Helper/ Sorting persons</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>400</td>
<td>12,000</td>
<td>96,000</td>
</tr>
<tr>
<td>7</td>
<td>Driver for Wheel Loader / Bobcat</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>500</td>
<td>15,000</td>
<td>60,000</td>
</tr>
<tr>
<td>8</td>
<td>Gardener</td>
<td>2</td>
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<td>2</td>
<td>350</td>
<td>10,500</td>
<td>21,000</td>
</tr>
<tr>
<td>9</td>
<td>Sweeper</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>350</td>
<td>10,500</td>
<td>21,000</td>
</tr>
<tr>
<td>10</td>
<td>Watchman</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>350</td>
<td>10,500</td>
<td>63,000</td>
</tr>
<tr>
<td></td>
<td><strong>Total (Rs./month)</strong></td>
<td></td>
<td></td>
<td>30</td>
<td></td>
<td></td>
<td><strong>3,93,000</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Total (Rs./day)</strong></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td><strong>13,100</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Total (Rs/Ton)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>131</strong></td>
</tr>
</tbody>
</table>

### Table 13.5: Maintenance

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Head</th>
<th>Capital Cost Rs. Lakhs</th>
<th>Rate</th>
<th>Amount Rs. Lakhs /A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Civil Works</td>
<td>800</td>
<td>1.50%</td>
<td>12.00</td>
</tr>
<tr>
<td>2</td>
<td>Mechanical, Electrical &amp; Instrumentation Works</td>
<td>4,500</td>
<td>2.00%</td>
<td>90.00</td>
</tr>
<tr>
<td></td>
<td><strong>Total (Rs./year)</strong></td>
<td>5,300</td>
<td></td>
<td><strong>102.00</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Total (Rs./day)</strong></td>
<td></td>
<td></td>
<td><strong>27,945</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Total (Rs/Ton)</strong></td>
<td></td>
<td></td>
<td><strong>279</strong></td>
</tr>
</tbody>
</table>

### Table 13.6: Other

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Head</th>
<th>Unit</th>
<th>Qty.</th>
<th>Unit Rate Rs.</th>
<th>Amount Rs./day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bagging of Compost</td>
<td>ton/day</td>
<td>8</td>
<td>200</td>
<td>1,600</td>
</tr>
<tr>
<td>2</td>
<td>Administration Expense</td>
<td>Lot</td>
<td>1</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>3</td>
<td>Sampling &amp; Testing</td>
<td>Lot</td>
<td>1</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>4</td>
<td>Miscellaneous</td>
<td>Lot</td>
<td>1</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>5</td>
<td>Rental Costs for Compactor, Trucks &amp; Cranes</td>
<td>Lot</td>
<td>1</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>6</td>
<td>Bailing Wire/ Wrapping Sheet</td>
<td>Lot</td>
<td>1</td>
<td>3,000</td>
<td>3,000</td>
</tr>
<tr>
<td>7</td>
<td>O&amp;M Supervision Charges</td>
<td>Lot</td>
<td>1</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td></td>
<td><strong>Total (Rs./day)</strong></td>
<td></td>
<td></td>
<td><strong>12,600</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total (Rs/Ton)</strong></td>
<td></td>
<td></td>
<td><strong>126</strong></td>
<td></td>
</tr>
</tbody>
</table>
Table 13.7: Summary of O & M Cost

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Head</th>
<th>O&amp;M Cost Rs./day</th>
<th>O&amp;M Cost Rs/Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Electricity</td>
<td>22,529</td>
<td>225</td>
</tr>
<tr>
<td>2.2</td>
<td>Diesel</td>
<td>16,050</td>
<td>161</td>
</tr>
<tr>
<td>2.3</td>
<td>Manpower</td>
<td>13,100</td>
<td>131</td>
</tr>
<tr>
<td>2.4</td>
<td>Maintenance</td>
<td>27,945</td>
<td>279</td>
</tr>
<tr>
<td>2.5</td>
<td>Others</td>
<td>12,600</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td><strong>Total (Rs.)</strong></td>
<td><strong>92,224</strong></td>
<td><strong>922</strong></td>
</tr>
<tr>
<td></td>
<td>For 100 TPD per year</td>
<td><strong>3,36,61,760</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>336.61 Lacs</strong></td>
</tr>
</tbody>
</table>
CHAPTER 14.0
Financial Framework
14.0 FINANCIAL FRAME WORK

14.1 Overview
An innovative financial framework had been created by the Government of India to make the SWM project workable in India in the long term. A JNNURM scheme, discussed below, is part of the innovative approach that has led to sustainable results in several other projects. Panaji is proposed as one of the cities to be financed under JNNURM. Substantial part of capital cost is proposed to be met mainly by grants from grants available from Government of India (GOI) under Jawaharlal Nehru National Urban Renewal Movement (JNNURM). The proposed project aims to optimize on funding mechanism instituted under the JNNURM scheme involving Central Government & State Government funding by devising financially and economically viable models.

The total cost of the proposed SWM project is 101.48 crores which will be funded in the share of 80:10:10 by Government of India, State Government and ULB respectively.

Such a model distributes the ownership of the project and makes the involved parties responsible for the long-term success of the project. The paragraphs below provide the details of the financial framework for the integrated solid waste management project for the City of Panaji, Goa.

14.2 Jawaharlal Nehru National Urban Renewal Mission (JNNURM)-Objectives
JNNURM launched in December 2005 along with Urban Infrastructure Development Schemes for Small and Medium Towns (UIDSSMT) under Ministry of Urban Development (MoUD) is an important step taken in response to the challenge of rapid urbanization. The scheme requires states and ULBs to under take prescribed set of reforms.

Under the scheme, contribution of funds for Panaji Goa would be in the ratio of 80:10 between Central Government & State Government and the balance 10% could be raised by the ULB from the financial institutions.

14.2.1 Grants under JNNURM
JNNURM scheme is area forms-driven, fast track, planned development of identified towns with focus on efficiency in urban infrastructure and services delivery, community participation and accountability of local governments to wards citizens. The salient features of this scheme are:

- Preparation of sector-wise project reports by identified cities listing projects and their priority. The thrust areas are re-development of inner (old) city areas, water supply and sanitation, sewerage and solid waste management, construction and improvement of drains/storm water drains, construction/upgradation of roads, highways/expressways, parking lots/spaces on public/private partnership basis etc.
- The grant assistance (both Central and State) to act as seed money to leverage additional resources from the ULB.
- Allocation of funds among states will be on the basis of the state's urban population (excluding Cities covered under UIDSSMT) to total urban population in the country (excluding cities covered under UIDSSMT).
• Cities/towns will be sanctioned project-based grants/loans, which in turn would leverage, to the extent feasible, additional resources from the ULB.
• Funds from MPLAD/MLALAD could be used towards project cost and to that extent the loan component/state share could be suitably reduced.
• States may allocate funds to towns/cities based on similar formula. However, funds would be provided to only those towns and cities where elections to local bodies have been held and elected bodies are in position.

14.2.2 Release of Central Assistance
Central assistance (grant) released will go directly to the nodal agencies identified by State government as Additional Central Assistance.
Release of Central share to nodal agency will be in two installments and will depend on availability of State’s share and submission of utilization certificates within 12 months of the closure of the financial year in accordance with the provisions of General Financial Rules.

The criteria for release of funds will be as under:

• 50% of the Central share will be released on signing of Memorandum of Agreement to the State nodal agency, after ascertaining availability of State’s share.
• Balance 50% of the central share would be released on submission of Utilization Certificates by nodal agency for 70% of funds (Central & State grants) released earlier.
• State level nodal agency will, however, release funds in the following manner:
  
  o 25% of Central grant on ascertaining availability of States share;
  o Balance Central grant after release of State grant and after assessment of progress of implementation of reforms.

JNNURM supported projects are bankable since a substantial part of financing is met out of grants.

14.2.3 Incentives

After due assessment of status of implementation of activities for which incentives are sought, State Level Sanctioning Committee (SLSC) may sanction additional central grant up to a maximum of 8.5% to incentivize implementing agencies as indicated below:

• 1.5% for preparation of Detailed Project Report
• 5% for training and capacity building relating to project/scheme
• 1% for bringing about efficiencies in the projects
• 1% for adoption of innovative approaches and adoption of proven and appropriate technologies

14.3 Additional Sources of Funding

14.3.1 Private Investment
The private investment has been involved in collection, transport of SWM, running and maintenance of ISWM through PPP mode of Design Built Own Operate Transfer (DBOOT) or Built Own Operate (BOO) in the
past by many corporations. The private party (PP) contributes through equity for part of capital expenditure and is remunerated by way of tipping fee.

This is a typical model, which has been followed by various corporations in the country.

However our observation has been that for any project to be developed on PPP basis, the project should be financially and economically viable for both the parties involved. It is only then that the project can be sustained for the years to come. For the private party to invest in, the project should generate attractive returns over the period of time such that the private party is able to not only recover the capital cost or investment but also make a reasonable profit from the operation of the plant.

In the business of Solid Waste Management, the revenue generated from the collection and the selling of waste is an important aspect of making the whole cycle of SWM financially viable.

It is evident from the operations and maintenance cost and the resource recovery that the operator will have a deficit in terms of meeting the collection as well as the operation cost only from the sale of products. Further more there is no possibility to recover the capital investment required for the proper functioning of the ISWM facility. This problem is more compounded as the plants are built (hence capital investment requirement) for a future projection of 25 years population and waste generation, while the waste quantum as received is as per present population. The resource recovery is based on present waste as received at the ISWM site.

Refer table 14.1 which indicates the Operation & Maintenance cost v/s Resource recovery and net income to the operator

<table>
<thead>
<tr>
<th>Sno.</th>
<th>Parameter</th>
<th>Rs/Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Operations &amp; Maintenance Cost</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operations and Maintenance of the facility</td>
<td>922</td>
</tr>
<tr>
<td>1</td>
<td>Total O&amp;M cost</td>
<td>922</td>
</tr>
<tr>
<td></td>
<td><strong>Resource Recovery</strong></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Resource recovery from operations to the operator</td>
<td>470</td>
</tr>
<tr>
<td>3</td>
<td>Net income to the operator (2-1)</td>
<td>-452</td>
</tr>
<tr>
<td>4</td>
<td>Operators % Loss Margin</td>
<td>-49%</td>
</tr>
</tbody>
</table>

Under such a situation, in case the Capital investment is also made by the operator, the tipping fee as charged by the operator will be very high and make the project unviable for the corporation to sustain. As it has been observed in the SWM segment, operators do not invest proper capital outlay in building modern and proper ISWM facility as the tipping fee burden is high and unviable for corporations to pay, as a consequence hardly any treatment takes place at site and in most cases waste is dumped in an unscientific and unacceptable manner. Hence, in order to have a proper, viable and environmentally safe ISWM approach, it is recommended to seek funds under JNNURM as a central grant in order to build up...
14.4 Recommendations and suggestions

14.4.1 Capital Expenditure
To ensure long term sustainability of the complete ISWM project, it is proposed that the capital outlay for collection, transport and ISWM facility shall be funded by a central JNNURM grant.

Table 14.2: Total capital investment

<table>
<thead>
<tr>
<th>Total Capital Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sno.</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Table 14.3: Funding pattern

<table>
<thead>
<tr>
<th>Funding pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sno.</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

14.4.2 Operations and maintenance expenditure

At present CCP is involved in collection and transportation of the waste from both primary (household) as well as secondary level (collection points). It is recommended that CCP will continue to do the same, including maintenance of the transport vehicles and the operator shall be responsible for the only the operations & maintenance of the ISWM facility.

As the income generated by the operator may not be sufficient to meet the O&M expenses, CCP shall pay a “viability gap funding” fee to the operator which shall be computed based on the expected growth of revenue with increase in the quantum of waste and population by charging a “user fee” concept from commercial establishments as well as households.

By charging a nominal “user fee” and improving of the collection efficiency, CCP can recover the O&M charges for running the facility and make the process sustainable, benefiting the entire community.

Refer table 14.2 for the same “viability gap funding” fee structure.
### Table 14.4 Calculation of VGF user charge

<table>
<thead>
<tr>
<th></th>
<th>YEARS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1 Quantum of waste (TPD) assuming 5% growth per annum</td>
<td>28</td>
</tr>
<tr>
<td>2 Resource Recovery (Rs/Ton) assuming 5% growth per annum</td>
<td>470</td>
</tr>
<tr>
<td>3 Resource Recovery (Rs/day)</td>
<td>13160</td>
</tr>
<tr>
<td>4 Operation &amp; Maintenance cost (Rs/Ton) assuming 5% growth per annum</td>
<td>922</td>
</tr>
<tr>
<td>5 O&amp;M Expenses (Rs/day)</td>
<td>25816</td>
</tr>
<tr>
<td>6 Deficit in the income = Viability Gap funding or VGF (Rs/day)</td>
<td>-12656</td>
</tr>
<tr>
<td>7 Viability gap funding (VGF) Rs/Ton</td>
<td>-452</td>
</tr>
</tbody>
</table>

This VGF shall be collected as a “user fee” from commercial establishments and households.

#### A Commercial establishments

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Nos. of commercial establishments</td>
<td>750</td>
<td>758</td>
<td>765</td>
<td>773</td>
</tr>
<tr>
<td>2 User fee per establishment per month</td>
<td>400</td>
<td>420</td>
<td>441</td>
<td>463</td>
</tr>
<tr>
<td>3 Assuming collection of revenue from 70% of establishments, amount collected per month (Rs/Month) in lakhs</td>
<td>2.1</td>
<td>2.22</td>
<td>2.36</td>
<td>2.5</td>
</tr>
</tbody>
</table>

#### B Households

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Residential units in Panaji</td>
<td>16000</td>
<td>16320</td>
<td>16646</td>
<td>16979</td>
</tr>
<tr>
<td>2 User fee per household Rs. per month</td>
<td>30</td>
<td>31.5</td>
<td>33</td>
<td>34</td>
</tr>
<tr>
<td>3 Assuming collection of revenue from 50% of households, amount collected per month (Rs/Month) in lakhs</td>
<td>2.4</td>
<td>2.57</td>
<td>2.74</td>
<td>2.88</td>
</tr>
</tbody>
</table>

#### C Total collection by CCP (Commercial + Households) (Rs/ Month) in Lakhs

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Collection (Rs/day)</td>
<td>14000</td>
<td>15966</td>
<td>17000</td>
<td>17933</td>
</tr>
<tr>
<td>2 Collections required to meet the VGF (Rs/day)</td>
<td>12656</td>
<td>14250</td>
<td>15469</td>
<td>17259</td>
</tr>
</tbody>
</table>
CCP has categories the commercial establishments wherein the charges vary depending upon the size/category of the commercial establishment from Rs. 100/- to Rs.7500/- per month and Rs. 30/- per month for residential units. This system shall be continued in the future years. However, the amount levied shall be reviewed from time to time to make necessary revisions in the fee charged. CCP shall also give rebate/benefits to the facilities taking waste minimization initiatives. Such schemes will encourage generators to take proactive initiatives for reducing waste generation quantities.

14.5 Salient Feature of Partnership
The contractual agreement among Private Operator & CCP, for any of the above arrangement, will include clearly defined services considering

- Health and safety
- Environmental protection
- Legal aspect of compliance towards legislation
- Cost recovery/operational economics

Clarity in definition of the services made in mutual agreement will ensure good and reliable services, which will be helpful at larger stage for monitoring and evaluation of services. The performance monitoring in terms of service efficiency, reliability, service quality and cost can be emphasized by defining operational standards, regulatory checks and periodicity of performance checks through public awareness and participation.

Of late, both reward and punishment systemshave are being incorporated for motivation and efficient performance of the private operator.

The private sector may, however, been encouraged to participate in a manner not affecting the interest of the existing labor force, not violating the provisions of the labor laws, and above all restricting exploitative labor practices at the same time reducing the establishment cost of CCP. Sound though the above may seem there are practical constraints and improvements can be achieved over a period of time through proper training, education and work force redeployment and implementation of a planned retirement and hiring policy. Investment in capital infrastructure without concurrent addressal of labor productivity issues and public awareness will be futile.

14.6 Additional Revenue for CCP and PO over a period of time
It is proposed to convert the ISWM facility into a tourist attraction and land fill sites into public parks on its closure. The transformation can help generate revenue from parking fees, kiosk rentals, and advertisement and entrance fees.

Also cash crops like cashew shall be planted in the green belt area, which can be a source of income for CCP or the operator.

14.7 Risks Associated with Plant Operations and maintenance
Risk is essential ingredient of all commercial projects. Bidder will evaluate the risk-return ratio while bidding and government would have to assess its gains of having a public utility asset created and maintained at much lower cost or no cost. It is important for the proposed project that the risks are identified and allocated appropriately between the two parties which are well equipped to deal with the risks.

There are three types of risks that could be associated with the project. We have also suggested risk
mitigation measures:

a. Commercial Risk
These are those events that business managers are well equipped to deal. This risk could arise when the services, which are being developed, are not giving the desired results to the people, which it was meant to be. Therefore, the people are not utilizing the services at the rate, which was forecasted. As a result the proposed project is not generating the enough revenues and is not financially self-sustainable. The private party who is managing the SWM activities could manage this risk in many ways such as: by controlling the operating cost and not letting them increase; introducing ways by which more number of people could utilize the facilities, increasing revenue from non core activities as explained later.

b. Political Risk
These risks are the result of the change in the government’s actions, policies and regulations, which the government has the greatest ability to determine and control. Sometimes, the government could change while the project is still in the construction phase and for the new govt. the same would not be on the priority list. As the government is showing consistency and stability at the state level. This project has negligible Political Risk till project begins/initialized. Since the project would run for a period as long as 25 years, the Contract terms would provide for risk mitigation such as forbidding change in commercial terms, freezing contract period, penalties for determination before term expires or forbidding price of public utilities from being increased, etc.

c. Credit risk
infrastructural projects are considered to be most risky during the initial years of construction being started as it has the risk of the project being delayed and could have the chances of never being completed. Reasons could range from lack of funding to bureaucratic entangle. Such risk can be mitigated by having a proper frame work of implementation and a skillful project management team to implement the contract.
CHAPTER 15.0
Proposed Institutional Framework
15.0 PROPOSED INSTITUTIONAL FRAME WORK

The sustenance of the proposed SWM services depends on robustness and capacity of institutional frame work. It is proposed to take steps for institutional strengthening and internal capacity building to ensure that endeavor to improve the existing scenario is successful. Institutional strengthening can be done by adequately decentralizing the administration, delegating adequate powers at the decentralized level, by inducting qualified and competent professionals into the administration and providing adequate training to the existing staff. Plan for capacity building of all stake holders including management staff, supervisors, workers, contractors and public is discussed in chapter 12.

15.1 Current Institutional Frame Work For Swm In Panaji

For management of sanitation services, Panaji city is divided into 12 zones. Corporation of City of Panaji (CCP) is over all in-charge for the solid waste management in Panaji city. There are 12 Supervisors for 12 zones. There are 15 additional supervisor deployed at various facilities. A total of 24 Drivers are deployed and 499 sanitary workers are engaged for various MSWM activities. Each sanitary staff has a designated area for daily cleaning. There is separate staff for waste transportation (drivers and helpers) responsible for lifting solid waste and dumping it on the outskirts of the city.

15.2 Recommendations For Institutional Strengthening

The recommendations for the institutional framework are based on the specific tasks to be carried out under the proposed MSW Project. The activities, which need to be focused as per the proposed plan include:

- Segregation of waste at source
- Mechanism of waste collection
- Primary collection
- Secondary collection
- Transportation of waste from secondary collection locations
- Development of integrated SWM processing facility
- Operation and maintenance of installed SWM system

In the above listed components, several activities/infrastructure developments are proposed to be taken up for implementation for the first time. The CCP requires capacity building to execute the proposed plan.

In many cities in India, in view of the limitations of ULBs, private sector participation has been introduced for establishing and operating SWM services. Such public private partnerships have put a check on growth in the establishment costs, brought economy in expenditure and introduced an element of healthy competition between the private sector and the public sector.

It is therefore proposed to consider the private sector participation for developing and operating new services.
Based on analysis of the merits and demerits of the existing system, it is proposed to have responsibility delegation for undertaking each activity under proposed SWM plan as follows:

**Table 15.1: Specific Roles and Responsibilities of Institutions involved in Implementation and O&M**

<table>
<thead>
<tr>
<th>Activities</th>
<th>Organization/Institution</th>
<th>Scope/Responsibilities</th>
</tr>
</thead>
</table>
| Segregation and Collection  | Corporation of City of Panaji | - Deploy of sanitary workers  
- Sensitization of residents/public about segregation.  
- Provide facilities/bins for segregation  
- Collection from households  
- Transportation of waste to bins.  
- Orientation/sensitization of sanitary workers.  
- Involve NGOs/CBOs in public awareness: |
| Transportation               | Corporation of City of Panaji, Private Agency | - Selection of party/agencies for procurement and execution  
- Work out finance Model with agency.  
- Funding  
- Monitoring and supervision of agency work.  
- Redressal of issues.  
- Monitoring management and coordination.  
- Procurement of equipments/facilities.  
- Installation of facility.  
- Safety of equipments.  
- Collection/lifting of waste from secondary collection points.  
- Operation and maintenance of vehicles.  
- Transportation of waste to site |
| Integrated SWM Facility     | Corporation of City of Panaji | - Selection of agency for execution  
- Funding  
- Monitoring of construction and management  
- Supervision of commissioning. |
| PPP                         |                          | - Design and construction  
- Commissioning  
- O&M |

At several levels of SWM, it is proposed to involve private operators who will deploy and manage staff, but ultimate responsibility of monitoring and ensuring that the people of Panaji are receiving desired quality of life lies with the CCP. The existing staff of CCP shall be adequate for doing monitoring of SWM services by different private operators but require capacity building to undertake this activity efficiently. Therefore, in addition to private operator participation, institutional strengthening is required within CCP to ensure sustainability. For institutional strengthening, it is proposed to decentralize the administration, delegate adequate powers at decentralized level and bring accountability at all levels. It is proposed to decentralize SWM functions at two levels:

- Zone level
- City level

**15.2.1 Zone level**
The zone level administration shall be fully responsible for ensuring storage of segregated waste at source, primary collection of waste, street sweeping and transferring waste to bins, cleaning surface drains and public places. The cleaning of each street, lane, by-lane, markets and public places shall be regularly supervised by the zone level supervisors. It is proposed to have two zones under one supervisor.

15.2.2 City Level

The city level administration shall supervise and support the zone administration. The city level administration shall monitor daily waste quantities collected and transported from each zone and enquire if any abnormality is reported. The central department is responsible for monitoring activities at the integrated solid waste management facility.

15.3 Proposed Institutional Framework For Operation And Maintenance

While the corporation shall be responsible for collection and transportation of the waste, assistance shall be taken from private companies to design, build, construct, and operate and maintain the plant as per CCP’s requirement.

Financial assistance shall be provided by JNNURM grant, supported by similar grants from the state and ULB.
CHAPTER 16.0

Public Awareness through Information, Education & Communication and Capacity Building of (CCP) For Sustainable MSW Management
16.0 PUBLIC AWARENESS THROUGH INFORMATION, EDUCATION COMMUNICATION AND CAPACITY BUILDING OF THE CORPORATION OF THE CITY OF PANAJI (CCP) FOR SUSTAINABLE MSW MANAGEMENT

16.1 INTRODUCTION

The key to the success of SWM system in any town is the cooperation of its citizens. The community participation can be strengthen through multi disciplinary approach of Information, Education & Communication (IEC) for the citizens one side and Capacity Building of the ULB officials and staff on the otherside. Citizens and community as a whole ought to be involved improper storage, collection and safe disposal of waste. At the same time, they hould be made aware of health risks associated with improper management of solid waste. At present, the existing management of solid waste in most of the towns in India depends entirely on their respective municipalities. But, due to rapidly growing urban population, urban local bodies (ULBs) are unable to provide an adequate level of services, posing a serious threat to public health and environment at large. Hence, for the success of SWM project, it is essential to understand the requirement of public participation and support.

16.2 Municipal Solid Waste Management In Panaji City

Panaji, the capital of the state of Goa is having approx. 8.2 sq. Km area under its corporation limit, divided into 12 Sanitation Zones. The overall population of the city is 59066(2001) and is estimated to be 73287 by the year 2013. Apart from the existing residential population, Panaji being the focal point of tourism in Goa has large influx of tourists as well. From past records, we see that December being the peak tourists' season shows maximum tourist arrival. In Dec 2007, 143623 tourists (Tourists Statistic 2008) arrived in Panaji. Though tourism is a boon as it is income generator for the Goa state but tourism relationship with environment is complex. The USP of Panaji is fading away as plastic litter is becoming prominent. The existing population generates approx.72.2 MT/day (2013) of waste, waste is being generated not only by these people but also by the influx of tourists, floating population, who come here for business or service and thus waste produced is high.

Like most municipalities, CCP started waste management with open community bins in different localities. These bins consisted of bottomless circular concrete ring and had mixed waste dumped into them by its citizens. But unlike other municipalities, CCP is quite actively participating in solid waste management from past many years. In 2003, CCP started waste management campaign "Bin Free in 2003". Concrete bins were replaced by metallic bins and then further no bins in the locality. Such initiatives have always been taken up by CCP and today the waste is being collected through local residential areas via door-to-door collection at a fee of Rs. 1/- per day. Also Segregation at Source (SAS) scheme was launched by the CCP and under this scheme citizen’s of Panaji city are segregating waste at source and contributing in the waste management programme. Also, contribution of the ULB staff can't be ignored in supporting the programme. The studies and our past experience in the field of Information, Education & Communication (IEC) says that IEC is a continuous process and requires to be carried out on regular basis. The present scenario of Panaji, where citizens are educated & tourist’s influx is at large, has been assessed. Apart from this, to ensure the municipal solid waste collection in segregated form, adequate handling and improved processing of the waste with new & better technologies the Municipal staff as well as the other stakeholders/ private operators involved in this
process should be properly trained and sensitized on regular basis. For this purpose, the need for Information, Education & Communication (IEC) plan and Training & Capacity Building of the staff responsible for Solid Waste Management has been assessed and is being proposed.

16.3 Objective Of The IEC Programme

IEC is a multi-level tool for promoting and sustaining positive behavioral change in individuals and communities by understanding barriers and bottlenecks and locating benefits that are personalized as well as normative through developing tailored messages through a variety of communication channels. IEC recognizes that the decision to adopt new ideas or behavior is the result of a complex process and takes place only over a period of time. Sustaining behavior change - moving from awareness to action to long-term behavioral maintenance - requires ongoing and systematic and differentiated approaches to communication.

The major objectives of the IEC and Capacity Building are as follows:

• Bringing of attitudinal and behavioral changes among the residence w.r.t. the segregation of waste and sanitation improvement.

• Public awareness through IEC programmes and educating the masses on various aspects of solid waste management and achieve the target of receiving segregated waste from each household & also reduction in the waste quantity.

• Creating Public Participation in Planning and Management of MSW Activities

• Capacity Building of the personnel involved in implementing MSW i.e. Institutional Capacity of staff of CCP, for improved MSW Management.

• Integration and involvement of private sweepers and rag pickers in improving MSW management

• Special focus and IEC campaigns for the tourists and the agencies, which are involved in management of big events during carnivals.

16.4. Public Participation & Awareness Through Information, Education & Communication Plan (IEC)

The success of any solid waste management scheme can be measured through the extent of cooperation and participation of people, effectiveness of the proposed system and operational efficiency. Communication is an integral part of planning for sustainable development. The development of human society is largely because of its ability to communicate information and ideas with each other and to use such information and ideas for progress.

The programmes being implemented by the Government Departments aim at sustainable holistic development in all development projects. The success of these programmes is critically dependent on the participation of the people, particularly target groups, in the implementation process. The approach should be to emphasize on communication with target groups, local community for the implementing programme of SWM at strategic locations in Panaji.
16.4.1 Approach of IEC Plan

The basic approach of Information, Education and Communication Plan is to make the public aware about the need of reduction and segregation of waste from the households along with the collection system of waste to take public cooperation for making the environment pollution free and to develop proper hygienic conditions. The main emphasis would be given to tourists (domestic & international) who are visiting Panaji not only for its tourist's sites but. Also for its character. Almost all the tourists coming to the state of Goa, visit Panaji city, high influx is making plastic litter prominent. Waste is not only generated by tourists and general public but also by the big companies and agencies who are advertise during the festivals and carnivals, efforts would be made to run campaigns focusing on all these things and thus resulting in mass awareness & better management of the waste.

Communication would be required through various techniques and modes. The proposed public participation & awareness programme may be carried out using localized and area specific popular tools that may be identified during project implementation period. However, some of the effective tools to forge public participation shall include the following:

- Focused Group Discussions (FGDs)
- Inter personal meetings
- Creating local committees comprising of local influential people, RWA /society members and important stakeholders.
- Printed materials and Audio-visual advertisements
- other locally popular media.

Focus Group Discussion & Public Meetings:

Through Focus group Discussions and public meetings people could be directly informed, educated and convinced for their role and responsibilities for the segregation at source and for their involvement in solid waste management. This is an effective tool; usually time taking as discussions last for 1or 2 hours.

Interpersonal meetings

For door-to-door information spreading, involvement of health workers (Sanitary staff) would be easy and speedy along with the volunteers. It will also create a platform for better communication among public and sanitary staff. The volunteers and health workers will help in spreading the project information with the help of support material, which will be helpful for providing effective information along with time saving.

Media Support:

Mass media is a great tool to spread information among the community in a very fast and effective medium. For the IEC purpose, print media as well as electronic media could have a great role for informing people about the project and how their support can do the changes for making their town clean and hygienic.
Creating local committees comprising of local influential people, RWA /society members and important stakeholders:

For social mobilization, attitudinal and behavioral changes of the residents’, involvement of major stakeholders’ is essential. For this purpose institutions and other organizations involved in social activities would be contacted as they are great awareness centers for social mobilization and public awareness. The organizations/ institutions/stakeholders’, which can play an active role in social mobilization, are listed below:

- Educational Institutions (Schools, Colleges, etc.)
- NGOs/ CBOs/ RWAs
- Sr. Officials/ Administration Officers/ Sr. Citizens

16.4.2 Identification and Action

The basic approach of Information, Education and Communication Plan is to make the public aware of the need of reduction and segregation of waste from the households along with the collection system of waste to take public cooperation to make hygienic structure of the area.

Selection of target groups plays a key role in creating effective awareness in residential. For solid waste management, it becomes more important as the source of MSW starts from houses due to which target starts from household female head, youths and children who requires some form of role model or different methods to influence their behavior. It is very important aspect, which could be at waste generators level and may reduce, reuse and recycle their waste. The other part of target groups may be waste collector and waste managers. These types of target groups are directly involved with the solid waste management. Along with this, there are other groups, which can be helpful for the better management of MSW segregated waste, collection, operation, handling and proper disposal.

The major target groups are as following (table16.1):

Table 16.1: Target Groups

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Target Group</th>
<th>Target Group Detail</th>
<th>Action Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Waste Generator</td>
<td>• Residential Areas (women children and youths)</td>
<td>- Holding locality-wise meetings seminars, with self-help groups on solid waste management.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Commercial Areas (Shopping areas, Vegetable markets, Offices, Hotels, Restaurants)</td>
<td>- Reaching public through technical and pictorial presentations to make them aware about health hazards from unhygienic environment and suggesting remedial measures and methods for improving sanitation conditions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Tourists sites</td>
<td>- Informing and suggesting them about the segregated waste management and their important role</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Institutional Areas (Jr. High Schools, Colleges)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Waste Collector</td>
<td>• Sweepers</td>
<td>- They all should be involved and sensitized about the need of segregated waste collection and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Rag pickers</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Truck Drivers</td>
<td></td>
</tr>
</tbody>
</table>
| 3 Waste Managers | • Administrators and supervisors  
| • Control and monitoring team  
| • Complaint handlers  
| • Computer software operators and specialists | • Landfill Supervisors | sanitation improvement.  
- Proper and timely collection, transportation and disposal of waste from the waste bins.  
- Providing training to the ULB staff for adopting best practices for waste handling & management |

| 4 Leaders | • Political Leaders  
| • Religious Leaders  
| • Community Leaders |  | These leaders can be motivated to participate actively in promotional efforts of community involvement in segregated solid waste management. |

| 5 School Teachers and Students | • Primary Schools  
| • Jr. High Schools |  | Informing school teachers and involving them in solid waste segregation and motivating them to educate children for maintaining cleanliness in their neighbourhood  
- Educating students and providing them training on waste segregation.  
- Creating monitoring and awareness team by forming some groups of students for sanitation improvement which will make a great impact on societies and communities. |

| 6 Media | • Print Media  
| • Electronic Media |  | Launching mass campaign for educating and motivating local communities and families about the need of segregation of solid waste and its management for maintaining clean and hygienic environment. |

| 7 Elite groups or social organizations | • NGOs Societies  
| • CBOs  
| • Sr. citizens Association  
| • Local clubs |  | Sensitizing and motivating local influential people like Sr. citizens, leading businessmen, social club members, NGOs and CBOs etc.to undertake or sponsor such activities for solid waste management for forming effective strategy for public participation and awareness. |
Once the target groups have been identified, the responsibility lies in developing the approach for educating these groups. For successful implementation of any programme involving public participation at large, it is essential to spell out clearly and make them know the manner in which the problem is proposed to be tackled to keep area clean and improve the quality of life.

16.5 Training And Capacity Building Programme

The basic approach of Training & Capacity Building is to bring effectiveness to the existing Solid Waste Management System in Panaji city and to increase operational efficiency of the sanitary staff of CCP. CCP has appointed many officials & sanitary staff for waste management in the city. To know their knowledge, to judge their efficiency, abaseline data would be collected through questionnaire survey, structured interviews of the ULB staff.

On the basis of the findings of the study, training programme and training modules would be prepared for different levels of the ULB staff. Training & Capacity Building programme would be planned and workshops would be organized for imparting training to the official. The primarily focus of the training would be on institutional development. For preparing training module, existing institutional frame work would be studied along with the respective roles and activities of each stake holder. The identification of roles and responsibilities of the implementing (CCP) and stake holder would help improve and us to identify various components of the institutional frame work for the sustainability of the system.

**Objective:** The Capacity Building/training program would be planned with the following aim:

- to sensitize the involved group with working knowledge of the benefits of waste reduction, segregation and management.

- to impart clear instructions about there spective roles from generator to waste managers

The training and capacity building program would be planned for different target groups, which areas under:

1. For the sanitary staff-sanitary workers
2. For the sanitary supervisors & sanitary inspectors
3. For stake holders, NGOs & RWAs

16.5.1 Capacity Building of Sanitary Workers

The sanitary workers are the most important link between the community and the solid waste management system of the city. They are the interface between the service providers and the seekers. A lot depends on the capacity of the sanitary workers on how they respond
to the needs of the community. They play important role in collection and disposal of waste Therefore, it is imperative to build their capacity on SWM issues. Therefore, motivating and building capacities of the municipal workers is of utmost importance for the success of the IEC campaign and its sustainability. Training programmer will be organized for the sanitary workers engaged in the collection and disposal of waste in their respective areas. The tentative plan, with the topic of discussion and methodology for the training programmer is given under:

Table 16.2 Tentative Plan for the Training Programme of Sanitary Workers

<table>
<thead>
<tr>
<th>Participants</th>
<th>Topics</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanitary workers</td>
<td>• SWM cycle</td>
<td>• Presentation by Solid Waste Expert</td>
</tr>
<tr>
<td></td>
<td>• Type of waste &amp; waste segregation</td>
<td>• Interaction between the sanitary workers and the trainers</td>
</tr>
<tr>
<td></td>
<td>• Effect of poor SWM on health and environment</td>
<td>• onsite training for primary collection of waste and subsequent storage in secondary bins</td>
</tr>
<tr>
<td></td>
<td>• PPE and use of PPE for safe handling of waste</td>
<td>• Demonstration of PPEs</td>
</tr>
<tr>
<td></td>
<td>• Public participation and its relevance to SWM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Present IEC Plan for public participation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Their Roles and responsibilities in waste management</td>
<td></td>
</tr>
</tbody>
</table>

16.5.2 Capacity Building of Supervisors and Sanitary Inspectors

The training programme for the supervisors and inspectors (managerial level) would be organized with the objective to sensitize them on the need of ensuring solid waste management in their city. The programme would broadly cover different aspects related to SWM, MSW rules 2000, role of IEC in creating awareness and public participation, approach and methods of IEC campaign and the impact of poor waste management on health and environment. The various topics that would be discussed during the training programme are given below:Table 16.3 Tentative Plan for the Training Programme of Sanitary Supervisors
Table 16.3 Tentative Plan for the Training Programme of supervisory/managerial level

<table>
<thead>
<tr>
<th>Participants</th>
<th>Topics</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervisory/Managerial level</td>
<td>• Present state of MSW Management vis-a-vis MSW Rules 2000</td>
<td>Presentation &amp; group discussions</td>
</tr>
<tr>
<td></td>
<td>• Need for IEC campaign &amp; Public Participation</td>
<td>• Visit to the Landfill Site,</td>
</tr>
<tr>
<td></td>
<td>• IEC strategy that can be Planned and implemented for waste management</td>
<td>• Visit to the Composting Plant</td>
</tr>
<tr>
<td></td>
<td>• Health hazards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Complaint Readressal System</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• New technologies for waste recycling</td>
<td></td>
</tr>
</tbody>
</table>

16.5.3 Capacity Building of Stake holders*/NGOs/RWAs/institutions Head

NGOs/RWAs/CBOs/Society Heads/ Religious Heads/Institutional Heads/market associations, play a very crucial role in catalyzing community action. They can provide valuable guidance and support to the municipality and can join hands with the municipal staff for undertaking mass awareness program. Recognizing, they have key role in SWM & IEC campaign, in general training programme can be planned for them. The tentative plan, with the topic of discussions and methodology for the training programme is given under:

Table 16.4 Tentative Plan for the Training Programme of NGOs/RWAs & other key

<table>
<thead>
<tr>
<th>Participants &amp; stakeholders’</th>
<th>Topics</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGOs / RWAs</td>
<td>• SWM cycle</td>
<td>• Group Discussion</td>
</tr>
<tr>
<td>&amp; stakeholders’</td>
<td>• Waste segregation &amp; waste management</td>
<td>• Sharing of some successful case studies</td>
</tr>
<tr>
<td></td>
<td>• Public Participation /Community Participation in SWM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Current &amp; Proposed system of SWM of the respective towns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Approach &amp; methods for Door to door Collection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Coordination among the municipal staff NGOs/RWAs and Institutions</td>
<td></td>
</tr>
</tbody>
</table>
The training programmes may be conceptualized and implemented to get the following results:

- Determine roles and responsibilities of each official in specific terms
- Establish better coordination amongst the staff and departments to carry out different functions related to MSW management in Panaji city.
- Enhance the knowledge base on problems and issues concerning to solid waste management for different areas of the city.
- Lead to develop effective O&M of facilities such as tri-cycles, dustbins and waste containers with the help of public
- Develop an effective monitoring mechanism with prime involvement of officials, responsible for maintaining the respective system in the area/city.
CHAPTER 17.0
Project Implementation Plan
Annexure 1.1 - 1.17
1.1 Recommendation of Hon’ble Supreme Court of India for Solid Waste Management Practices for Class I Cities

1. Waste shall be stored at source of generation in two bins/bags, one for food/bio-degradable wastes and another for recyclable waste. Domestic hazardous waste, as and when produced, shall be kept separately from the above two streams.

2. Both the streams of waste, organic/biodegradable waste as well as recyclable waste shall be collected from the doorstep.

3. Work norms ranging from 250 to 750 running meters of road have been recommended, depending on the density of the area and local conditions.

4. Provisions of litter bins at railway stations, market places, parks, gardens, and important commercial streets may be made, to prevent littering of streets.

5. Transportation of waste shall be done on a regular basis before the temporary waste-storage containers start over-flowing. Transfer stations may be set up in cities where the distance to waste-disposal sites is more than 10 kilometers (km).
1.2 Municipal Solid Waste Management Rules published by the Ministry of Environment and Forests (MoEF)

In accordance with Sections 3, 6, and 25 of the Environment (Protection) Act, 1986, the MoEF published the MSW (Management and Handling) Rules in 2000. As per these rules, 'every municipal authority shall, within the territorial area of the municipality, be responsible for the implementation of the provisions of these rules, and for any infrastructure development for collection, storage segregation, transportation, processing and disposal of municipal solid wastes'. In addition, 'the CPCB shall coordinate with the State Pollution Control Boards (SPCB) and the Pollution Control Committees in the matters of MSW disposal and its management and handling'. A summary of the SWM rules is provided below:

1. The setup of composting facilities for Class I cities (with population ranging between one to 10 lakhs) shall be implemented by December 31, 2001. Monitoring of disposal facilities for Class I cities shall be performed once in six months on a yearly basis. The existing landfill sites shall be improved by December 31, 2000, and the identification of future landfill sites shall be completed by December 31, 2001.

2. The MSW generated shall be collected from house to house using containerized collection, community bin collection, collection of regular pre-informed timings and scheduling by using bell ringing/musical vehicle. Collected waste from residential and other areas shall be transferred to community bin by hand-driven containerized carts and shall not be handled manually.

3. The MSW shall be stored special ‘bins’ designed for easy handling, transfer, and transportation of waste. In addition, these bins shall be categorized based on the type of waste collected. The biodegradable waste shall be stored in green colored bins, the recyclable wastes shall be stored in white colored bins, and other wastes shall be stored in black colored bins. These storage facilities shall be cleared daily by the Municipal authorities.

4. The MSW shall be transported to the disposal or processing site in covered vehicles. The biodegradable wastes shall be processed using composting, vermicomposting, anaerobic digestion, or any other appropriate biological processing for stabilization of waste. Any recoverable waste such as paper and glass shall be sent to a recycling unit. Inert and non-biodegradable wastes and other wastes unsuitable for recycling or biological processing shall be disposed of at a landfill site.

5. The landfill site shall be designed to last for at least 20-25 years and shall be located away from habitation clusters, forest areas, water bodies monuments, National Parks, Wetlands, and places of important cultural, historical or religious interests and at least 20 kilometers (km) from the airport, including the airbase. In addition, a buffer zone shall be maintained around the landfill site and shall be incorporated in the Town Planning Department's land-use plans.

6. The storm water drains shall be diverted away from the landfill site to minimize leachate
generation, prevent pollution of surface water, and to avoid flooding and creation of marshy conditions. The landfill site shall be well-compacted using landfill compactors to provide high density waste and lined immediately with at least 10 centimeters (cm) of soil. During rainy reasons, a soil lining of 40-50 cm thickness shall be provided. The final soil cover shall be of 60 ems of clay, topped by an additional drainage layer of 15 ems, and a vegetative layer of 45 ems.

7. In order to ensure that the ground water within 50 meters (m) of landfill site is not contaminated beyond acceptable limit decided by the Ground Water Board or the State Board or the Committee, the site shall be monitored periodically.

8. The surface runoff from the landfill site shall be prevented from entering any stream, river, lake or pond.

9. In order to maintain the air quality, a landfill gas control and collection system shall be installed at the site. The concentration of methane gas generated at the Landfill site shall not exceed 25-percent of the lower explosive limit.

10. The closed landfill site shall be monitored for its integrity and effectiveness of the final vegetative cover. If required, repairs shall be done to the final vegetative cover to prevent erosion or leaching from the site.
1.3. Objectives of Jawaharlal Nehru National Urban Renewal Mission

The following summary of objectives of the JNNURM scheme was taken from the JNNURM brochure.

The primary objective of JNNURM is to create economically productive, efficient, equitable, and responsive cities. In line with this objective, the mission focuses on:

1. Integrated development of infrastructure services.
2. Securing linkages between asset creation and maintenance, for long-run project sustainability.
3. Accelerating the flow of investment into infrastructure services.
4. Planned development of cities including semi-urban areas, outgrowths, and urban corridors.
5. Renewal and re-development of inner city areas.
6. Universalization of urban services so as to ensure the iravailability to urban poor.
1.4 Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) Guidelines

This scheme has been introduced in 2005-06 and will be active for seven years. The main objectives of this scheme are to improve the existing urban infrastructure in towns and cities in a planned manner and encourage public-private partnership in infrastructure development. Till this scheme covers the cities and towns of India (as per Census 2001) not covered under the JNNURM.

The funds will be allocated to the States on the basis of population. The States in turn distribute these funds to the cities and towns where local body elections have been held and are in position, Neff for infrastructure development, Scheduled Caste/Schedule Tribe populations, and geographical characteristics of the city/town. The various components of this scheme are:

1. Urban renewal or redevelopment of inner city areas. The renewal activities include widening of narrow streets, shifting of industrial/commercial establishments from inner city areas to city outskirts, replacement of old water supply pipes with new-high capacity pipes; and renewal of sewerage/drainage/solid waste disposal sustains.
2. Water supply (including de-salivation plants) and sanitation
3. Sewerage and solid waste management
4. Construction and improvement of storm water drains
5. Construction/Up gradation of roads, highways/expressways
6. Parking lots/spaces on Public-Private-Partnership basis
7. Development of heritage areas
8. Prevention and rehabilitation of soil erosion/landslides only in case of Special Category States where problems are common
9. Preservation of water bodies

However, certain areas such as power and telecommunication works, buses and trains, Health and education, urban transport, wage employment programs, and staff components, and maintenance works are not included in this scheme.

In order to get these projects appraised, the Urban Local Bodies (ULB) shall submit a Detailed Project Report (DPR) to the designated State Level nodal agencies. These reports are forwarded to the Ministry of Urban Development (MoUD), Planning Commission, and Town and Country Planning Organization (TCPO) for further review. The projects will be approved on a need basis with a higher priority for water supply and sanitation, sewerage, solid waste management, road network, and drainage.
1.5 Twelfth Finance Commission’s (TFC) Recommendations on Local Body Grants and Inter-State Distribution

The Twelfth Finance Commission (TFC) (founded by the Department of Expenditure, Government of India) of India has recommended measures to augment the Consolidated Funds of the States to supplement resources of the Rural Local Bodies (RLBs) (Panchayats) and Urban Local Bodies (ULBs) (Municipalities). These funds are allocated to the RLBs and ULBs based on the recommendation made by the State Finance Commissions (SFC) s. In addition, in accordance with the recommendations made by the TFC, Rs20,000 cores and Rs.5,000 cores have been allocated for RLBs and ULBs, respectively, for the period 2005-10.

The primary objectives of the Local Bodies Grants Scheme include improvement of water supply and sanitation in RLBs and providing SWM services in ULBs through public-private partnerships. The TFC has recommended that high priority has must be given to development and maintenance of accounts database at the grass-root levels. The TFC recommendations pertinent to SWM practices are summarized below:

1. The resources of local bodies should be estimated based on an assessment of revenues and expenditure rather than forecasts made from historical trends.

2. At least 50-percent of the funds granted to the ULBs shall be allocated for SWM services through public-private partnership. The municipalities should focus on collection, segregation, and transportation of solid waste.

3. Every State shall constitute a High Level Committee (HLC) to ensure proper utilization of Local Bodies Grants. The HLCs shall approve projects at the beginning of every year taking into account the physical and financial implications and propose a schedule for project completion.

4. The HLC shall be responsible for monitoring the physical and financial implications and ensure adherence to the conditions pertinent to each grant.

5. The Local Bodies Grants shall be released in two equal installments in July and January every year.
Annexure — 1.6
Sample Information (Survey) Sheets
## HOTEL

<table>
<thead>
<tr>
<th>Contact Person</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Designation</td>
<td></td>
</tr>
<tr>
<td>Name of Hotel</td>
<td></td>
</tr>
<tr>
<td>Telephone Number</td>
<td></td>
</tr>
<tr>
<td>Address/ Ward No.</td>
<td></td>
</tr>
<tr>
<td>Capacity of Hotel (Total no. of rooms)</td>
<td></td>
</tr>
<tr>
<td>Average Occupancy per day (No. of Guests):</td>
<td></td>
</tr>
<tr>
<td>Quantity of Waste generated per day. in kg:</td>
<td></td>
</tr>
<tr>
<td>Composition of Waste (% wise, approx.):</td>
<td></td>
</tr>
</tbody>
</table>

### Food | Plastic | Paper | Others
---|---|---|---

## BANQUET HALL

### No. of Banquet Halls

#### (a) Peak Season:

(i) Duration of Months

(ii) No. of functions per day.

(iii) Average Occupancy for each function

| Quantity of Waste generated per day: |  |
| Composition of Waste (% wise, approx.): |  |

### Food | Plastic | Paper | Others
---|---|---|---

#### (b) Slack Season:

Duration of Months

No. of functions per day.

Average Occupancy for each function

| Quantity of Waste generated per day: |  |
## Composition of Waste (%wise, approx.):

<table>
<thead>
<tr>
<th></th>
<th>Food</th>
<th>Plastic</th>
<th>Paper</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Is different type of waste stored at different place/ bins/ boxes, specify

## Waste Management Practice followed: (Tickmark the practice followed)

<table>
<thead>
<tr>
<th></th>
<th>Food</th>
<th>Plastic</th>
<th>Paper</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>Sold/ Dump at designated site/ Dump</td>
<td>Dump at dhalao given to waste collector/ Kabadiwala</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic</td>
<td>Dump at designated site/ Dump</td>
<td>Dump at dhalao given to waste collector/ Kabadiwala</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper</td>
<td>Sold/ Dump at designated site/ Dump</td>
<td>Dump at dhalao given to waste collector/ Kabadiwala</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NAME of external Agencies involved in waste disposal Mechanism

Expenses incurred in SW Disposal
### PANAJI

#### RESTAURANT

<table>
<thead>
<tr>
<th>Contact Person</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Designation</td>
<td></td>
</tr>
<tr>
<td>Name of Hotel</td>
<td></td>
</tr>
<tr>
<td>Telephone Number</td>
<td></td>
</tr>
<tr>
<td>Address/ Ward No.</td>
<td></td>
</tr>
</tbody>
</table>

- **capacity of Restaurant (No. of Seats):**
- **Average Occupancy per day (No. of Guests):**
- **Quantity of Waste generated per day:**
- **Composition of Waste: (% edgewise, approx.)**

<table>
<thead>
<tr>
<th>Food</th>
<th>Plastic</th>
<th>Paper</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is different type of waste stored at different place/bins/ poxes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Waste Management Practice followed:

<table>
<thead>
<tr>
<th>Food</th>
<th>Plastic</th>
<th>Paper</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>Sold/ Dump at designated site/ Dump openly/ Dump at dhalao given to waste collector/ Kabadiwala</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic</td>
<td>Sold/ Dump at designated site/ Dump openly/ Dump at dhalao given to Waste collector/ Kabadiwala</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper</td>
<td>Sold/ Dump at designated site/ Dump openly/ Dump at dhalao given to waste collector/ Kabadiwala</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Names of external Agencies involved in waste disposal Mechanism

#### Expenses incurred in SW Disposal
Detailed Project Report – Volume 1  Solid waste management in Panaji, Goa

PANAJI

----------------------------------

Household Survey

1. Ward No.: Photograph No.: 
2. Contact Person: 
3. Residential Address with Contact No: 
4. Category of living conditions: LIG/MIG/HIG/EWS 
5. No. of Individual: Adults: Child: Total: 
6. Waste Characteristics (at time of inspection)

<table>
<thead>
<tr>
<th></th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>Total Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitchen waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horticulture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste Paper</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cloth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass/Ceramics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any other {specify}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Procedure of waste collection and disposal from doorstep including newspapers/magazines 

8. Collection Schedule 

9. Any Facilities provided by Corporation for waste collection and disposal 

10. Suggestions/Comments 

VEGETABLE MARKET

<table>
<thead>
<tr>
<th>Contact Person</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of Subzi Mandi</td>
<td></td>
</tr>
<tr>
<td>Telephone No.</td>
<td></td>
</tr>
<tr>
<td>Address/ Ward No.</td>
<td></td>
</tr>
<tr>
<td>Name of Association</td>
<td></td>
</tr>
</tbody>
</table>

Quantity of Waste generated per day:
- Peak duration:
- Slack Duration

Peak Duration (in months) |  |
Slack Dura-it-on (in months) |  |

Waste Management/Disposal mechanism:
- Collected by MC truck
- Private Operator
- Opendump
- Dump in Dhalao
- Sold/Other use/Recycled

Remarks:
WORKSHOP DETAILS

1. Location:

2. Area/Layout map

3. Photographs(SnapNos.)

4. Workshop—Infrastructure

<table>
<thead>
<tr>
<th>s. No.</th>
<th>Type</th>
<th>No. of Rooms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Workshop office</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Garage</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Vehicle Washing</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Staff Quarters</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Toilet/Bathrooms</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Others</td>
<td></td>
</tr>
</tbody>
</table>

5. Staff Details

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Staff</th>
<th>Nos.</th>
<th>Contact Person Name/ Contact No.</th>
<th>Role/Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Skilled Unskilled</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In charge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Senior staff/Inspector</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mechanics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electrician</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Driver</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Helper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. Equipment Details

<table>
<thead>
<tr>
<th>s. No.</th>
<th>Equipment</th>
<th>Nos.</th>
<th>Utility</th>
<th>Condition</th>
<th>Power Consumption/day</th>
<th>Water Consumption / Day</th>
</tr>
</thead>
</table>

---
7. Water facility

<table>
<thead>
<tr>
<th>S/N</th>
<th>Water Sources</th>
<th>Nos.</th>
<th>Timeslot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Municipality Water Supply</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tube well</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hand Pumps</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. (A) Supply Power
- Power availability (in hrs.)
- Nearby Substation
- Expenditure (approx. /month)
- Possibility of new power connection / required

9. (b) Generator
- Power availability
- Running hours
- Fuel consumption
- Expenditure (approx. /month)

10. Drainage/Sewerage fidelity
- Distance of nearby drainage/sewerage

11. Number & Capacity of Vehicles

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Type</th>
<th>No. of Vehicles</th>
<th>Capacity</th>
<th>Model</th>
<th>Condition</th>
<th>Frequency of breakdown of vehicles reasons</th>
</tr>
</thead>
</table>

221
12. Transportation System

13. If there are any Farm defined route for movement of vehicles

If yes List Chart (Copy to be enclosed)

14. If no, then what is the mechanism

15. Existing Limitation / problems in transport system

16. Vehicle maintenance system

- Servicing / washing
- Schedule
- If done at workshop, provision for wastewater treatment and disposal
- Whether Outsourced?

17. Suggestions for improvement

18. Responder Name with Designation & Contact Details
- Signature & Seal
- Note: Enclosed data/documents as annexure
Annexure-1.7
Technical Specifications of Sanitary Landfill Facility
Annexure 1.7
TECHNICAL SPECIFICATIONS

1.0.0 PREPARATIONOFWORKAREA/CLEARINGSITE

1.1.0 Scope
This section covers site preparation of the area as indicated in the drawings.

1.2.0 General Requirements
All laboratory equipments and materials required for complete performance of the work in accordance with the drawings and specifications herein.

1.3.0 Clearing Site
Clearing and grubbing operations shall be performed in the entire landfill area. The sites should be cleared of all vegetation, rubbish and all other objectionable or organic matter such as dismantling of RCC, PCC, Brick work, RR masonry and structural steel of abandoned above ground and underground structures along with abandoned cables pipes etc. Trees of specified girth and/or any other cleared material shall be stockpiled and handed over to the Engineer in Charge or disposed as per direction of the Engineer-in-Charge.

2.0.0 STRIPPING

2.1.0 Scope
This section of the specification covers stripping of foundation for embankment and in the landfill area as described herein:

2.2.0 General Requirement
The implementing agency shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the Drawings and as described herein.

2.3.0 Stripping of foundations.
The entire area of embankment and landfill area as shown in the drawings shall be stripped to 0.15 meter as directed by the Engineer-in-Charge to remove all unsuitable materials. In the portion of the embankment where ground slope is steep the stripping shall be done in a fashion as directed by the Engineer-in-Charge. The unsuitable materials shall include all debris, vegetable matter including roots, weathered and disintegrated rocks, organic silts materials. That are unsuitable for use in the permanent construction or that might interfere with the proper binding of the embankment with the foundation, or the proper compaction of the materials in the embankment, or that may be otherwise objectionable. The stripping shall be kept far enough in advance of other items of work to ensure that no undesirable material will get mixed with approved embankment material and to allow for inspection and measurement.
Materials from stripping operations shall be deposited on either side of the embankment away from the heel and toe of the embankment and unsuitable material shall be disposed off beyond 50 m but upto a lead of 500 m to an area identified by the Engineer-in-Charge.

Should the excavation be done deeper by error, the same shall be made good by filling the same with approved earth and properly compacted so that the required formation level is obtained at the Implementing agency's cost except in areas where further excavation is required for laying clay foundation. In such cases, the extra excavation under stripping may be considered under excavation if approved by Engineer-in-Charge.

3.0.0 EXCAVATION & FILLING WORK

3.1.0 Scope

3.1.1 This section of specification covers the technical requirements for excavation and filling in and around structures, pipes, trenches, wall foundations, pits, drains and similar works. This also covers filling areas and plinth with selected materials, conveyance and disposal of surplus soils and/or stacking them properly as directed by Engineer-in-Charge.

3.1.2 Existing trees, shrubs, any other plants, pole; lines, signs, monuments, buildings, pipelines, drains, sewers, facilities within or adjacent to the works being carried out which are not to be disturbed shall be protected from damage by the Implementing agency. The implementing agency shall provide and install suitable safeguards approved by the Engineer-in-Charge for this purpose.

3.1.3 During excavation, the implementing agency shall take all necessary precautions against soil erosion, water and environmental pollution and where required undertake additional works to achieve this objective. Before start. Of operations, the implementing agency shall submit to the Engineer-in-Charge for approval, his work plan and procedure. He intends to follow for disposal of waste material etc. and the schedule for carrying out temporary and permanent works. However, the approval of the Engineer-in-Charge shall not absolve the implementing agency of his responsibility for safe and sound work.

3.2.0 Excavation in Soil

3.2.1 Sides and bottoms of excavation shall be sharp and true to line and level. Undercutting shall not be permitted. When machines are used for excavation, the last 300 mm before reaching the required level shall be excavated manually or by such equipment, such that soil at the required final level will be left in its natural condition. Suitability of strata (at the bottom of excavations) for laying the foundation there on shall be determined by the Engineer-in-Charge.
3.2.2 The bottom of all excavations shall be trimmed to required levels.

3.2.3 Necessary arrangements i.e. Cofferdams, sheeting, shoring, bracing; maintaining, suitable slopes, draining etc shall be provided and installed to the satisfaction of the Engineer-in-Charge.

3.2.4 Any water collected in excavated pits and other areas due to rain water, ground water, sludge's, springs etc. Shall have to be constantly pumped out and maintain dry working conditions at all times until the excavation, placement of Foundation /liner arrangement, backfilling, etc. Is completed. All slush/muck from the excavated areas shall be removed to keep the work area dry.

3.2.5 All materials shall be removed arising from excavations from the vicinity to the work either for direct filling, stacking and subsequent filling or for ultimate disposal as directed by the Engineer-in-Charge. In no case shall the excavated soil be stacked within a distance of 1.5 m from the edge of excavation or one-third the depth the excavation whichever is more. Material to be used for filling shall be kept separately.

3.3.0 Rock Excavation

3.3.1 Rock, when encountered, shall be removed up to the formation/bed level or as otherwise indicated on the Drawings. Where, however, unstable shale's or other Unsuitable materials are encountered at the formation/bed level, these shall be excavated to the extent of 500 mm below the formation/bed level or otherwise specified. In all cases; the excavation operations shall be so carried out that at no point on cut formation/bed the rock protrudes above the specified levels.

3.3.2 Where excavation is done to levels lower than those specified, the excess excavation shall be made good to the satisfaction of the Engineer-in-Charge.

3.3.3 Slopes in rock cutting shall be finished to uniform lines corresponding to slopes shown on the Drawings or as directed by the Engineer. Notwithstanding the foregoing, all loose pieces of rock on excavated slope surface which move when pierced by the crowbar shall be removed.

3.4.0 Carriage of excavated materials beyond the initial lead of 50 M

3.4.1 The disposal/stacking areas for excavated materials shall be indicated by the Engineer-in-Charge. The carriage of excavated materials shall be done by the methods mentioned below:
1. The excavated materials shall be carried beyond the initial lead of 50 m but up to 500 m by manual/animal labour or by mechanical means. If directed by the Engineer-in-Charge, this material shall be used directly for filling purposes.

2. For leads exceeding 500 m, the implementing agency shall transport the excavated materials by mechanical means or as directed by the Engineer-in-Charge, City Corporation Panaji. The Implementing agency shall allow for movements on Kuchha road etc. Providing and maintaining Kuchha road shall be responsibility of the implementing agency.

3. The transported material shall be neatly stacked and dressed as directed by Engineer-in-Charge.

3.5.0 Filling

3.5.1 Materials
Materials to be used for filling purpose shall be selected excavated material free from shingle, salts, organic materials, large roots and excessive amount of sod, Lumps, concrete or any other foreign substances, which could harm or impair the strength of the substructure in any manner. In any case, the materials to be used for filling purpose shall have the prior written approval of the Engineer-in-Charge.

3.5.2 Filling Procedure

1. After completion of foundation, footings, walls and other construction below the elevation of the final grades, and prior to filling, all temporary shoring, timber etc. shall be sequentially removed and excavation cleaned of all trash, debris and perishable materials. Filling shall begin with the approval of the Engineer-in-Charge. Also areas identified for filling shall be cleared of all soft pockets, vegetation, bushes, slush etc. In case of plinth and similar filling, the ground shall be dressed and consolidated by ramming and light rolling.

2. Filling materials shall not be dropped directly upon or against any structure or facility where there is danger of displacement or damage. Filling shall be started after the concrete masonry has fully set and shall be carried in such a manner so as not to cause any undue lateral thrust on any part of the structure.

3. All space between foundation (concrete or masonry) and the sides of excavation shall be filled to the original surface after making allowance for settlement. Fill shall be placed in horizontal layers not exceeding 200 mm loose thickness. Each layer shall be watered and compacted with proper moisture content and with such equipment as may be required to obtain a compaction/density as specified.
4. Fill adjacent to pipes shall be free of stones, concrete etc. and shall be hand placed and compact uniformly on both sides of the pipe and where practicable up to a minimum depth of 300 mm over the top of pipes. While tamping around the pipes, care should be taken to avoid unequal pressure.

5. Filling shall be accurately finished to line, slope, cross section and grade as shown on the drawings. Finished surface shall be free of irregularities and depressions and shall be within 20 mm of the specified level.

3.5.3 Compaction

1. Compaction to 95% Standard Proctor Density shall be done by mechanical means only. Where access is possible, compaction shall be by 8 to-10 tonnes rollers smooth wheeled, sheep foot or wobbly wheeled as directed by the Engineer-in-Charge smaller weight roller may be permitted by the Engineer-in-Charge. In special cases, but in any case not less than 6 passes of the roller will be accepted for each layer. Each layer shall be wetted or the material dried by aeration to moisture content of 3-5% above the optimum moisture content to be determined by the Implementing agency. Each layer shall be watered, rammed and compacted to the density as required.

2. For compacting each sand layer, water shall be sprayed over it to flood it and it shall be kept flooded for 24 hours to ensure maximum compaction: Vibro-compactors shall also be used if necessary to obtain the required degree of compaction. Any temporary works required to contain sand under flooded condition shall also be undertaken. The surface of the consolidated sand shall be dressed to required levels or slope.

3. The degree of compaction of compacted fill in place will be subjected to tests by the Engineer-in-Charge as the work progresses, and the Implementing agency shall provide the necessary facilities to make such tests. If, any test indicates that the compaction achieved is less than the specified degree of compaction, the Engineer-in-Charge, City Corporation, Panaji may require all fill placed subsequent to the last successful test to be removed and re-compacted by the Implementing agency. Compaction procedure shall be amended as necessary to obtain satisfactory results.

3.6.0 Sampling, Testing and Quality Control

3.6.1 General

1. The Implementing agency shall carry out all sampling and testing in accordance with the relevant Indian Standards and / or International Standards and shall conduct such tests as are called for by the Engineer-in-Charge. Where on specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Engineer-in-Charge. Tests shall be done in the field.
and at a laboratory approved by the Engineer-in-Charge and the implementing agency shall submit to the Engineer-in-Charge, the test results in triplicate within three days after completion of a test. The Engineer-in-Charge may at his discretion, waive some of the stipulations given below, for small and unimportant operations.

2. In case, work found unsuitable for acceptance shall be removed and replaced by the Implementing agency. Such work shall be redone as per specification requirements and to the satisfaction of the Engineer-in-Charge.

### 4.0.0 EXCAVATION OF TRENCHES

#### 4.1.0 Scope

This section of the specification covers excavation of trenches for laying HDPE pipes underneath the embankment and other cross drainage works.

#### 4.2.0 General

The Implementing agency shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings. Schedule of items and as described herein.

#### 4.3.0 Excavation for trench

Drawings for trenches shall be prepared by the bidder and approved by the Engineer-in-Charge. Trenches as shown in the drawing shall be excavated below the foundation grade and the slopes of the excavation shall be as indicated in the drawings or as directed by the Engineer-in-Charge. The alignment and cross-section shown in the drawings will be subject to such changes as may be found necessary by conditions disclosed during the excavation. Excavation of trench shall be carried out in a manner as specified under the clause for the item of "Excavation & Filling work".

Material excavated from the trenches shall, if suitable, be used in the embankment after stock piling as directed. The suitability or otherwise of the material shall be determined by laboratory tests. Material excavated from trench shall not be placed in the embankment till the foundation for the embankment has been cleared, stripped and prepared as specified and adequate arrangements made for watering and rolling the layers of earth fill in the embankment.

### 5.0.0 BORROW AREAS

#### 5.1.0 Scope

All materials required for the embankments which are not available from trench excavation or from other excavations shall be obtained from approved designated borrow
areas. The impervious material required for foundation shall be brought from any approved borrow areas.

The depths of cut in all parts of the borrow areas will be determined by the Engineer-in-Charge depending on the level of water table at the time of excavation and the cuts shall be made to such depths only. The excavation in borrow areas shall not be done below the water table. The type of equipment used and the operation in the excavation of materials in borrow areas shall be of such type that will produce the required uniformity of mixture of materials for the embankment.

Borrow area shall be opened so as not to impair the usefulness or mar the appearance of any part of the work or any other property. The excavation surfaces and surface of waste materials shall be left in a reasonably smooth and even condition. When the borrow area is located contiguous to the embankment alignment then it must be ensured that the borrow area shall not be opened within a distance of five times the height of embankment contiguous to the heel or the toe of the embankment or 25 meter whichever is more.

The material required for embankment construction and liner foundation shall be free of admixture of stiff clay, refuse, stumps, roots, rock, brush, weeds or other material which would be detrimental to the proper compaction of materials in the embankment.

5.2.0 Preparation of Borrow Areas
5.2.1 Site clearance

All areas required for borrowing earth for embankment shall be cleared of all rank vegetation and stumps, roots, bush, rubbish, and other objectionable material. Particular care shall be taken to exclude all organic matter from the material to be placed in the embankment. All unsuitable materials including rank vegetation, stumps shall be disposed off as specified elsewhere in this specification. The cleared areas shall be maintained free of vegetation growth during the progress of the work. The unsuitable materials will be filled back, after borrowing earth for earthen embankment construction, as directed by the Engineer-in-Charge.

5.2.2 Stripping of Borrow Areas

Borrow areas shall be stripped of topsoil, sod and any other matter which is unsuitable for the embankment construction. Materials from stripping shall be disposed off up to a lead of 500 m at a place and in manner at the discretion of the Engineer-in-Charge and as directed by him. The depth of stripping shall be decided by the Engineer-in-Charge depending upon the nature of topsoil and the vegetation present.
5.2.3 Borrow Area Watering/Dewatering

The natural moisture content of material in the borrow areas as well as the optimum moisture content corresponding to the Proctor’s maximum dry density for the material in the particular borrow area shall be obtained from laboratory tests. Additional moisture if required shall be introduced into the borrow area. By any borrow area before or during excavation there is excess moisture, steps shall be taken to reduce the moisture by the selective excavation to secure the materials of required moisture by excavating drainage ditches, by allowing adequate time for drying or by other means. To avoid formation of pools in the borrow areas during excavation operations, drainage ditches from borrow areas to the nearest outlets shall be excavated.

6.0.0 CAST-IN-SITU CEMENT CONCRETE

6.1.0 Scope

This section of the specification deals with cast-in-situ cement concrete plain or reinforced for Leachate collection sump, leak detection sump and other miscellaneous items as shown in the drawings and covers the requirements for concrete materials, their properties, storage, handling, grading, concrete mix design, strength and quality, pouring at all levels, testing, protection, curing, finishing, admixtures, and other associated works.

6.2.0 General Requirements

The provision of latest IS: 456 shall be complied with unless permitted otherwise and any other Indian Standards Codes shall form the part of the specification to the extent it has been referred to or applicable within this specification.

The Implementing agency shall furnish all labour, materials and equipment to form, place, and compact and finish all structural concrete, plain concrete works for general and architectural works and miscellaneous items complete as indicated on the drawings and as described herein.

6.3.0 Materials

6.3.1 Materials Properties

1. Aggregates

For reinforced concrete work, aggregate conforming to IS: 383 & 2386 having a maximum size of 20 mm shall be used. However for lean concrete maximum size up to 40 mm shall be used.

Aggregates (coarse or fine) with a specific gravity below 2.6 shall not be used without special permission of the Engineer-in-Charge. Machine-made sand will be acceptable.
provided the constituent is sound, hard, and dense and is acceptable to the Engineer-in-Charge. Sand natural gravel and crushed rock shall be prepared for use by such screening or washing or both, as necessary to remove all objectionable foreign matter.

2. Water

Water used for mixing and curing concrete shall be clean and free from injurious amounts of oils, acids, alkalis; sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete.

6.3.2 Storage & Handling of Materials

IS: 4082 shall be followed as a general guidance for storage and handling of construction materials at site and IS: 7969 shall be followed for safety measures.

1. Cement

The cement shall be stored in leak proof, weatherproof enclosed sheds. Different consignments of different types of cement shall be stacked separately with clear identifiable stack numbers. Consignments shall be stored as received and shall be consumed in the order of their delivery. The implementing agency shall make their own arrangement for the storage of adequate quantity of cement.

2. Aggregates

Coarse and fine aggregates shall be stored separately on brick soling, or on an equivalent platform. The stack height of coarse aggregates shall not exceed 120 mm to avoid coning and segregation.

6.3.3 Grades of Concrete

All concrete used for RCC work shall be of minimum M 25 grade design mix and in grades designated as specified in Drawing.

6.3.4 Nominal Mix Concrete

Nominal mix concrete shall be used only for plain cement concrete works and where shown on drawings or specifically allowed by the Engineer-in-Charge. Such concrete shall not require preparation of trial mixes and all such concrete shall be mixed in a mechanical mixer. A proportion for nominal mix concrete shall be according to Table-9 of IS: 456-2000. In addition standard proportion by volume shall be used wherever specified.

6.3.5 Design Mix Concrete

Design mix concrete shall only be used for all reinforced concrete works, except where specified otherwise or specially permitted by the Engineer-in-Charge. The mix proportion for all grades of concrete shall be designed to obtain the required workability and the
characteristic strength not less than the appropriate values given in Table 1 below, using standard deviation specified in IS: 10262. The minimum value of target strength of design mix of various grades of concrete shall be as per Table 1 below considering the quality control as 'good' as specified in IS: 10262. However, the Engineer-in-Charge may allow changing the target strength values based on adequate numbers of works test results.

Table.-1: GRADE OF CONCRETE

<table>
<thead>
<tr>
<th>Grade Designation of concrete</th>
<th>Compressive strength of a 15 cm cube at 28 days (in N/Sq.mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preliminary Test Strength or (Target strength of trial mix) (N/mm2)</td>
</tr>
<tr>
<td>M-15</td>
<td>20.8</td>
</tr>
<tr>
<td>M-20</td>
<td>27.6</td>
</tr>
<tr>
<td>M-25</td>
<td>33.7</td>
</tr>
<tr>
<td>M-30</td>
<td>39.9</td>
</tr>
<tr>
<td>M-35</td>
<td>45.4</td>
</tr>
</tbody>
</table>

In designing the mix proportions of concrete, the quantity of both cement and aggregate shall be determined by mass. The Engineer-in-Charge may allow the quantity of aggregates to be determined by equivalent volume basis after the relationship between the weight and volume is well established by trial and the same shall be verified frequently.

Water shall be either measured by volume in calibrated tanks or weighed. All measuring equipment shall be maintained in a clean and serviceable condition, and their accuracy periodically checked.

To keep the water cement ratio to the designed value, allowance shall be made for moisture contents in both fine and coarse aggregates and determination of the same shall be made in accordance with IS: 2386 (Part-III) as frequently as directed by the Engineer-in-Charge.

6.4.0 Mix Design

Preliminary tests/trial mix as specified or as directed by the Engineer-in-Charge shall be carried out sufficiently ahead of the actual commencement of the work to arrive at the grading of aggregates, water cement ratio, workability and the quantity of cement required to give Preliminary (target) compressive strength as specified in Table 1.
Minimum cement contents, from durability consideration, for different exposures and sulphate attack shall be as per IS: 456. In case higher value is obtained from trial mixes from strength consideration, same shall be provided.

At least four trial mixes shall be made and minimum six test cubes shall be taken from each trial mix noting the slump for each type of mix. The cubes shall then be properly cured and three cubes for each mix shall be tested in a laboratory (approved by Engineer-in-Charge) at 7 days and reaming three at 28 days for compressive strength

The implementing agency shall submit the test reports for mix design to the Engineer-in-Charge, indicating design criteria analysis and proportions of materials etc. The mix proportion by mass and water cement ratio determined on the basis of above reports shall yield the concrete with desired characteristic strength & suitable workability. The mix design to be adopted on the works shall be approved by the Engineer-in-Charge.

6.5.0 Workability

The workability of concrete shall be checked at frequent intervals. Workability of concrete measured in accordance with IS: 1199 shall be recorded with corresponding compressive strength results. The degree of workability necessary to allow the concrete to be well compacted and to be worked into the corners of form work and around the reinforcement to give the required surface finish shall depend upon the type and nature of the structure and shall be based on experience and tests. The limits of consistency for various types of structures, shall be in accordance with IS: 1199.

6.6.0 Batching and mixing plant

A modern dependable hatching and mixing plant with two mixers each of 20 cum./hr. Capacity preferable tilting type capable of producing concrete of specified quality and output required to meet the schedule shall be installed at a centralized location with the approval of the Engineer-in-Charge. Transporting, handling, and placing equipment shall be provided at a location in a manner approved by Engineer-in-Charge. The concrete hatching and mixing plant shall be completely installed and operated for sufficient length of time prior to scheduled date of placement of first concrete, to enable the Engineer-in-Charge to assess the performance for its satisfaction.

6.7.0 Conveying and Placing Concrete by pumping
6.7.1 Conveying Concrete

The suitably designed concrete will be conveyed by pressure applied by the pump through either rigid pipe or flexible hose and discharged directly into the desired area. Requisite number(s) of modern dependable concrete pump(s), capable of pumping concrete of specified quality/density at a rate required meeting the schedule, together with a balanced complement of pipe lines, accessories, spares, power controlled placers, experienced pump operators and maintenance staff shall also be provided.

The pump shall be of piston type pump with net concrete pumping capacity of not less than 20m³/hr. at a horizontal distance of 400 m and vertical distance of 30 m. The pumps shall be designed with adequate protection against adverse usage, shall be insensitive to rough treatment and operation on construction sites, have sturdy construction and easy to maintain.

Implementing agency shall make necessary standby (by providing additional spare/standby pumps) or alternate concreting arrangement in the event of failure of pumps.

6.7.2 Placing Concrete

Form work and reinforcement steel shall be approved in writing by the Engineer-in-Charge before concrete is placed. The formwork in contact with the concrete shall be cleaned and thoroughly wetted and treated with an approved composition before placing the concrete. Care shall be taken that such approved composition is kept out of contact with the reinforcement. Concrete shall be deposited in its final position without segregation, re-handling or flowing. Care should be taken to avoid displacement of reinforcement or movement of formwork while placing concrete. Any drop over 180 cm shall have to be approved by the Engineer-in-Charge. Concrete when deposited shall have a temperature of not less than 4.5 degrees C and not more than 38 degrees C, it shall be compacted in its final position within 30 minutes of its discharge from the mixer. Once the concrete is deposited in its final position, it shall not be disturbed. IS: 7861 (Part-I) shall be followed for concreting in extreme hot weather.

The placing of concrete shall be a continuous operation with no interruption in excess of 30 minutes between the placing of continuous portion of concrete. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes unless proper construction joint is formed as per direction of the Engineer-in-Charge. Concrete shall be placed in continuous horizontal layers of 150 mm or higher thickness as directed before placing the next layer.
All excavated areas for concreting shall be kept under dry working conditions until such concrete work is completed. The implementing agency shall make provisions and furnish equipment as required for such dewatering, subject to the approval of the Engineer-in-Charge.

Concrete shall not ordinarily be placed under water. In unavoidable cases, such concreting shall be done only with the specific approval of the Engineer-in-Charge for the methods, equipment, materials and proportions of the mix to be used and relevant clauses of IS: 456 adhered to. No concrete shall be placed in open while it rains. If there has been any sign of washing of cement and sand, the concrete shall be entirely removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended.

Slabs, beams and similar members shall be poured in one operation normally. Except where otherwise agreed to by the Engineer-in-Charge concrete shall be deposited in horizontal layers, but it must be ensured that under layer is not already hardened. Bleeding of under layer, if any, shall be effectively removed. Holes shall be provided and bolts, sleeves, anchors, fastenings or other fixtures shall be embedded in concrete as shown on the drawings or as directed by the Engineer-in-Charge.

After the concrete has been placed, it shall be thoroughly compacted by approved mechanical vibrators to a maximum subsidence without segregation and shall be thoroughly worked around reinforcement or other embedded fixtures into the correct form and a shape. Care must be taken to ensure that the inserts, fixtures, reinforcement and formwork are not displaced or disturbed during compaction of concrete.

Immersion vibrators shall be a ‘no load’ frequency amplitude and acceleration as per IS: 2505 depending upon the size of the vibrator. Immersion vibrators shall be operated by experienced men for their use IS:3558 shall be followed. Immersion vibrators shall penetrate both the layer pouted and the under layer and shall not be allowed to come in contact with steel reinforcement, forms and finished surfaces after start of initial set.

These vibrators shall be immersed not more than 450 min apart and withdrawn when air bubbles cease to come to the surface. Such vibrators shall in no case be used to push concrete inside the forms and vibrators shall be withdrawn slowly.

6.7.3 Construction Joints
When the concreting work is to be interrupted, the concrete shall be rebated at joint so such shape and size as may be required by the Engineer-in-Charge or as
shown on the drawings. All vertical construction joints shall be made with stop boards, which are suitably fixed, for sufficient lateral rigidity and slotted to allow for the passage of the reinforcement steel. In the case of water and/or underground structures, water stop of a approved material shall be provided if so specified on the drawings or as desired by the Engineer-in-Charge. Construction joints shall be provided in positions as shown or described on the drawings. Where it is not described, the joints shall be in accordance with the following.

1. In a column, the joint shall be formed about 75 mm below the lowest offset of the beams framing into it.

2. Concrete in a beam shall be placed throughout without a joint, but if the provision of a joint is unavoidable, the joint shall be vertical and within middle third of the span.

3. A joint in a suspended floor slab shall be vertical, at one quarter point of the span and at right angle to the principal reinforcement.

4. In forming a joint, concrete shall not be allowed to slope away to a thin edge. The location of construction joints shall be planned by the Implementing agency well in advance of pouring and have to be approved by the Engineer-in-Charge.

Before fresh concrete is placed, the cement skin of the partially hardened concrete which was poured earlier shall be thoroughly removed and aggregates shall be exposed by wire brushing, backing, water jetting or any other approved method, as directed with Engineer-in-Charge. The rough surface shall be thoroughly wetted and surface water shall be removed and shall be coated with 10-15 mm thick layer of 1:1 freshly mixed cement sand slurry. Care shall be taken to ensure that the first layer of concrete placed after a construction joint is thoroughly rammed against the existing layer.

6.7.4 Cleaning and Finishing

All concrete surfaces shall have an even finish, free from honey combs, air bubbles, fins or other blemishes.

The formwork joints marks and other projections on concrete work exposed to view shall be rubbed out with carborundum stone and made smooth and air holes, cavities and similar imperfections shall be first saturated with water and filled with cement sand mortar (1:2) and cured.

Except where a separate finish is to be applied, or where a trowel finish is called for, horizontal concrete surface shall be floated and steel troweled after achieving initial set to prevent excess fine materials from working to the surface.
Concrete surfaces to be subsequently plastered or where brickwork shall be built against it shall be adequately hacked as soon as the form is stripped off so that proper bond can develop.

6.8.0 Curing and Protection of Concrete

Newly placed concrete shall be protected by approved means from rain, sun, and wind. Concrete placed below the ground level be protected from falling earth during and after placing. Concrete placed in ground containing deleterious substances shall be kept free from contact with such ground or with water draining from such ground during placing of concrete and for a period of at least three days or as otherwise instructed by the Engineer-in-Charge. The ground water around newly poured concrete shall be kept to an approved level by pumping or other approved means of drainage. Adequate steps shall be taken to protect immature concrete from damage by debris, excessive loading, shocks, vibration, abrasion, traffic, rapid temperature changes, mixing with earth or other deleterious material, etc. that may impair the strength and durability of concrete.

As soon as the concrete has hardened sufficiently for the surface to be marked, it shall be covered either with wet sacking, canvas or similar materials and kept continuously wet for at the discretion of the Engineer-in-Charge, up to fourteen (14) days. Concrete slabs and floors shall be cured by flooding with water of minimum 25 mm depth for the periods mentioned above. Masonry work over the foundations concrete may be started after 48 hours of its laying but the curing of concrete shall be continued for a minimum period of 7 days.

6.9.0 Sampling and Testing Criteria

6.9.1 General

1. Facilities required for sampling & testing materials and concrete in the field and in the laboratory shall be provided by the Implementing agency. All sampling and testing shall be done in accordance with relevant Indian Standard and this specification Tests shall be done in the field in the presence of the Engineer-in-Charge and the Implementing agency shall submit the test result in triplicate Within 3 days after completion of any test.

2. Concrete samples shall be cured under laboratory conditions, except when in the opinion of the Engineer-in-Charge extreme weather conditions may prevail at which time the Engineer-in-Charge may require curing under job conditions.

3. If the "test strength" of the laboratory controlled cubes for any portion of the concrete work falls below the compressive strength specified, the Engineer in-
Charge shall have the right to order a change in the proportions or the water content for the remaining portion of the structure, and shall have the right to require provisions for temperature and moisture control, during the period of curing, as necessary to secure the required strength, and may require re-tests on the basis of core test as given in IS: 456

4. Concrete found unsuitable for acceptance shall be removed and replaced by the implementing agency. The work shall be redone as per specification and to the satisfaction of the Engineer-in-Charge and at no extra cost to the owner.

5. Rebound hammer test shall be carried out for ascertaining the quality of concrete work, as directed by the Engineer-in-Charge.

6. Core test shall be done as described in IS: 516. The number of cores required shall be as decided by the Engineer-in-Charge and shall be represented of whole of the concrete concerned. In no case, however, shall fewer than three cores be tested.

Concrete in the member represented by a core test shall be considered acceptable if the average equivalent cube strength of the cores is equal to at least 85 percent of the cube strength of the grade of concrete specified for the corresponding age and no individual core has a strength less than 75 percent.

6.9.2 Sampling of Concrete
Sampling from fresh concrete shall be taken according to IS: 1199 tested as per IS: 516. Normally only compressive test shall be performed but the Engineer-in-Charge may require other tests to be performed in accordance with IS: 516.

1. Trial Mixes
At least four trial mixes shall be made with, minimum 6 test cubes for each.

2. Works Tests

a. The minimum frequency of sampling of concrete of each grade shall be according to clause 15.2.2 of IS: 456-2000. However, after getting continuous satisfactory results and in the case of voluminous concrete works, the Engineer-in-Charge may at his discretion reduce the frequency of sampling.

b. For each grade of concrete, and for each 8 hours (shift) of work or part thereof, at least one sample consisting of six specimens shall be taken from each 50 cum. Of concrete or part thereof, 3 specimens shall be tested at 7 days and remaining 3 shall
betested at 28 days. However, in all cases, the 28 days compressive strength shall alone be the criterion for acceptance or rejection.

To control the consistency of concrete from every mixing plant, slump tests and/or compaction factor tests in accordance with IS: 1199 shall be carried out by the implementing agency every two hours or as directed by the Engineer-in-Charge. Slumps corresponding to the test specimens shall be recorded for reference.

The strength of sample shall be the average of the strength of three specimens. The individual variation should not be more than ± 15% of the average.

6.9.3 Acceptance criteria for concrete

The acceptance criteria of concrete shall be in accordance with Clause No.16 of IS: 456. However, in exceptional circumstances, the Engineer-in-Charge may, at his discretion, accept concrete of lower strength than that specified at reduced rates pro-rata to the strength obtained. The concrete shall be deemed to comply with the strength requirements, if:

1. Every sample has test strength not less than the characteristic value

Or

2. The strength of one or more samples, though less than the characteristic value, in each case is not less than the greater of

   a. The characteristic strength minus 1.35 times the standard deviation and
   b. 0.80 times the characteristic strength: and the average strength of all the samples is not less than the characteristic strength + [1.65 - 1.65/ square root of (No. of Samples)] times the standard deviation.

6.9.4 Tolerance Limits

Unless otherwise specified, the tolerance in construction shall be as follows:

<table>
<thead>
<tr>
<th>Description of item/structural element</th>
<th>Permissible Deviation in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>The dimensions of concrete as cast when compared with those on the drawings shall be within the tolerance given below:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ 25</td>
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<tr>
<td></td>
<td>- 10</td>
</tr>
<tr>
<td>Faces of concrete in foundation and structural members against which backfill is placed</td>
<td></td>
</tr>
<tr>
<td>Eccentricity of footing</td>
<td>2% of footing width of direction of misplacement but limited to 50 mm +5</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Cross sectional dimensions of walls, slabs and similar structural elements</td>
<td>+5 -5</td>
</tr>
<tr>
<td>Deviation from specified dimensions of cross section of columns and beams</td>
<td>+12 -6</td>
</tr>
<tr>
<td>Embedded parts (in any direction)</td>
<td>+5 -5</td>
</tr>
<tr>
<td>Centers of pockets of grooves with greatest lateral dimension not exceeding 150 mm</td>
<td>+10 -10</td>
</tr>
<tr>
<td>Plump</td>
<td>3 mm for every meter subject to a maximum. Of 10 'mm</td>
</tr>
</tbody>
</table>

**7.0.0 FORMWORKANDSTAGING**

**7.1.0 Scope**

This section of the specification deals with the requirements for the supply erection, dismantling of formwork and staging required for cast-in-situ concrete works including for making pockets.

**7.2.0 General Requirements**

The implementing agency shall supply, fabricate erect and dismantle (after use) all temporary and permanent formwork and staging that is required for all activities covered under the specifications.

**7.3.0 Materials**

Formwork shall compose of steel, plywood or best quality wood. Timber shall be free from significant knots and shall be of medium grain as far as possible and hard woods shall be used as caps. Timber shall be well seasoned, free from sap, worm holes, wraps or other surface defects and shall smooth finish.

Staging unless specified otherwise shall generally be of mild steel tubes, steel beams and channels etc. or strong sowbellies 150 mm in diameter or above.
7.4.0 Quality of Formwork and Staging

The forms and staging shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete and the effects of vibration. The joints in the formwork shall be sufficiently tight to prevent any leakage of mortar. The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes.

Beveled strips 25 x 25 mm shall be provided to form angels and in corners of columns and beam boxes for chamfering of corners if shown in drawings or directed by the Engineer-in-Charge. The implementing agency shall maintain necessary camber in centering for all floor slabs and beams in all spanning directions, so as to offset the deflection and assume correct shape.

7.5.0 Construction Operation

All forms shall be thoroughly cleaned of old concrete, wood shavings, saw dust, dirt and dust sticking to them before these are fixed in position. Before formwork is placed in position, the form surface that will be in contact with concrete shall be treated with approved non-staining oil or composition which is insoluble in water and not injurious to concrete. Care shall be taken that the oil or composition does not come in contact with reinforcing steel or stain the concrete surfaces.

7.6.0 Removal of Formwork

The implementing agency shall begin the removal of formwork only after approval of the Engineer-in-Charge. He shall place on record the dates on which the concrete is placed in different parts of the work and the dates of the removal of formwork therefrom. This record shall be checked and countersigned by the Engineer-in-Charge.

Forms of various types of structural components shall, under normal circumstances, not be removed before the minimum periods specified in clause 11.3 of IS: 456-2000, which shall also be subject to the approval of the Engineer-in-Charge. In normal circumstances and where ordinary Portland cement is used, forms may generally be removed after the expiry of the following periods, according to clause no. 11.3 of IS:456-2000.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>Walls, columns and vertical faces of all structural members as directed by the Engineer-in-Charge</td>
</tr>
<tr>
<td>b)</td>
<td>Slabs (Props left under)</td>
</tr>
<tr>
<td>c)</td>
<td>Beams off its (props left under)</td>
</tr>
<tr>
<td>d)</td>
<td>Removal of props under slabs</td>
</tr>
<tr>
<td></td>
<td>Spanning up to 4.5 M</td>
</tr>
<tr>
<td>In case PPC/PSC is used instead of OPC, the removal of shuttering/support shall be after 50% more time from that being applied for OPC unless otherwise permitted by the Engineer-in-Charge. For concrete temperature above 40 Degree C. Stripping time shall be increased.</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>7.7.0 Reuse of Forms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before reuse, all forms shall be thoroughly scraped, cleaned, holes and leaks satisfactorily plugged, joints examined and inside surfaces treated as specified herein before. Formwork shall not be used/reused, if declared unfit or unserviceable by the Engineer-in-Charge.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7.8.0 Dimensional Tolerance for Formwork</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levels and heights ±6mm</td>
</tr>
<tr>
<td>Plumb 3 mm for every meter subject to maximum Of 10mm</td>
</tr>
<tr>
<td>Unevenness of any surfaces ±3mm</td>
</tr>
<tr>
<td>Length or breadth ±12mm</td>
</tr>
<tr>
<td>Diagonals ±15mm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8.0.0 REINFORCEMENT</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>8.1.0 Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>This section of the specification covers the technical requirements for fabricating and placing in position of mild steel or High strength deformed steel reinforcement bars for all RCC works as indicated in the drawings and as directed by the Engineer-in-Charge.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8.2.0 General Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>The implementing agency shall arrange for transport; fabricate and place reinforcement to shapes and dimensions as indicated in the approved drawings and specifications and/or as directed by the Engineer-in-Charge. The reinforcement shall be either mild steel or cold deformed twisted steel bars</td>
</tr>
</tbody>
</table>
conforming to relevant IS specifications as specified in Schedule of Items and Drawings.

The implementing agency shall prepare bar bending schedules on the basis of information furnished in the drawings, approved for construction, and submit the same for approval by the Engineer-in-Charge. No work shall be commenced without the prior approval of the schedule by the Engineer-in-Charge.

Any adjustments in reinforcement to suit field conditions, construction joint etc other than those shown on the drawings shall be subject to the approval of the Engineer-in-Charge, before placing.

8.3.0 Storage and Handling

Reinforcement and structural steel (including steel required for embedment) shall be stored consignment wise and size wise off the ground by at least 150 mm and protected from rusting, oil, grease and distortion by providing suitable cover. The storage area shall be such that water does not accumulate and steel does not get corroded.

8.4.0 Bending and Placing

8.4.1 Bending

Reinforcing bars supplied bent or in coils shall be straightened in cold without damaging the bars, before these are cut to size. Reinforcing steel shall be bent in accordance with procedure specified in IS: 2502 and/ or as approved by "the Engineer-in-Charge. Bends and shapes shall comply strictly with the dimensions shown on the approved bar bending scheduled they shall be rechecked by the implementing agency before bending and he shall be entirely responsible for their correctness. The details of reinforcement shall be in accordance with IS: 5525 and SP: 34. Welding of bars to obtain continuity shall not be allowed particularly for cold twisted.) Jars unless specifically approved by the Engineer-in-Charge. If welding is unavoidable, the work shall be carried out as per IS: 2751 and IS: 9417 and as directed by The Engineer-in-Charge.

8.4.2 Placing in Position

All reinforcement shall be accurately fixed and maintained in position as shown on the drawings by means of steel chairs and or concrete spacer blocks as per IS:2502. Bars intended to be in contact and crossing points, shall be securely bound together at all such points by two numbers annealed steel wire of 1.2 mm size conforming to IS:280.
The vertical distance between successive layers of bars shall be maintained by provision of spacer bars, and shall be so spaced that the main bars do not sag perceptively between adjacent spacers. Laps and anchorage length of reinforcing bars shall be as shown on the drawings and shall be in accordance with IS: 456.

8.5.0 Covert Reinforcement

Unless shown otherwise on the drawings, minimum clear concrete cover for reinforcement (exclusive of plaster or other finishes) shall be as per provisions of IS: 456, subject to minimum of the following:

For bottom reinforcement in footings, 75 mm, if concrete is laid against the ground or 50 mm if laid on a layer of lean concrete.

For retaining walls, grade beams, top and sides of footings and similar surfaces exposed to weather or ground, 50 mm for bars larger than 16 mm and 40 mm for bars up to 16 mm.

For concrete members exposed to the action of harmful chemicals, acids, alkalies, atmosphere, sulphurous smoke, sea water etc., the cover shall be as shown on the drawings.

For liquid retaining structures 40 mm or diameter of main bar whichever is larger.

Clear distance between reinforcing bars shall be in accordance with IS: 456 or as shown on approved drawings.

9.0.0 STRUCTURAL STEEL WORK

9.1.0 Scope

This section of specification covers the technical requirement for supply fabrication & erection of structural steel and associated works.

The specification covers structural steel works involving rolled sections, pipes, plates, chequered plates, beams, fixing of embedded parts.

9.2.0 General Requirement

The implementing agency shall furnish all labour, plant, equipment's, consumables, scaffolding, tools, tackles, materials etc., required for the completion of work on schedule in accordance with drawings and as described herein and/or as directed by the Engineer-in-Charge.
9.3.0 Safe working

The implementing agency shall strictly follow, at all stages of fabrication, transportation and erection of steel structures, the stipulation contained in the Indian Standard Safety Code for erection of structural steel work IS: 7205.

9.4.0 Detailed Working/Fabrication Drawings

Fabrication drawings shall be prepared by the implementing agency based on the scope of drawings supplied by the owner. The detailed working drawings shall indicate complete details of fabrication and erection weld size, lengths etc.

9.5.0 Materials

Structural steel rolled sections and plates shall conform to IS: 2062. Pipes shall conform to IS: 1161. Chequered plates shall conform to IS: 3502. All other materials shall be as per the relevant Indian Standards and as specified in IS:800.

9.6.0 Fabrication

Fabrication work shall be carried out in accordance with IS: 800 as well as stipulations contained in these specifications.

All steel materials shall be straightened and/ or flattened, wherever required by straightening machine, though minor kinks or bends may be corrected by limited heating under careful supervision.

9.7.0 Cutting Plan

The implementing agency shall prepare cutting plan according to detailed working drawings, taking into consideration the availability of material, the cut pieces generated during work with the objective of minimizing waste.

9.7.1 Straightening and Cutting

All steel materials shall be straightened and/ or flattened, wherever required by straightening machine, though minor kinks or bends may be corrected by limited heating under careful supervision.
9.7.2 Cutting

Cutting may be effected by shearing, cropping sawing or by gas cutting by mechanically controlled torch. Gas cutting by hand may only be used when specifically authorized in writing by the Engineer-in-Charge.

9.7.3 Grinding

All the edges cut by flame shall be ground before they are welded.

9.7.4 Assembly

The components parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged.

9.7.5 Welding

Welding shall be carried as per IS:816 and IS: 9595 and the welding procedure duly approved by the Engineer-in-Charge.

All structural welding shall be done by welders who qualify the appropriate Testes laid down in IS:1181. The entire weld of any structure joint shall be made by one welder.

9.7.6 Electrodes

The electrodes used shall be of suitable type and size depending upon specifications of the parent materials, the method of welding and quality of weld desired.

Where coated electrodes are used they shall meet the requirements of IS:814. All electrodes shall be stored properly as per manufacturer’s recommendations.

Specific approval of the Engineer-in-Charge shall be taken by the implementing agency for the various electrodes proposed to be used on the work before any welding is started.

9.7.7 Preheating

Preheating shall, be done wherever required as per IS: 9595

1. When base metal not otherwise required to be preheated is at a temperature elow 0°C it shall be preheated to at least 20°C.
2. Thermo-chalk or other approved methods shall be used for measuring the plate temperature.
All welding shall be done in a proper sequence.

9.8.0 Inspection of Welds

9.8.1 Visual Inspection

100 percent of the welds shall be inspected visually after cleaning the weld surface with steel wire brushes/chisels to remove slag, scales, and the spatter metal. The weld shall be correct in size, length and shall be of regular height and width and shall be free from defects like craters on the surface under cuts, and visible cracks. Weld gauges shall be used to measure the weld sizes.

Wherever above mentioned defects are noticed, the welds, in such locations shall be removed by gouging process. The joints shall be prepared again by clearing the burrs and residual matters with wire brushes and grinded and re-welded.

9.9.0 Erection Procedure

Before any steel work leaves the implementing agency's fabrication site it shall be suitably marked in accordance with the approved fabrication drawings.

9.9.1 Erection Scheme

The implementing agency shall submit for approval of the Engineer-in-Charge is erection scheme giving full details of the method of handling, transport, hoisting and erection including false work/staging, temporary bracing, guying etc.

Erection shall commence only after approval of the implementing agency's proposed erection scheme.

9.9.2 Dismantling of Steel Work

The new structure shall be dismantled wherever called for. Such dismantling shall be done carefully without causing damage to other structures and further modifications shall be done in the fabrication yard.

9.9.3 Modification

The work of modification may involve cutting of certain portions or gouging of welds, cuttings, grinding, fabrication, welding drilling holes, straightening, removal
of bends, painting and touch up painting, transporting the cut and removed parts/items and new steel to be added.

9.9.4 Re-erection

The work of re-erection includes transportation of structures from field fabrication yard to erection site, lifting of same to the required portion aligning, erection in position, inclusive of erection bolts, tack welding, final welding and touch up painting etc., complete to the satisfaction of the Engineer-in-Charge.

9.10.0 Painting

After inspection and issue of test acceptance certificate, all steel surfaces shall be painted, as per the specifications given in the tender document and to the satisfaction of the Engineer-in-Charge.

9.10.1 Surface Preparation

The surface preparation shall be done as per IS: 1477 (Part-I) The surface shall be cleaned, degreased and descaled manually.

9.10.2 Application of Priming Coat

The primers shall consist of red oxide zinc chromate conforming to IS: 2074. Two coats of primer paint shall be applied first at the shop and the second after the erection is completed.

Application of primer shall be done by brush or by any other method specified in IS: 1477'(Part-II) Touch up painting shall be done after erection.

9.10.3 Application of Finishing Coats

Before application of finishing coats the second coat of primer paint shall be completed. Finishing coat shall be synthetic enamel paint conforming to IS: 2932 & IS: 2933. Total coating thickness (DFT) of the painting shall not be less than 100 micron.

9.10.4 Embedded Parts

The embedded steel parts shall be properly placed in position with lugs. Temporary supports shall be provided to ensure proper installation of the embedded parts and these shall be in plumb and level. Concrete around the
embedded parts shall be properly compacted so as to avoid voids or honeycombing. The structure shall be hoisted and placed in position carefully without any damage to itself or to the structure in which it is to be fixed and injury to workmen. If necessary, appliance such as lifting shall be used.

9.10.5 Hand Railings

Pipe hand rails shall be of standard weight galvanized steel pipes of flush welded construction, ground smooth, using 32 mm nominal bore medium class pipes with double rail, 1.2 meter above platform level and pipe posts spread not more than 1.5 meters apart as per the drawings or instructions of Engineer-in-charge.

9.10.6 Covers

Chequered plates shall be fixed to supporting members by tack welding or by counter sunk bolts. Care shall be taken to avoid distortion of the plate while welding of stiffening angles/vertical stiffening ribs.

9.11.0 Bolts

9.11.1 Bolts

Stainless steel Bolt with a 38 x 6 mm stainless steel flat bar shall be used to bind the HDPE liner with the concrete in leachate collection sump, leachate detection sump etc as shown in the drawings. Bolts shall generally conform to IS:5624. All bolts shall be embedded in concrete in plumb and in level at true location. The threads shall be protected by using PVC taps. Hexagonal nuts and locknuts shall conform to 15:4218.

9.11.2 Permanent Bolts

Permanents bolts used for connection of structural steel members shall conform to 15:1363, 15:13643 and 15:1367. These shall be provided with washers, nuts and locknuts.

10.0.0 STONE WORK-RANDOM RUBBLE MASONRY

10.1.0 Scope

This section covers the furnishing of all labour, materials and equipment and the performing of all operations required for the stone masonry work and f incidental
items pertinent thereto all in accordance with the drawings, specifications, schedule of items and as directed by the Engineer-in-Charge.

10.2.0 General Requirements

The stone shall be of the type specified, shall be hard, sound and free from decay and weathering. This shall be obtained from an approved quarry. Stones with round surface shall not be used. Stones shall be properly hammered dressed on the face, the sides and the beds to enable it to come in close proximity with the neighbouring stone. IS: 1597 shall be followed as general guidance for construction of stone masonry.

10.3.0 Mortar

Mortar used for joining shall be as specified and the ingredients shall conform to relevant IS codes or as specified.

10.4.0 Laying

All stones shall be wetted before use. The vertical faces shall be carried up truly plumb, or to the specified batter. Face stones shall extend well into backing. These shall be arranged to break joints as much as possible and to avoid vertical lines of joints. Their height shall not be greater than the breadth at the face of the depth inwards. The hearting or interior filling of the wall face shall consist of rubble stones which may be of any shape but do not pass through a circular ring of 15 cm. Inner diameter, thickness of these stones in any direction shall not be less than 10 cm. These shall be carefully laid, hammered down with a wooden mallet into position and solidly bedded in mortar, chips and spells of stone being used wherever necessary to avoid thick mortar beds or joints and at the same time ensuring that no hollow spaces are left anywhere in the masonry. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 20% of the quantity of stone masonry.

10.5.0 Bond Stones

Bond or through stones running right through the thickness of walls shall be provided in walls up to 60 cm thick. If the walls are more than 60 cm thick, two or more bond stones over lapping each other by at least 15 cm shall be provided in a line from face to back. At least one bond stone or a set of bond stones shall be provided for every 0.5 sq. meter of wall surface.
10.6.0 Quoins

The quoins shall be selected stones neatly dressed with the hammer or chisel to form the required angle and laid header and stretcher alternately. No quoin stone shall be less than 25 x 25 x 25 cm.

10.7.0 Joints

Stones shall be so laid that joints are full of mortar. Face joints shall not be more than 2.5 cm thick.

10.8.0 Curing

Green work shall be protected from the effects of sun, rain etc. by suitable covering. All the masonry work shall be kept constantly moist on the face for a period of seven days.

10.9.0 Embedding of Fixtures

All fixtures to be embedded in mortar and masonry units shall be properly fixed as indicated in the drawings.

10.10.0 Encasing of Structural Steel and Pipes

This shall be done by building masonry work round fringes, webs etc. and filling the gap between steel and masonry by minimum 12 mm thick mortar. Encased members shall be wrapped with chicken wire mesh of 18 gauge when shown on drawings or instructed by the Engineer-in-Charge. The minimum lap in chicken wire mesh shall be 50mm.

11.0.0 FILLING FOR CLAY LINER AND FOUNDATION

11.1.0 Scope

This Section of specification covers the item of filling clay liner and foundation as indicated in the drawings. This section also covers borrowing approved quality of impervious clay from approved designated borrow area.

11.2.0 General Requirements

a. The Implementing agency shall furnish all labour, equipment and material required for complete. Performance of the work in accordance with the drawings, schedule of items and as described herein.
b. The foundation and clay liner shall be constructed in layers not exceeding 200 mm in compacted thickness and in the manner described under placing the Earth fill in clause 8.5.0 using impervious clayey soil obtained from Approved designated borrow areas having hydraulic Conductivity in the range of 10-7cm/ see and plasticity index between 10 to 30%. The soil layers shall not contain soil particles or chunks of rocks larger than 25 mm in size the suitability or otherwise of the material shall be determined by laboratory tests. Each layer of earth deposited shall the be compacted to have a dry density not less than 95% of the maximum dry density (standard proctor) for the soil with suitable tractor drawn heavy sheep foot tamping rollers or by any other method approved by the Engineer-in-Charge. The compaction will have to be uniform throughout the length and breadth of the layers. The roller should be made to travel over the entire section of each layer so that the earth is fully compacted and the roller leaves no visible marks on the surface, Where smooth rollers are used with the approval of the Engineer-in-Charge, the surface of each layer of compacted material shall be roughened with a harrow and thoroughly furrowed or raked before depositing the succeeding layer of material. Care shall be exercised to avoid occurrence of horizontal seams. Earthwork should be continuous from day-to-day. In case of break in compaction exceeding four days, the dried surface shall be well watered and harrowed before a fresh layer of earth is laid on it.

c. Before placing the HDPE pipes within the embankment, construction of embankment up to 600 mm above the RCC lining for pipes shall be carried out without actually placing the pipes. Later on, trenches shall be excavated for pipes and lining work and pits for cut off collars. These trenches shall then be filled using CL-ML type soil (plasticity index 720). Earth layer deposited in these trenches shall be compacted with plate compactors to have a dry density not less than 95% of the maximum dry density (standard proctor).

d. The spreading of the next layer shall be carried out only after the underlying layer has been approved by the Engineer-in-Charge or his authorised representative.

11.3.0 Water for Clayfilling works

The Implementing agency has to make his own arrangements for the supply of water for earth filling works. It shall be the responsibility of the Implementing agency to identify and develop water source or sources, running a pipe line/pipe lines laid at a distance not less 10 meters away from the toe/heel of the embankment for conveying the water required for the work from the
supply sources, tapping water from manifolds provided at suitable intervals along the pipe line with the aid of water hoses and sprinkling jets for sprinkling water uniformly over the entire area (and not poured in patches) for bringing up the layers to the required moisture content. Alternately he may employ sufficient number of water tankers also. No separate payment for the above will be made and entire cost on account of the same shall be included in the rates for relevant items of schedule:

12.0.0 FOUNDATION FOR EMBANKMENT

12.1.0 Scope

This section covers the preparation/ compaction of foundation of the embankment as indicated in the drawings and described herein.

12.2.0 General Requirements

a. Foundation preparation shall be performed as per drawings and as described herein subsequent to stripping of foundation and excavation, if any. No material shall be placed in any section of the fill portion until the foundation for that section of the fill has been dewatered, suitably prepared and has been approved by the Engineer-in-Charge. All portions of excavations made for test pits or other sub-surface investigation and all other existing cavities, found within the area are to be filled with earth and properly compacted and which extend below the established lines of excavation for foundation shall be filled with earth of the corresponding zone and properly compacted. The foundation should be free from all organic materials, vegetable sods. The topsoil of foundation should be stripped properly such that vegetable sods and top layers are removed to ensure proper bond between embankment and foundation.

b. Masonry surfaces of the back of retaining walls, wing walls and box culverts · etc. against which the fill is to be placed, shall be cleaned and moistened prior to placing the earth. The foundation immediately adjacent to the masonry/concrete structures shall be thoroughly cleaned of loose materials and moistened. Pools of water shall not be permitted in the foundation and shall be drained and cleaned prior to placing the first layer of embankment material.
13.0.0 EARTHEN EMBANKMENT

13.1.0 Scope

This section of specification covers the earthwork involved in the embankment formation as per the drawings and as mentioned herein.

13.2.0 General Requirement

The Implementing agency shall furnish all labour, equipment and materials required for complete performance of the work in accordance with drawings, schedule of items and as described herein.

13.3.0 Earthen Embankment

The embankment shall be constructed to the lines and grades shown on the drawings. Placement of fill shall be performed in an orderly way and in an efficient and workman like manner, so as to produce fills having such quantities of density, strength and permeability as will ensure the highest practicable Degree of stability and performance of the embankment.

No bushes, roots, sods or other perishable or unsuitable materials shall be placed in the embankment. The suitability of each part of the foundation for placing embankment materials thereon and of all materials for use in embankment construction shall be determined by the Engineer-in-Charge. The embankment may be constructed in separate portions, provided that:

a. The slopes of the bonding surfaces between the previously completed portions of the embankment and materials to be placed in each zone shall not be steeper than 2.5 horizontal to 1 vertical along the centreline of the embankment.

b. The embankment is constructed right across the whole section in each portion.

13.4.0 Fill Materials

The materials for embankment shall be obtained from the designated borrow areas and available excavated material. In general all materials. From the particular borrow area shall be a mixture of materials obtained for the full depth of the cut. Some earth material available from the excavation in the landfill area if found suitable will also be used for the embankment construction.
13.4.1 Placing the fill material

a. Before placing the fill the foundation shall be prepared and compacted. Prior to placing the first layer of embankment, the foundation moistening and compaction shall be done. Prior to placing the first layer of embankment on the foundation, moistening and compacting the surface by rolling to achieve dry density not less than 95% of maximum dry density (Standard Proctor) shall be done. The distribution and gradation of materials throughout the fill shall be as shown in the drawings or as directed. The fills shall be free from lenses, pockets, streaks, or layers of material differing suitably in texture or gradation from the surrounding material. The combined excavation and placing operations shall be such that the materials when compacted in the fill will be blended sufficiently to produce the specified degree of compaction and stability. The earth obtained from a particular borrow area as far as possible shall be used forming the complete cross-section of the fill for a particular stretch. Sequencing of the placing of fill material shall be such that it shall be possible to identify at all stages of construction which borrow area material is used in which stretch of the fill/embankment.

b. No stones, cobbles, or rock fragments, having maximum dimensions of more than 5 cm shall be placed in the fill. Such stones and cobbles shall be removed either at the borrow pit or after being transported to the site but before the materials in the fill are rolled and compacted. Such stones or cobbles shall be placed in other portions of embankment if found suitable or rejected as directed. The materials shall be placed in the fill in continuous horizontal layers, stretching right across the whole section, not more than 20 cm in compacted thickness and rolled as herein specified. During construction a small transverse slope from center towards the edges should be given to avoid pools or water forming due to rains. The surface of materials to be placed thereon shall be moistened and/or worked with harrow, or other suitable equipment, in an approved manner to a sufficient depth to provide a satisfactory bonding surface before the next layer of fill material is placed. If the rolled surface of any fill is found to be too wet for proper compaction, it shall be raked up, allowed to dry, or shall be worked with a harrow or any other approved equipment to reduce the moisture content to the required amount and then it shall be re-compacted before the next layer of earth is placed.

c. When compacting the soils against steep rock abutment or walls or masonry or concrete structure, the construction surface of embankment shall be sloped away from rock or masonry or concrete structures for a distance of 3m to 4m at an inclination not steeper than 6 horizontal to 1 vertical. If the foundation surface is too irregular to allow the use of a large roller directly against a structure or rock outcrop, the roller shall be used to compact the soil as close to the structure or the outcrop as possible and the portion of the embankment directly against the rock or the structure shall be compacted with pneumatic hand tampers in thin layers; The
moisture contempt of the earth placed against the rock or the structure shall be high enough to allow it to be compacted into all irregularities of the rock. Care shall be taken in placing the first layer of the fill so that no damage is caused by the hauling machinery to the base grade as this may get concealed by the spread layer or fill. Sheep foot roller shall not be employed for compacting till the thickness of the layers already compacted by other means is greater by 30cm than the depth of the feet on the roller drum. The soil for the first layer shall be at moisture content sufficient to enable bonding of the fill with the rock surface:

13.5.0 Weather Conditions

Embarkment materials shall be placed only when the weather conditions are satisfactory to permit accurate control of the moisture content in the embankment materials.

13.6.0 Moisture Control

Prior to and during compacting operations, the materials in each layer of earth shall have moisture content about 2% less than the optimum moisture content. Laboratory investigations may impose some restrictions on the lower limits of the practicable moisture contents on the basis of studies of compaction in embankment. As far as practicable the materials shall be brought to the proper moisture content in the borrow area before excavation. If additional moisture content is required, it shall be added by sprinkling water before rolling. The implementing agency shall make his own arrangements for supply of water in a manner described under water for earth fill work. If the moisture content is greater than required, the material shall be spread and allowed to dry before starting rolling. The moisture content shall be uniform throughout the layer of material and plugging, dicing, harrowing or other methods of mixing may be required to obtain uniform distribution. If the moisture content is more or less than the range of the required particle, moisture content, or if it is not uniformly distributed throughout the layer, rolling shall be stopped and shall be started again only when the above conditions are satisfied.

13.7.0 Compaction Equipment

While the specifications provide that equipment of a particular type and size is to be furnished and used, it is to be understood that the use of improved equipment is to be encouraged. Tamping (sheep foot) rollers or pneumatic rollers and vibratory rollers shall be used for compacting cohesive materials and pneumatic rollers and vibratory rollers shall be used for compacting cohesion less materials.

a. Tamping (Sheep foot) Rollers

Tamping rollers shall conform to the following requirements
b. Roller drums

c. Tamping Feet
At least one tamping foot shall be provided for each 600· sq.cm of drum surface. The shape measured on the surface of. The drum between the centers of any two adjacent tamping feet shall not less than 25 cm. The length of each tamping foot from the outside surface of the drum shall be maintained at not less than 25 cm. The cross sectional area of each tamping foot shall not be more than 60 sq. cm at a plane normal to the axis of the shank 15 cm from the drum surface and shall be maintained at not less than 4-5 sq. cm and not more than 60 sq. cm at a place normal to the axis of the shank 20 cm from the drum surface.

d. Roller Weight
The weight of a roller when fully loaded shall not be less than 7000 kgs per drum. The loading used in the roller drums and operating of toilers shall be as required to obtain the desired breakdown and compaction of materials. If more than one roller is used on anyone layer of fill, all rollers so used shall be of the same type and essentially of the same dimensions. Tractors used for pulling rollers shall have sufficient power to pull them at a speed of about 4 km per hour with drums fully loaded. During the operation of rolling the spaces between the tamping feet shall be kept clear of materials, which could impair the effectiveness of the tamping rollers. If the rollers used are tandem, the tamper spacing shall be set so that the circumferential rows of the rear drums are in line with the midpoint between the circumferential rows on the forward drums.

e. Pneumatic rollers
Pneumatic rollers shall have four wheels equipped with pneumatic tires and a body suitable for ballast loading so that the load per wheel may be varied as necessary from 7000 kgs to 11000 kgs. Tire pressure shall not exceed 2.5 kgs/sq.cm. The tyres shall be of such size and ply as can be maintained. During rolling operations with tire pressure not greater than 2.5 kgs/sq.cm for a 11000 kgs wheel load. The roller wheels shall be located abreast and each wheel and tire shall be mounted 'in such a way that all. Wheels exert approximately equal loads when traversing uneven grounds the spacing of the wheels shall be such that the distances between the nearest edges of adjacent tyres at the imprint will not be greater than 50 per cent of the width of single tire. When one pneumatic roller is attached to a tractor, the entire tractor and roller unit -shall-be capable of executing a 1.80 dig turn on-a 5-m.radius.

f. Vibratory Rollers
Vibratory rollers shall have dead weight 5 to 15 tones and the vibrators shall have frequency between 1100 and 1800 pulses per minute and amplitude of vibration shall between .0.5 mm and 1.5 mm.

13.8.0 Rolling and Tamping

a. Rolling

When each layer of material has been conditioned, so as to have the proper moisture content uniformly distributed throughout the material, it shall be compacted by passing the roller. The exact number of passes shall be decided after necessary field tests. The layers shall be compacted in strips overlapping not less than 0.6 m. The rollers or loaded vehicles shall travel in a direction parallel to the axis of the embankment. Turns shall be made carefully to ensure uniform compaction. Rollers shall always be pulled. Density tests shall be made after rolling and the dry density attained shall be not less than 95% of maximum dry density (Standard Proctor) obtained in the Laboratory for the type of material used.

b. Tamping

Rollers will not be permitted to operate within 1.0 m of concrete and masonry structures. In locations where compaction of the earth fill material by means of the roller is impracticable or undesirable, which would be designated at the sole discretion of the Engineer-in-Charge the earth shall be spic ally compacted.

Fill shall be spread in layers not more than 20 cm in compacted thickness and shall be moistened to have the required moisture content. When each layer of material has been conditioned to have the required moisture content it shall be compacted to achieve the dry density of not less than 95% of Maximum Dry Density (Standard Proctor) by special rollers mechanical tampers, hand held vibratory tampers or by other approved methods and all equipment and methods used shall be subject to approval based on evidence of actual performance. The moisture control and compaction shall be equivalent to that obtained in the earth actually placed in the embankment in accordance with clause 8.7.0 and 8.9.1.

13.9.0 Inspection Test

Control tests shall be carried out in laboratory from time to time to determine whether the earth produced by methods employed satisfies the requirements of the specifications. Routine field tests shall also be carried out by the Engineer-in-Charge and the work shall be inspected regularly. Field density test should be particularly and specially made in the following areas.

a. Where the degree of compaction is doubtful.
b. Where embankment operations are concentrated i.e. where 2 or more layers are placed one over the other on the same day.

c. To represent every 1000 cu. meters of embankment placed.

d. At least one test for every full or part shift of compaction operations and

e. At least one test for every 250m length of embankment in each layer

The Engineer-in-Charge shall determine whether the desired results are being obtained.

The Implementing agency shall provide all facilities such as labor conveyance equipment etc. required for collection of samples and to conduct test in situ or at laboratory. Relevant test to be conducted by the Engineer-in-Charge at his discretion at the borrow area, on embankment and at laboratory are listed out in the Annexure II.

13.10.0 Dressing and Trimming of the slopes

The outer slopes of the embankment shall be neatly dressed to line. Compaction shall extend over the full width of the embankment and the material in the slopes shall be compacted as for the rest of structure. To ensure proper compaction at the outer edge, the fill shall be constructed for a minimum of 0.5 m extra width on either edges or the outer edge dressed to true width and slope after compaction. No earth slope shall be left without trimming to design slope. Slopes shall be maintained until final completion and acceptance. Any material that is lost by weathering or due to any other cause shall be replaced. The trimmed material is permitted for reuse in the embankment. No separate payment will, however be made for forming extra width offsets or trimming the slopes and the unit rates for the embankment work shall therefore provide for the same.

13.11.0 Provision for Settlement

While forming the embankment due allowance shall be made to allow for settlement so as to maintain the top of embankment at designed elevation.

14.0.0 TURFING

14.1.0 Scope

This section of specifications covers turfing on the slope of the embankment as Indicating, the following drawing and mentioned herein with turf sods.
14.2.0 General Requirement

The implementing agency shall furnish all labor, equipment and materials required for the complete performance of the work in accordance with. The drawings, schedule of items and as described herein.

Grass turf sods of approved variety shall be used in this work. No directing planting of grass on the embankment slope shall be permitted.

14.3.0 Placing

The slope of the embankment including berms if any shall be turf sodded. After the slope has been dressed to line, it shall be slightly roughened and scarified. The entire slope surface shall then be covered with a layer of turf sod consisting of blocks of thin lining grass growth of approved species. The sods shall include a mat of roots and earth. Thick Sod Containing an excessive amount of obnoxious weed growth shall be excluded. Sod shall be carefully handled' in transportation and placing so that a minimum amount of earth will be lost from the root mass. The blocks of sod shall be laid on the slope in close contact and then tamped firmly in place so as to fill and close the joints between block. The interval of time between cutting and laying shall be kept to a minimum and sod shall not be permitted to dry. Immediately after placing the sods, slope shall be thoroughly wetted and then kept moist for 3 months or till such time the grass establishes itself uniformly on the surface whichever is later. The watering shall be done. The growth of weeds on the turfing shall be prevented by removing them and disposing off. The finished work shall be to the satisfaction of the Engineer-in-Charge and his decision shall be final in the matter.

15.0.0 HDPELINER

15.1.0 Scope

This section covers the specifications for the supply, laying, jointing and testing of HDPE geo-membrane liner as per the drawings and specifications mentioned herein to the satisfaction of the Engineer-in-charge.

15.2.0 SheetMaterial

The HDPE sheet shall conform to the minimum average roll value requirements listed below in Table-2. The minimum width of the roll shall be 8 m and the minimum length shall be 150 m.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Method</th>
<th>Minimum values</th>
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</thead>
<tbody>
<tr>
<td>Dumbbell at 2 inch/ min</td>
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<td>Elongation at Break</td>
<td>ASTM D 638, Type IV Dumbbell at 2inch/ min</td>
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<td>Carbon Black</td>
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<td>No crack</td>
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<td>Water absorption</td>
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<td>&gt; 2000 hrs.</td>
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<td>Volatile Losses</td>
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<td>Tear Resistance</td>
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<td>Water Vapor Transmission</td>
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<td>Puncture Resistance</td>
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<td>Seam Properties</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Peel Strength (hot wedge fusion)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peel Strength (filled extrusion)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(filled extrusion)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASTM D 4437</td>
<td></td>
<td>13.8 Mpa, 10.3 Mpa, 9.0 Mpa</td>
</tr>
<tr>
<td>Change in weight (%)</td>
<td>EPA 9090A, Chemical Compatibility Test</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Change in Volume (%)</td>
<td>EPA 9090A, Chemical Compatibility Test</td>
<td>10</td>
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<tr>
<td>Change in tensile strength(%)</td>
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<td>&lt;20</td>
</tr>
<tr>
<td>Change in elongation at break (%)</td>
<td>EPA 9090A, Chemical Compatibility Test</td>
<td>&lt;30</td>
</tr>
<tr>
<td>Change in modulus (%)</td>
<td>EPA 9090A, Chemical</td>
<td>&lt;30</td>
</tr>
<tr>
<td>Parameter</td>
<td>Test Method</td>
<td>Minimum values</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Compatibility Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in hardness (%)</td>
<td>EPA 9090A, Chemical Compatibility Test</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

15.3.0 QA/QC Requirements for Membrane Raw Materials

All raw material supplied to the manufacturer shall be delivered in rail car batches and must be supplied with test certification from the raw material supplier. The certification must state the results of tests, which confirm the quality of the resin. The raw material supplier must also confirm that each batch of resin is all of the same type and is 100% Virgin. Each batch of resin shall be given identification (batch) number which shall be used and remain, on file to keep track of all rolls manufactured from each batch.

The use of any off spec, recycled or blends of resins will not be considered. Prior to the production of the membrane, the membrane manufacturer shall test the raw material batches to certify the raw material ‘Suppliers test results and entity of the singular, resin. The membrane manufacturer shall provide certification and all available test result for raw materials prior to the delivery of materials to site.

15.4.0 QA/QC Requirements for Membrane Manufacturing

The manufacturing process shall be a fully automated Flat-Cast extrusion process controlled by a fully computerized system. The control system shall provide for the continuous monitoring of the parameters like; Temperature; Pressure, and Speed. The manufacturing process must also provide for the automated continuous monitoring of thickness and sheet quality.

15.4.1 Thickness: Each roll shall be tested automatically and evenly over its entire surface area, the minimum parameters acceptable for testing each roll shall be 6,000 thickness point checks. The acceptable thickness for each roll shall not be greater than -5% to +10% of the specified material thickness.

15.4.2 Sheet Quality Each roll shall be tested automatically for High Voltage Test over its entire surface area for any point of Electrical Continuity through (across) the ‘thickness of the sheet. The high voltage scanner shall be capable of detecting any pinhole, void or significant reduction of electrical resistance. Any roll detected to
have holes or electrically conductive inclusions shall be rejected and not sent to the site.

Each roll delivered to site shall be provided with a roll test data report, these reports must provide the following information and test results as per the specified ASTM standards, reports must also carry the manufactures laboratory QA/QC approval seal.

The liner material shall be supplied with a 125mm-film sheet along the roll longitudinal edges in order to keep this zone clean and to stop oxidization. This film shall be removed immediately before welding.

The overlapping and welding area shall be marked to assure an optimum welding. The HDPE liner shall have a glossy smooth surface.

15.4.3 Roll Identification

1. Roll Number and dimensions
2. Production Date
3. Area of Sheet on Roll
4. Roll Length
5. Roll Width
6. Roll Weight

15.4.4 Resin Lot Information

1. Batch Number
2. Resin Type
3. Resin Test Results as per following ASTM Test methods
   a. Density D792
   b. Moisture D570
   c. Brittleness D746
   d. Melt Index D1238
   e. O.I.T. D3895

15.4.5 Membrane Property

The implementing agency will arrange to carry out the following tests, at third cost, at a reputed and approved laboratory at the time of execution of work to ascertain and assure the quality of material received at project site. The tests shall be witnessed by client /consultant at their discretion. The frequency of tests for physical and mechanical properties and their conformity norms are indicated in following Table.
<table>
<thead>
<tr>
<th>Frequency</th>
<th>Property</th>
<th>Norms (ASTM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/50000m²</td>
<td>Thickness</td>
<td>D-5199</td>
</tr>
<tr>
<td>1/5000 m²</td>
<td>Density</td>
<td>D-792</td>
</tr>
<tr>
<td>1/ 5000 m²</td>
<td>Carbon black content</td>
<td>1/5000 m²</td>
</tr>
<tr>
<td>1/50000m²</td>
<td>Carbon black dispersion</td>
<td>D-1603</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Property</th>
<th>Norms (ASTM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/1500 m²</td>
<td>Mechanical Properties resistance</td>
<td>D-638 Mod. NSF 43</td>
</tr>
<tr>
<td>1/2000 m²</td>
<td>Shear test (on seam)</td>
<td>D-4437, 6.3 NSF mod.</td>
</tr>
<tr>
<td>1/ 2000 m²</td>
<td>Peel test (onseam)</td>
<td>D-4437, 6.2 NSF mod. US-EPA</td>
</tr>
<tr>
<td>Every lbt</td>
<td>ESCR</td>
<td>ASTM D 1693-B</td>
</tr>
<tr>
<td>1/5000 m²</td>
<td>Puncture Resistance</td>
<td>ASTM D4833</td>
</tr>
<tr>
<td>1/5000 m²</td>
<td>Tear Resistance</td>
<td>ASTM D 1004</td>
</tr>
</tbody>
</table>

**Note**: Sample size for conformity test a meter of the enter width for the roll and must not be taken in the first thickness.

**15.5.0 QA/QC at site**

The material shall be inspected after it is delivered at site as follows:

1. Rolls or portions of rolls that appear damaged shall be marked.
2. Verification shall be done to ensure that materials are stored in secure place and are protected against dirt; theft, vandalism, and passage of vehicles.
3. Rolls shall be properly labeled with date and roll size.

Any material rejected on site by the Engineer-in-charge shall be jointly inspected by the Engineer-in-Charge and the Manufacturer / Installer. If required, the material shall be tested and if the material is unable to meet the specification, it shall be replaced by the Manufacturer / Installer at his cost.

**15.6.0 Preparation for HDPE Liner Deployment**

Prior to commencement of HDPE liner deployment, layout drawings shall be prepared to indicate the panel configuration and general location of field seams for the project. The actual panel layout may vary, but shall have to be approved by the Engineer-in-charge, in order to accommodate field conditions. Each panel used for the installation will be given a number that will correlate with a batch or roll number.
Overlap the panels of geo-membrane approximately six (6") inches prior to toweling. Ocean the seal area prior to seaming to assure the area is clean and free of moisture, dirt or debris of any kind. No grinding is required for fusion welding.

Adjust the panels so that the seams are aligned with the fewest possible number of wrinkles and "fish mouth". Grind seams overlap prior to welding within one (1) hour of the welding operation in a manner that does not damage the geo-membrane. Grind marks should be covered with extrude whenever possible. In all cases, grinding should not extend more than one quarter inch (1/ 4") past the edge of the area covered by the extrude welding.

15.6.1 Special Instructions for Installation

Implementing agency shall protect the sub soil desiccation, flooding protection, if required may consist of a thin plastic protective cover (or other Lateral as approved by Engineer-in-Charge installed over the completed sub-soil until such times as the placement of geo-membrane liner begins. Sub soil found to have desiccation cracks greater than help inch (1/2") in width or depth or which exhibit swelling, heaving or other similar conditions shall be replaced or reworked by the implementing agency to remove these defects.

15.6.2 Sub-base Preparation

The sub-base must be properly prepared and compacted for installation of HDPE liner. The sub-base must not contain any particles. The sub-base must be checked for footprints or similar depressions before laying the liner. The seaming equipment tends to get caught in such small depressions, causing burnout and subsequent repair. A small piece of the synthetic membrane placed below the membranes that are being seamed (this-piece is moved-forward along with the seaming equipment) may reduce burnout due to small depressions.

15.7.0 Field Panel Placement

HOPE deployment will generally be not done during any precipitation in the presence of excessive moisture, in an area of standing water, or during high winds.

Installation of field panels shall be done as indicated on the approved layout drawing keeping the provision for settlement of the soil. If the panels are deployed in a location other than that indicated on the layout drawings, the revised location will be noted in the field. Information relating to HDPE panel placement including date, panel number, and panel dimensions may be maintained on a site-specific basis. A portion of a roll is
set aside to be used at another time, the roll number will be written on the reminder of
the roll at several places.

The method and equipment used to deploy the panels must not damage the HDPE or
the supporting sub grade surf ace. No personnel working on the HDPE engage in
actions that could result in damage to the HOPE. Adequate temporary loading and/ or
anchoring, (i.e. sandbags, tires) which will not damage the HDPE, will be placed to
prevent uplift of the HDPE by wind.

The HDPE will be deployed with adequate allowance for typical thermal expansion. Any
area of a  panel seriously damaged (torn, twisted, or crimped) will be marked and
repaired as explained earlier in the chapter.

15.8.0 HDPE Field Seaming

In general, seams shall be oriented parallel to the slope, i.e. oriented along, not across-
the slope. Whenever possible, horizontal seams should be located on the base of the
cell, not less than five (5') feet from the toe of the slope. Each seam made in the field
shall be numbered. Seaming information shall include seam number, welder ID,
machine number, temperature setting and weather conditions.
All personnel performing seaming operations shall be trail. Fled in the operation of the
specific seaming equipment being used and will qualify by successfully welding a test
seam as described earlier in this chapter.

15.9.0 Equipment

15.9.1 Fusion Welding

Fusion Welding consists of placing a heated wedge, mounted on a self-propelled
vehicular unit, between two (2) over-lapped sheets such that the surface of both sheets
is heated above the polyethylene's melting point. After being heated by the wedge, the
overlapped panels pass through a set of pre-set pressure wheels, which compress the
two (2) panels together to form the weld. The fusion welder is equipped with a device,
which continuously monitors the temperature of the wedge.

15.9.2 Extrusion Fillet welding

Extrusion fillet welding consists of introducing a ribbon of molten resin along the edge
of the overlap of the two (2) HDPE sheets to- be welded; A hot air pre heat and the
addition of molten polymer causes some of the material of each sheet to be liquefied
resulting in a homogeneous bond between the molten weld bead and the surfaces of
the overlapped sheets. The extrusion welder is equipped with gauges giving the
temperature in the apparatus and a numerical setting for the pre-heating unit. Factors
such as the HDPE temperature, humidity, wind, precipitation, etc., can affect the
integrity of field seams and must be taken into account when deciding whether or not seaming should proceed.

15.10.0 Seam Testing of HDPE

All field seams shall be nondestructively tested over their full length using test equipment and procedures described herein. Seam testing shall be performed as the seaming work progresses, not at the completion of the field seaming.

15.10.1 Air Pressure Testing

The welded seam is composed of a primary seam and a secondary track that creates an unwelded channel. The presence of an unwelded channel permits fusion seams to be tested by inflating the sealed channel with air to a predetermined pressure and observing the stability of the pressurized channel over time.

15.10.2 Equipment for Air Testing

The equipment required for air testing consists of following components

1) An air pump (manual or motor driven) capable of generating and sustaining a pressure between 20 to 60 psi.
2) A rubber hose with fittings and connections.
3) A sharp hollow needle or other approved pressure feed device with a pressure gauge capable of reading and sustaining a pressure between 0 to 60 psi.

15.10.3 Procedure for Air Testing

Both the ends of the seam to be tested should be sealed. Needle or other approved pressure feed device should be inserted into the sealed channel created by the fusion weld.
Test channel should be inflated to a pressure of approximately 30 psi, and the pressure should be maintained within the range listed in Initial Pressure Schedule given below. Valve should be closed and the initial pressure should be observed and recorded.

<table>
<thead>
<tr>
<th>MATERIAL (MIL)</th>
<th>MIN. PSI</th>
<th>MAX. PSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td>60</td>
<td>27</td>
<td>35</td>
</tr>
</tbody>
</table>
Initial Pressure settings shall be recorded after an optional two (2) minute stabilization period. The purpose of this “relaxing period” is to permit the Air temperature and pressure to stabilize. The initial pressure reading may be recorded once stabilization has taken place. The air pressure should be observed and recorded five (5) minutes after. The initial pressure setting is recorded. If loss of pressure exceeds the following or if the pressure does not stabilize, the suspect area should be located and repaired in accordance with Para. 11.0.0 of this chapter.

### Maximum Permissible Pressure Differential After 5 Minutes

<table>
<thead>
<tr>
<th>MATERIAL (MIL)</th>
<th>PRESSURE DIFF.</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>4 PSI</td>
</tr>
<tr>
<td>60</td>
<td>3 PSI</td>
</tr>
<tr>
<td>80</td>
<td>2 PSI</td>
</tr>
</tbody>
</table>

At the conclusion of all pressure tests, the end of the air-channel opposite the pressure gauge shall be cut. A decrease in gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated from the point of blockage. If the point of blockage cannot be found, air channel shall be cut in the middle of the seam shall be cut and each half shall be treated as a separate test. Pressure feed needle shall be removed and the resulting hole shall be sealed by extrusion welding.

#### 15.10.4. Procedure for Non-Complying Test

In the event of a Non-complying Air Pressure Test, the following procedure shall be followed.

1. Seam end seals should be checked and seams should be retested.
2. If a seam does not maintain the specified pressure, the seam should be visually inspected to localize the flaw.
3. If no flaw is found, area to be vacuum tested should be marked. Entire length of the seam should be vacuum tested as explained in this chapter.

   a. If leak is located by the vacuum test, it should be repaired by extrusion fillet welding. Repair should be tested by vacuum testing.
   b. If no leak is discovered by vacuum testing, the seam will be considered to have passed nondestructive testing.
15.10.14 General Air Testing Procedures
1. The opposite end of the air channel will in all cases be pierced to assure that no blockages of the air channel have occurred.
2. Whenever possible, seams should be air-tested prior to completing butt seams to avoid having to cut into liner. All cuts through the liner as a result of testing will be repaired by extrusion welding.
3. All needle holes in air channels, within the boundaries of the active cell, will be repaired with an extrusion bead or repaired by patching at the discretion of the Engineer-in-Charge.

15.10.5 Air Pressure Testing Documentation
All information regarding air-pressure testing (date, initial time and pressure, final time and pressure, pass/fail designation, and Technicians number) will be written on one end of the seam, or portion of seam tested.

15.10.6 Vacuum Testing
This test is used on extrusion welds, or when the geometry of a fusion well makes air pressure testing impossible or impractical, or when attempting to locate the precise location of a defect believed to exist after air pressure testing.

15.10.7 Equipment for Vacuum Testing
The equipment required for vacuum testing shall consist of following components:

1. Vacuum box assembly consisting of rigid housing with a soft neoprene gasket attached to the open bottom, a transparent viewing window, port hole or valve assembly, and a vacuum gauge.
2. Vacuum pump or Ventura assembly equipped with a pressure controller and pipe connection.
3. A rubber pressure/vacuum hose with fittings and connections.
4. A bucket and means to apply a soapy solution.
5. A soapy solution.

15.10.8 Procedure for Vacuum Testing

1. Excess overlap from the seam should be trimmed, if any.
2. Vacuum pump/compressor should be turned on to reduce the vacuum. Box to approximately 10 inches of mercury, i.e. 5-psi gauge.
3. A strong solution of liquid detergent and water should be applied to the area to be tested.
4. Vacuum box should be placed over the area to be tested and scent downward pressure should be applied to "seat" the seal strip against the liner.
5. Bleed valve should be closed and vacuum valve should be opened.
6. A minimum of 5-psi vacuum should be applied to the area as indicated by the gauge on the vacuum box.
7. It should be ensured that a leak tight seal is created.
8. The suction should be held for an adequate time to thoroughly examine the HDPE through the viewing window for the presence of soap bubbles.

9. After this period vacuum valve should be closed and bleed valve should be opened, the box should be moved over the next adjoining area with a minimum three inch (3") overlap, and the process should be repeated.

**15.10.9 Procedure for Non-Complying Test**

1) All the areas where soap bubbles appear should be marked and repaired
2) The repaired areas should be retested.

**15.10.10 General Vacuum Testing Procedures**

1) Vacuum box testing will be performed by qualified construction personnel.
2) Overlap must be trimmed prior to vacuum boxing all seams.
3) Special attention shall be exercised when vacuum testing "T" seams or patch intersections with seams. Vacuum testing crew will use Mean Streak permanent markers to write online indicating tester's ID number, date, and pass/fail designation on all areas tested. Records of vacuum testing shall be maintained on non-destructive testing form.

**15.10.11 Destructive Testing**

The purpose of destructive testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore, destructive testing should be held to a minimum to reduce the amount of repairs to the HDPE.

**15.10.12 Procedure for Destructive Testing**

1. Destructive test samples shall be marked and cut out randomly at a minimum average frequency of one (1) test location every 500 feet of seam length, unless otherwise specified or agreed.
2. Destructive samples should be taken and tested as soon as possible after the means are welded (the same day), in order to receive test results in a timely manner.
3. Qualified personnel will observe all field destructive testing and record date (time, seam number, location, and test results on Destructive Testing Form.
4. Sample Size

   (a) The sample should be twelve inches (12") wide with a seam sixteen inches (16") long centered length-wise in the sample. The sample may be increased in size to account for independent laboratory testing by the Owner at the Owner's request or by specific project specifications.
(b) A one-inch (1") specimen shall be cut from each end of the test seam for field-testing. The two (2) one inch (1") wide specimens shall be tested on a field tensiometer for peel strength. If either field specimen does not pass, it will be assumed the sample would also not pass laboratory destructive testing.

15.10.13 Procedure for Non-Complying Destructive Test

1. Additional field samples should be cut for peel testing. In the case of a field production seam, the samples must lie a minimum of ten (10) feet in each direction from the location of the initial non-complying sample. A field test should be performed for peel strength. If these field samples pass, then laboratory samples can be cut and forwarded to the laboratory for full testing.
   (a) If the laboratory samples pass, the seam between the two (2) passing sample locations should be repaired according to procedures detailed in Para 11 of this chapter.
   (b) If either of the samples is still in non-compliance, then additional samples should be taken in accordance with the above procedure until two (2) passing. Samples are found to establish the zone in which the seam/seams should be reconstructed.

2. All passing seams must be bounded by two (2) locations from which samples passing laboratory destructive tests have been taken.

3. In cases of repaired seams exceeding 150 consecutive feet, a sample must be taken and pass destructive testing from within the zone in which the seam has been reconstructed.

4. All destructive seam samples shall be numbered and recorded on Destructive Test Form.

15.10.13 Laboratory Testing of Destructive Seam Samples

1. Seam destructive samples may be sent to laboratory or tested on site when permitted by a site-specific quality control plan or in the event that third party laboratory destructive testing is not being performed.

2. Destructive samples will be tested for “Shear Strength” and "Peel Adhesion" Five (5) specimens shall be tested for each test round. Four (4) out of the five (5) specimens must exhibit for each round of peel and shear testing. In addition, four (4) of the five (5) individual specimens must meet, or exceed the strength requirements as listed in Material pacification sheet in order for the seam to pass the destructive test.

15.11.0 Testing for Pinholes, Cuts

Laid HDPE sheet on liner shall be tested for cuts, pinholes, seam leakage's etc. by using modern Gee-electrical leak detection/vacuum boon complete lining profiles before putting the next layer. The implementing agency shall give the detailed methodology for testing. Any defect remediation or repair modification as required by this test shall be carried out by the implementing agency.
15.12.0 Defects and Repairs

15.12.1 Repair Procedures

Any portion of the HDPE or HDPE seam shown a flaw, or having a destructive or non-destructive test in non-compliance shall be repaired. Procedures for repair include the following:

15.12.2 Patching

Patching shall be used to repair large holes, tears and destructive staple locations. All patches shall extend at least three inches (3”) beyond the edges of the defects and all corners of patches shall be rounded. The total area of patches in no case shall exceed 1.0% of the panel area.

15.12.3 Grinding and Welding

Grinding and welding shall be used to repair sections of extruded fillet seams.

15.12.4 Spot Welding or Seaming

Spot welding or seaming shall be used to repair small tears, pinholes or other minor localized flaws.

15.12.5 Capping

Capping shall be used to repair lengths of extrusion or fusion welded seams.

15.13.0 Verification of Repairs

Every repair shall be non-destructively tested. Repairs, which pass the non-destructive test, shall be deemed acceptable. Repairs in excess of 150 consecutive feet of seem shall require a destructive test.

15.14.0 Control and Verification Tests on Geo-membrane Installation

These tests will verify the welds’ mechanical resistance to peel and shear. No assembling equipment will be used on site without a previous calibration test. The Installer must prepare samples of a minimal length of one (1) meter by a width of 300mm, with the weld centered-on the samples width. Two (2) specimens will be taken from each end of the samples of peel and shear. For each sample, two paired peel and shear results will thus be obtained. Calibration of all welding equipment must be performed and documented by the installer for each instrument used, at the start of each work shift, following abrupt changes in weather conditions and as requested by the Engineer-in-Charge.
Calibration of equipment will be performed by tests on geo membrane samples under the same weather conditions as those expected on site during panel assembling. Once removed, samples will be tested on site with a calibrated portable tension meter and must meet with the requirements of welds resistance to peel and shear as described in the Technical specification.

The Installer shall provide the Engineer-in-Charge with recent certificates of standardization for all control instruments (tension meter speed, tensile level etc.) The Engineer-in-Charge reserves the right to demand any additional calibration test at any time. All documentation on the calibration tests performed by the Installer shall be submitted to the Engineer-in-Charge. The installer shall identify each calibration test with the following information:

- Date and time
- Identification of destructive test
- Identification of weld
- Welded panel’s identification number
- Quantified results of peel and -shear test
- Identification of type of rupture
- Quality control technician’s identification
- Localization on "As-built" plan

The Quality Assurance technician shall perform small perforations in the lining in order to assess the efficiency of the Installer's non-destructive testing program. The Quality Assurance technician shall perform those perforations with an approximate frequency of one (1) each 1000 meters of weld at least three (3) instances of the project. The quality Assurance technician shall document those punching or perforations by including at least the following information:

- Date and time of operation
- Identification of weld
- Exact location of perforation
- Quality Assurance. Technician’s identification
- Results of Installer’s non-destructive tests
- Date and time of repair.

If the Installer's non-destructive testing program fails to find the punching- or perforations made, the Installer will repeat non-destructive testing on the faulty weld, as well as on the welds before and after it.

The Quality Assurance technicians shall perform verification destructive tests at an approximate frequency of one (1) for each 1000 meter of weld. A special testing frequency will be used at the Engineer-in-Charge discretion when visual observations indicate a potential occurrence of problems. Verification tests may be performed in the following cases:
• Variation on the thickness of the weld
• Doubtful cleanliness of overlapping.
• Dirty equipment or in poor coalition
• Different personnel than the one authorized
• Adverse weather conditions
• Welding equipment failure
• Visible variation in material’s quality
• Close confined or complex working space
• Beginning and end of panels
• On the Engineer-in-Charge request

15.15.0 Warranty

Written warranties addressing HDPE material and installation workmanship shall be submitted to and a approved by Engineer-in-Charge. The manufacturer's warranty shall state that the installed material meets all requirements of the contract drawings and specifications and that under typical local atmospheric conditions and weather aging, the sheet material is warranted for at least 20 years. The installer's warranty shall state that the HDPE field and factory seams. Will not fail within at least 20 years of the installation under similar conditions.

16.0.0 CLAY LINER

16.1.0 Scope

This section covers the specifications for the supply, laying and testing of clay liner as per the drawings and specifications mentioned herein to the satisfaction of the Engineer-in-Charge. Composite Clay liner serves as a hydraulic barrier to flow of leachate the properties required for contacted clay liner as per specs is as follows:

• Minimum thickness of each composite clay liner/ layer (primary & Secondary) shall -be 0.60 m (Total0.9 m).
• Maximum hydraulic conductivity of $1 \times 10^{-7}$ cm / sec $(k \ 1 \times 10^{-9} m/s)$. The minimum requirements recommended achieving above specified hydraulic conductivity:

16.2.0 General Requirements

The soil used in the liner shall meet the following minimum criteria:
1. Be classified under the Unified Soil densification System CL, CH, SC and OH (IS 2720 Part IV/ ASTM Standard D248769)
2. Allow greater than 20 - 30 percent (dry weight) passage through no 200 sieve (75 um) (grain size analysis as per IS: 2720 Part IV/ ASTM Test D1140)
3. Plasticity index greater than or equal to 7 to 10\% (IS 2720 Part V)/ Plasticity greater than or equal to 15 units (ASTM Test D424)
4. Gravel content shall not be exceeding more than 30\%
5. Maximum particle size shall be between 20 to 50 mm
6. Have a pH of 7.0 or higher
7. Have a liquid limit equal to or greater than 30 units (IS 2720 Part VI ASTM Test D423)
8. Moisture Density relationship as per IS: 2720 Part VIII
9. Permeability test as per IS: 2720 Part XXXVI.

16.3.0 Quality control aspects

General quality control aspects which shall be adhered to are as follows:

1. The material (soil) used for filling shall be free from boulders, lumps, tree roofs rubbish or any organic deleterious matter.
2. Pre-processing may be carried out for water content adjustment removal of oversized materials pulverization of any clumps, homogenization the soils, and introduction of additives such as betonies.
3. Ensure that a sub-grade on which a compacted clay liner will be constructed is properly prepared by compacting and obtaining required firmness.
4. Proper compaction of liner materials is to be carried out to ensure compacted clay liner meets hydraulic conductivity specified above.
5. Determine the appropriate thickness (as measured before compaction) of each of the several lifts that will make up the clay liner. Also proper bonding between lifts is to be ensuring to avoid formation of preferential pathways.
6. Preventive measures to protect compacted layers from desiccation are to be provided during construction.

16.4.0 Laying of day liner

This specification and the method of measurements described herein are applicable for construction of compact clay liner at the base and on the sides of the landfill.

1. The implant tenting agency has to identity the borrow soil (if required). Are having the requisite properties as mentioned above and make his own approach and access roads (as required) from the borrow area to the demarcated landfill area. No, claim shall also be admissible to the Implementing agency on account of his having to take longer leads or routes for earth movement, than envisaged by him, either due to any road cuttings, non-availability of routes, or any other grounds whatsoever.
2. In case total filling required in any area consists of earth both from borrow areas and available approved excavated material from within site area or use of any amended soil to achieve the stipulated permeability. The necessary laboratory tests/demonstrations/calculation are to be furnished to Engineer-in-Charge for approval.
3. In the event of filling of soil material as mentioned above, joint levels shall be taken before commencing the filling with earth froth borrows areas

4. Prior to the placement of the clay in the desired location, the sub grade under the clay liner shall be checked. This shall be usually performed by proof- rolling the sub grade. Any weak zones shall be removed and appropriately backfilled and all debris should be removed. The clay may then be placed above the sub grade in loose lift.

5. Compacted clay liners shall be constructed in a series of thin lifts for proper compaction and homogeneous bonding between lifts. The lift thickness of clay liner shall be 20 to 22.5 cm before compaction and 15 cm after compaction. The soil placed in a loose lift shall be no thicker than about 230 mm. After the soil is placed, a small amount of water may be added to offset evaporative losses, and the soil may be tilled one last time prior to compaction. Each lift of clay liner shall be bonded to the underlying and overlying lifts. The surface of a previously compacted lift must be rough so that the new and old lifts blend into one another.

6. Sheep foot rollers shall be used for compacting the clay liner. The roller with fully penetrating feet (of 22.5 cm shaft length) shall be used for compact the liner. The minimum weight of the roller shall be 10000 kg (10 Tones) the minimum foot length shall be between 180 to 200 mm and Minimum number of passes shall be 5. A pass shall be reckoned as one pass of the compactor not just an axle, over a given area, and the recommended minimum of five passes is for a vehicle with front and rear drums. The compaction shall be continued till the specified hydraulic conductivity is obtained and verified by Engineer-in-Charge.

7. Each layer shall be tested in field for Moisture Content and Hydraulic Conductivity (Undisturbed Sample) before laying the next layer. A minimum of 1rest for 500 sq. m for each layer shall be conducted.

8. Successive layers of clay shall not be placed until the layer below has been thoroughly compacted to satisfy the requirement laid down in specifications.

9. Prior to compaction the moisture content of material shall be brought to within plus or minus 2% of the Optimum Moisture Content as described in is 2720 Part VII. The moisture content shall preferably be on the west side for potentially expansive soil.

10. After compaction of a lift, the soil must be protected from desiccation, which causes the cracking of the Clay liner. Desiccation shall be minimized by smooth rolling the surface to form a relative impermeable layer at the surface or the soil can be periodically moistened. The protective ensures stipulated above shall apply to each lift as well as the Completed liner or cover barrier.

11. The lifts shall be placed in horizontal layers. For liners to be construed slopes, the lifts shall be placed parallel to the slope.

**17.0.0 LEACHATE COLLECTION SYSTEM**

**17.1.0 Scope**

The primary function of the leachate collection and removal system (LCRS) is to collect and convey leachate out of the landfill unit to control the depth of leachate above the liner. The leachate collection system is placed over the unit’s liner system. The bottom line should have
a minimum slope of 2 percent to allow the leachate collection system to gravity flow to a collection sump or alternate arrangements for pumping shall be made.

The implementing agency shall design a leachate collection and removal system using adequate water balance equations or appropriate modes to estimate leachate generation for the landfill and to maintain less than 30 cm depth of leachate, or ‘head’, above the liner.

Leachate Collection and detection system should include a high permeability drainage layer perforated leachate collection pipes, a protective filter ladler, and a leachate removal system. Design considerations for each of these elements are given below.

High permeability drainage layer:
(a) Damage materials are to be placed on the liner system at the same minimum 2 percent grade.
(b) The drainage materials (sand and gravel) shall be provided per specifications given in the CPHEEO manual.
(c) It should be demonstrated that the layer will have sufficient bearing capacity to stand the weight load of full unit.
(d) Geo-synthetic drainage materials may be used in addition to or in place of, soil materials.
(e) The flow rate of geo-net can be evaluated by ASTM D-4716.

2. Perforated Leachate Collector Pipe’s.
3. Perforated piping system should be ideated in the drainage layer to rapidly transmit the leachate to the sump and removal system. (a) The design of perforated leachate collection pipes hold consider necessary flow rates, pipe sizing and pipe structural strength.

4. Protective filter Layer:
(a) To protect the drainage layer and the perforated leachate piping from clogging, a filter layer is to be placed over the high permeability drainage layer.
(b) The filter layer should consist of a material with smaller pore space than the drainage material or the perforation openings in the collection pipes.
(c) Leachate Removal system
(d) A leachate collection sump shall be designed and constructed of materials compatible with and impermeable to leachate formed in Landrieu. The final leachate collection sump shall be common for the total secure landfill area and shall be located and sized accordingly.
(e) The sump should be accessible for removal of leachate if the pump becomes inoperative and the stand pipe becomes damaged.
(f) Pumps are to be provided to remove leachate that has collected.
(g) The pump should be placed at adequate depth to allow enough leachate collection to prevent the pump from running dry.
(h) A level control, standby pump and warming system are to be provided 6 Ensure proper sump operation.
(i) Standpipes should also be provided to remove leachate from the sump.
(j) The leachate shall be pumped for treatment in the leachate treatment plant

The primary leachate collection system shall be placed over the primly liner in this project is a composite liner (geo-membrane with compacted clay beneath). The secondary leachate collection system also called leak detection system shall be placed over the secondary liner i.e. between two composite liners. The leachate if any shall be collected at low point (provision shall be made sufficiently) and periodically sampled so as to assess the adequacy of primary liner against leakage of leachate.

Material for Filter shall meet the following requirements

The drainage and filter material shall be placed dry and may be lightly compacted with a vibratory roller care must be taken, to ensure that vehicles are up to driven over the naked HDPE liner.

Laying of Perforated Leachate Collection Pipes

The upper half of the pipe above the spring line shall be perforated, whereas the lower half of the pipe shall remain un-perforated. The bidder shall provide details of supplier of the HDPE pipes along with the three pipe parameters i.e. Compressive yield strength, wall crushing, wall buckling.

The perforated pipes shall be laid out in ‘v’ trenches and the trenches shall be backfilled. All care shall be taken to avoid digging the trench below the levels indicated in the drawing. All the perforated-pipes shall be connected to a solid HDPE header pipe, through a Standard T-joint”.

18.0.0 HDPE PIPES

18.1.0 Scope

This section covers the specifications for the supply, lying jointing and testing of HDPE pipes as per the drawings and specifications mentioned herein to the satisfaction of the Engineer-in-charge.

18.2.0 Specifications

The pipe shall conform to the material grade PE-80 of latest edition of IS: 4984.

The pressure rating shall be PN-6.

The pipe and fittings shall be chemically resistant and shall be suitable for all pH ranges i.e. 0 to 14.

These shall have smooth internal bore enhancing the hydraulic flow properties with low frictional losses.
The pipes and fittings shall be strong and resilient enough to withstand static and hydrodynamic both with regard to internal as well as external pressures.

The pipe shall have excellent elastic properties and can take sufficient curvature. The pipes and fittings shall have the property that it can be joined conveniently with no leakage.

The pipe and fittings shall be UV rays resistant and shall also be resistant to wear and abrasion. The pipes flange should be provided wherever required with joints having HDPE long stub ends. The flange shall conform to DIN-PN-10 and drilling shall be to match with the counter flange of valves/ pipes/ pumps etc.

### 18.30 Piping system

All piping systems shall be capable of with stand fug the maximum prestige it the corresponding lines at the relevant temperatures. The mining thickness for pipes and fittings shall be adhered to higher thickness in equivalent material is acceptable. However, no credit will be given for higher thickness.

All the piping systems, fittings and accessories supplied under this package shall be designed to operate with normal maintenance for a plant service life of 20 years and shall withstand the operating parameter fluctuations which can be normally expected during this period.

All piping system shall be properly laid to take care of hydraulic shocks and pressure surges, which may arise in the system during operation. Necessary protective arrangements like anchor blocks / anchor bolts etc. shall be provided for the safeguard of the piping system under above-mentioned conditions. External and internal attachments to piping shall be designed so as not cause flattering of pipes excessive bending stresses or harmful thermal gradients of pipe walls.

Pipes and fittings shall be manufactured by an approved firm of repute. A list of approved manufacturers is given in the tender document. They shoulder truly cylindrical of clear internal diameter as specified in the IS code, of uniform thickness, smooth, and strong, free from dents, cracks and holes and other defects. They shall allow ready cutting, chipping or drilling, welding etc.

### 19.0.0 SAND LAYER

#### 19.1.0 Scope

This section of the specification covers supplying and laying sand layer in the Leachate collection and removal system and leak detection system as shown in the drawings and as mentioned herein.
19.2.0 General Requirements.

The implementing agency shall furnish all labor and material required for the complete performance of the work in accordance with the drawings, schedule of item and as described herein.

19.3.0 Sand Layer

Graded sand filter of 100 mm thickness shall be laid as indicated in the drawing in the landfill area in the leachate collection and removal system and leak detection system.

19.4.0 Material

The material for sand layer shall consist of clean, sound and well graded coarse sand. The material shall be free from debris. Above the gravel bed, clean sand (425 micron to 4.75 mm) shall be placed. The thickness of the sand layer shall be 100 mm. The effective size (d10) of the sand recommended is 0.4 mm with uniformity coefficient of 1.5. The sand shall be laid on the top of the gravel layer manually and spread to the specified thickness. The minimum thickness of 100 mm shall be ensured after spreading water.

The sand layers shall be well watered and rammed. Care shall be taken that materials of different layers do not get mixed, both at the time of placing and during compaction. The sand material shall be clean, sound, durable and well graded. No debris, wood, deleterious material etc., shall be permitted.

20.0.0 GRAVEL LAYER

20.1.0 Scope

This section of the specifications covers supply and placement of the gravel in the leachate collection and removal system and leak detection system as indicated in the drawings released for the construction or as directed by the Engineer-in-Charge.

20.2.0 General requirements

The implementing agency shall furnish all labor, equipment and material required for the complete performance of the work in accordance with the drawings and as described herein.

20.3.0 Materials

1. Gravel layer in the leak detection system the gravel shall be rounded, cleaned and free from disintegrated and foreign material. The size of the gravel shall decrease upwards. The size of the gravel recommended is 4.75 - 65 mm. The gravel shall be stockpiled at site separately and shall be mixed as per the specifications and then laid on the ground. Average density of the
The gravel's shall be well graded as directed by the Engineer-in-Charge.

2. Gravel layer in the leachate Collection and Removal System The gravel shall be rounded, cleaned and free from disintegrated and foreign arterial. The size of the gravel shall be 4.75 mm to 80 mm. The gravel shall be stockpiled at site separately and shall be mixed as per the specifications and then laid to the ground. Average density of the gravel recommended is 1600 kg/m³. The gravel's shall be well graded as directed by the Engineer-in-Charge. Graded gravel's shall be constructed as indicated in the drawings. The gravel's shall be placed in layers of uniform thickness as shown in the drawings and care shall be taken to avoid segregation of coarse and fine materials and formation of pockets.

21.0.0 VERTICAL CENTRIFUGAL PUMP

21.1.0 Scope
This specification covers the works of the design, manufacture, construction features, testing, delivery to site, erection, commissioning, performance of vertical centrifugal pumps. (Non-clog type)

21.2.0 Code and Standards
The design, manufacture and performance of the pump shall comply with all currently applicable statutes, regulation and safety codes in the locality where the equipment will be installed. The equipment shall also confirm to the latest applicable Indian or equivalent international standard.

21.3.0 Design Requirements
1. The pumps shall be capable of handling Liquid of pH 0 to 10. These pumps shall be designed for parameters specified in tender drawing and shall be suitable for continuous (normal) operation and intermittent operation.

2. The total head capacity curve shall be continuously rising towards the shut off with the highest at shut off. The pump speed shall not exceed 1500 rpm.

3. Pumps of particular category shall be identical pumps and shall be suitable for parallel operation with equal load division. Impellers shall preferably be of non-over loading type.

4. Pumps shall run smooth without undue noise and vibrations. The magnitude of peak-to-peak vibration at shop will be limited to 75 decibel at the bearing housing. After installation at site the magnitude of vibration shall be limited to 50 db.

5. The KW rating of the pump motor shall be;
Sufficient to drive the pump through the entire range of head capacity curve, and KW/HP rating of the drive shall be calculated for additional 20% reserve power to take care of overloading on entire operating range.

6. The pump shall be capable of developing the specified total head at the specified rated capacity while operating in parallel and be capable of operating continuously at run-out capacity condition.

7. Pump shall be supplied with level control as per manufactures standard

21.4.0 Features of Construction

Pumps shall be of vertical centrifugal non-clog type with required number of stages suitable for the service conditions. Materials of construction offered by the Bidder for pumps, drives and accessories shall be as per Galigher standards. All wetted parts shall be inside and outside rubber lined and shall be suitable to handle liquid of pH 0 to 10.

Written guarantee addressing pump material shall be submitted to and approved by Engineer-in-Charge. The manufacturer’s guarantee shall state that the installed material meets all requirements of the contract and specifications and that under typical local atmospheric/operating conditions and weather aging, the pump material is suitable.

21.4.1 Accessories

1. All accessories required for proper and safe operation shall be furnished with the pumps.
2. Each stage of pump unless self-venting, shall be provided with a suitable vent connection, complete with valves.
3. Tapping suitably plugged for pressure gauges shall be provided on delivery flanges.

21.4.2 Drives

Privet motor shall be connected to the line shaft of the pump with the help of a V-belt and shall have maximum rpm of 1500. The pulley shall match the rpm of pump.

21.5.0 Testing at Manufacturers Works

Materials and performance of the pumps and its components shall be tested in accordance with the relevant standards. Test certificates for these shall be furnished for the Owner’s approval.

21.5.1 Noise and Vibration Measurement

Noise and vibration shall be measured during the performance testing at shop as well as during the site test. The Noise and vibration levels measured at shop test shall be furnished to
21.5.2 Visual Inspection

Pumps shall be offered for visual inspection to the Owner before dispatch. The components of the pumps shall not be painted before inspection.

21.5.3 No weld repair on cast iron shall be allowed

21.5.4 Field Testing

After installation, the pumps offered shall be subjected to mechanical run testing and trial operation at field. If the performance at field is found not to meet the requirements, then the equipment shall be rectified or replaced by the implementing agency, at no extra cost to the Owner. The procedure of the above testing will be mutually agreed between Owner and Implementing agency.

Based on observations of the trial operation, if modifications and repair are necessary the same shall be carried out by the Implementing agency to the full satisfaction of the Engineer-in-Charge.

21.6.0 Drawings to be submitted

The following drawings along with datasheet shall be submitted by the Bidders for Owners-approval:
1. Outline dimensional drawings showing the details of pump and motor assembly
2. Performance curves, showing capacity V/s total head, efficiency, NPSH and power consumption ranging from maximum flow to shut-off head.
3. GA drawing of pump house showing mounting arrangements, sump details, center to center distance of pumps etc.
4. Necessary Catalogues

21.7.0 VALVES

22.1.0 Scope

This specification covers the design, performance, manufacture, and construction features, testing, packing and forwarding to site erection, commissioning of the Butterfly Valve.
22.2.0 Code and Standards

The design, manufacture and performance of valves and specials shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable Indian /British / USA standards / or equivalent International standards.

22.3.0 Specification for Butterfly Valve

Butterfly valves shall be of double flanged confirming to AWWA-C-504 class or BS: 5155 Class 150. The Butterfly Valves shall be manually operated as well as motor operated as per the requirement of the system, The motor shall be suitable for 415 V, 3 phase, 50 Hz and outdoor service. The motorized operated valves shall also have the manual override.

The various components of butterfly valves shall be of the following material of construction. The specification mentioned below is the minimum requirement; however bidder shall confirm that these are suitable for handling the liquid having pH range of 0 to 10. If any lining etc. is required on the wetted part of the valves, the bidder has to provide.

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<td>2.</td>
<td>Disc</td>
<td>Cast Iron- ASTM A 4840; BS: 1452, Gr. 200, SG on- BS:2789, Neoprene rubber lined Cast Steel - ASTM A 216 Gr. WCB. BS: 1504 Eq. Gr,</td>
</tr>
<tr>
<td>3.</td>
<td>Shaft.</td>
<td>ASTM.A296 Gr.CF 8M/ AISI316:AISI420;BS:970 Gr. 316516; BS: 970Gr.420 S45.</td>
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<td>4.</td>
<td>Seat rings</td>
<td>Nitrile rubber, ED.M. (Ethylene propylene rubber), Hypalon</td>
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<tr>
<td>5.</td>
<td>Motor</td>
<td>Suitable for 415 V, 3 phase, 50Hz and outdoor service</td>
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Thermally valves shall be fitted with sleeve type bearing such as PTFE. Valves of 350 NB and above shall be provided with one or two thrust bearing to hold the disc securely in the center of valve seat without hydraulic or external axial shaft loads. Sleeve and other bearings fitted into the valves body shall be self-lubricated materials that do not have any effect on the fluid handled and other components of the valves.

All the manually operated. Butterfly valves shall be provided with Hand wheel or Hand lever as per the requirements. For larger sizes i.e. 150 NB and above; Hand wheel shall be provided. For lever/wrench operated valves, means shall be provided for positively holding the disc is not less than three intermediate positions. Manually operated valves shall be provided with reduction gear unit for valves of size 200 NB and above. All the valves shall be equipped with adjustable mechanical stop-limiting devices to prevent over travel of the valve disc in the
open and closed positions. The valve operators shall be designed as per relevant International Standard.

All the butterfly valves shall be provided with an indicator to show the position of the disc. Flanges shall conform to ANSI B 16.5 C150.

22.4.0 Tests

All the valves shall be tested hydro-statically for strength, tightness of seats and tightness of back seating at the pressures specified in relevant code. The procedure for testing the tightness of seats of valves shall be as follows. The valves shall be subjected to water pressure of a minimum 2.812 kg/cm. The pressure shall there be increased to the specified seat test pressure. Valves shall then be cracked open at this pressure to determine the tightness of the seat ring in the body. Butterfly valves shall be tested on both sides of disc. The testing in general shall confirm to the relevant IS standard Vendor shall furnish five sets of the following certificates for all types of valves. Certified physical and chemical analysis certificates, metallurgical test reports of all components of the valves and specialties. Certified Hydrostatic test reports for all body castings.

22.5.0 Painting and Corrosion Protection

A shop coat of paint shall be applied to all steel and cast iron exposed surfaces as required to prevent corrosion, after release has been given for painting and before dispatch. All parts shall be adequately protected for rust prevention, grease shall not be used on mechanical surfaces.

22.6.0 Drawings and Manuals

Bidder shall furnish the following drawings along with datasheet for Owners approval:
- Dimensional outline drawings.
- Cross section drawing.
- Instruction manual.

22.7.0 Name Plate

All valves shall have permanent name plates indicating the service, type, size of the valves.

23.0.0 LEACHATE TREATMENT PLANT

23.1.0 Scope

This specification covers the design, performance, manufacture, construction, site erection, commissioning and testing of the Leachate treatment plant.
3.2.0 General requirements

The capacity of leachate treatment plant shall be as per design documents. However, the implementing agency shall review the site, collect rainfall and other relevant data, and shall work out the capacity and design of the plant. All the drawings in this regard would be submitted to the Engineer-in-Charge for approval.

For designing the system, the implementing agency shall account for:
1. The anticipated flow rate which will require treatment;
2. The composition of the leachate at source;
3. The discharge composition required by the regulating authority.

From this information, the technology needed to meet the discharge consent shall be selected. There are estimated to be approximately twenty principal technologies that can be employed for leachate treatment.

Each of which shall be combined in various modes with other standard chemical, engineering unit processes.

23.3.0 Specifications

The equipment, pipes, pumps, valves, filter, material civil works shall be provided in accordance with the specifications given in the relevant chapters of this tender document.

23.4.0 Painting and Corrosion Protection

A shop coat of paint shall be applied to all steel and cast iron exposed surfaces as required to prevent corrosion. After release has been given for painting and before dispatch, all parts shall be adequately protected for rust prevention. Grease shall not be used on mechanical surfaces.

23.5.0 Drawings and Manuals

Bidder shall furnish the following drawings and documents for Owners approval:

- Dimensional outline drawings.
- P&ID
- Instruction manual.
- Operational Manual

23.6.0 Guarantee

Written guarantee addressing material shall be submitted to and approved by Engineer-in-Charge. The manufacturer's guarantee shall state that the installed material meets all requirements of the contract and specifications and that under typical local atmospheric/operating conditions and weather aging, the material is suitable.

The bidder shall also submit a guarantee for treated water quality parameters. The treated water quality parameters shall be in accordance with the relevant code.