in employment.

9.6 PREDICTION OF IMPACTS: OPERATION PHASE

9.6.1 General

The operation phase of the project will include conveyance of tapped sewage from nalas and pumping stations to sewage treatment plants. It also includes the operation of sewage treatment plants. The predicted impacts of these activities are discussed below.

Overall, the predicted adverse impacts during the operational phase will be minor as compared to the construction phase. During the operation phase all the beneficial impacts of the project will be realised.

9.6.2 Beneficial Impacts of the Project during the Operation Phase

The rehabilitation and extension of sewerage and the treatment of all the city sewage will improve the quality of life and the life style of the people. Better sanitation facilities mean better health conditions, and a cleaner environment. The risk of contagious diseases can be minimised and to an extent even mitigated. Implementation of sewer system in the city would reduce the chances of contamination of the groundwater and in the water supply pipelines therefore minimising the incidence of diseases resulting in improved health and economic well being of the community.

Also, the discharge of sewage wastewater in the nala, and the discharge of sullage into road drain and then into nala, which emanate foul smells and are unsightly, will be eliminated.

In sum, the overall impact of the project on the socio-economic environment is expected to be beneficial and positive. The residents of Lucknow will benefit due to the improvements in public health.

9.6.3 Sewerage and Pumping Station Impacts (Operation Phase)

The impacts of sewerage and pumping station during operation phase are summarised in Table 9.36.

9.6.4 Sewage Treatment Plant Impacts (Operation Phase)

(1) Receiving Water Quality and Treated Effluent Re-use

The wastewater after treatment will be generated to the tune of 305mld (year 2030) and 100mld (year 2015). It is proposed that the treated wastewater will be used for irrigation on the agricultural fields near the Mastemau site. Currently there is plenty of land available at Mastemau, Bakkas, Chilaula and Ardaunamau where there is a potential to use the treated wastewater. Although there is no norm or a ratio to estimate the quantity of wastewater per hectare of land, considering the previous trend and after studying few reports, it can be safely presumed that 1 mld of treated wastewater is sufficient to irrigate a land of 20 ha.

The potential of land irrigation was calculated by referring to “Practical Handbook on Public Health Engineering by G.S. Bajwa, pp 900, published by Deep Publishers, Shimla”.

Accordingly the calculations are as follows:

Irrigation intervals during summer	5 days
Irrigation intervals during winter	10 days
Hydraulic loading rate for sandy soil =	200-250 Cu.M/ ha /day

Loading Rate/ha/day in summer	=	250 /5 = 50 Cu.M /ha/day
Loading Rate/ha/day in winter	=	250 /10 =25 Cu.M /ha/day
Area required for 305mld	=	305000/50 = 6,010 Hectares required during summers
For 1 MLD area required is	=	6010/ 305 = 19.7 (say 20ha) required during summers

It is proposed that from the total amount of wastewater generated, partial quantity will be used for irrigation, while the remaining wastewater will be discharged into the river.

Currently the crops grown are rice, wheat, pulses and vegetables. The present practice of the farmers is to use ground water for irrigating their lands. From discussions with various officials, it was understood that the continuous use of groundwater is resulting in depletion of the groundwater resources. With the use of treated effluent for the crops, there will be sufficient reduction in the use of groundwater. Further, there will also be reduction in power consumption, which is now being used to pump the ground water.

Considering this, it can be concluded that the application of treated water for agricultural use will prove beneficial both for safe disposal of effluent and secondly beneficial to the farmers.

However, there should be certain norms and standards that should be followed while practicing this method and they are being discussed in the chapter on mitigation measures.

During the rainy season, the amount of wastewater to be used for irrigation will reduce drastically since much of the land will receive good rainfall in the months of July and August. Since the treated sewage will be further diluted, it will not pose any risk towards the pollution of the river.

(2) Use of Sludge for Land Application

The sludge produced at the proposed STP will have the characteristics as given in Table 9.36.

Table 9.36 Quality of Sludge at the Proposed STP

	N % (W/W)	P % (W/W)	K % (W/W)
Sludge	1.7	0.9	0.2

Application of sludge to land will improve the soil conditions of the area and supplement conventional fertilisers usually at a little or no cost. The organic matter increases the soil's ability to hold water, and opens up the soil to allow better air and water movements into the soil. Application of sludge will permit easier root penetration and reduce water runoff and soil erosion.

Sludge produced at the proposed STP site can be sold directly to the farmers near the site.

On average the sludge production will be approximately 56.3 m^3/day from the STP. It will be dried on the sludge drying beds. During the drying process, there will be a nuisance of insects around the sludge drying beds. It can be minimised by spraying insecticides in the area, also by proper maintenance of sludge drying beds, and proper drainage. The wet sludge should be raked often and the dried sludge removed frequently.

The dried sludge can be given or sold to farmers as manure if it can be handled properly by them. The value of sludge as an organic fertiliser has long been recognised and this offers reduced fertiliser costs to the farmer. Monitoring of the quality of the sludge is however required, especially the monitoring of heavy metals. The sludge should also not contain non-degradable materials. Movement of sludge tankers from sewage treatment to agricultural land can create traffic problems and give rise to noise and odour nuisance.

(3) Odour Production

There is a possibility of generation of localised odours in the case of UASB reactors and sludge drying beds proposed at the STP of Mastemau. Since there is no habitation near the STP site, generation of odour will not lead to any inconvenience. Further, the technology adopted will ensure that minimum or no odour is generated. Plantation and other mitigative measures will help in controlling the smell.

(4) Noise level

Higher noise levels will be generated near the DG sets and gas engines. Although this will be significant, the impact of the noise will be reduced by enclosing the noise generating equipments in a double walled structure.

(5) Worker's and Public Health

Even though the STP will be useful to improve the health of the citizens, it may not be so in regard to the health of the workers who are operating the plant. In the operation phase of the STP, care needs to be taken for the workers' health. The workers may suffer from epidemic diseases, malaria and respiratory diseases if proper precautions are not taken. The impact on their health would be adverse and significant. The workers should be provided with safety equipment for safe handling of the sewage treatment plant - sewage and sludge - and must be instructed in its use. This will eliminate any possibility of adverse health effects on the workers during plant operations. Adequate medical help should also be provided.

Similarly, the farmers will also have to be protected against infection, and special equipment, especially to handle the sludge, should be made available and they should be educated on how to wear it.

9.7 ENVIRONMENTAL MITIGATION PLAN

9.7.1 Introduction

The objective of preparing an Environmental Mitigation Plan (EMP) is to formulate measures, whose implementation will:

- Mitigate adverse effects on various environmental components and resources as have been identified in the EIA study;
- Protect environmental resources wherever possible;
- Enhance the value of the environmental component wherever possible.

The EMP also includes a plan for monitoring so as to enable evaluation of the success or failure of environmental management measures and reorientation of the plan if found necessary.

The mitigation measures to be adopted cover both the construction phase and the operation phase. These measures normally are short term during the construction phase and long term during the operation phase.

The community must be informed in advance about the benefits of the project and possible inconvenience to them. The implementing agency must seek co-operation of the local authorities, and execute the project effectively and efficiently. Success of the project depends upon participation and support of the community. Efforts need to be made to involve the population at different stages of project execution and in subsequent maintenance. The construction work should be carefully planned and managed in order to cause minimum disturbances to people.

A summary of the mitigation measures proposed during construction and operation phases are presented in Table 9.37. The description of each mitigation measure in detail is described below.

9.7.2 General Mitigation Measures

(1) Construction Phase

The construction phase impacts have been outlined in previous section. All these adverse impacts have been taken into consideration. Following measures should be adopted in general for all activities:

1. Minimum damage to existing flora and fauna, structures, electricity and telephone cables.
2. Minimum disturbance to the local activities and business should be ensured.
3. The sewer pipes should be stacked properly in a pre-determined location and should not be cluttered around blocking the pedestrian area alongside the roads.
4. Excavated earth should be prevented from getting washed into drainage channels, rivers and canals.
5. Surplus excavated earth should be disposed of immediately.
6. Measures should be taken to prevent direct discharge of polluted waters from construction activities into lake, rivers and irrigation canals.
7. Dust pollution should be controlled with the measures outlined in the Table 9.37.
8. Pavements and roads should be repaired immediately following the construction activity and the project and surrounding area should be restored as near as possible to pre-project conditions.
9. Adequate measures should be taken to minimise construction related noise.
10. Proper precautions should be taken against risk of accidents.

(2) Operation Phase

All the adverse impacts have been taken into consideration. The following measures should be adopted in general for all activities:

1. The treated water quality should be maintained as per the requirements at all times.
2. Air and noise quality should be monitored and corrective action taken in case it exceeds applicable norms.
3. Proper precautions should be taken for the good health of the operators and the population.
4. Greenbelt has been proposed for all the pumping stations of CGPS, TGPS and Martinpurwa. The greenbelt areas are shown in Figures 9.3, 9.4 and 9.5, respectively.

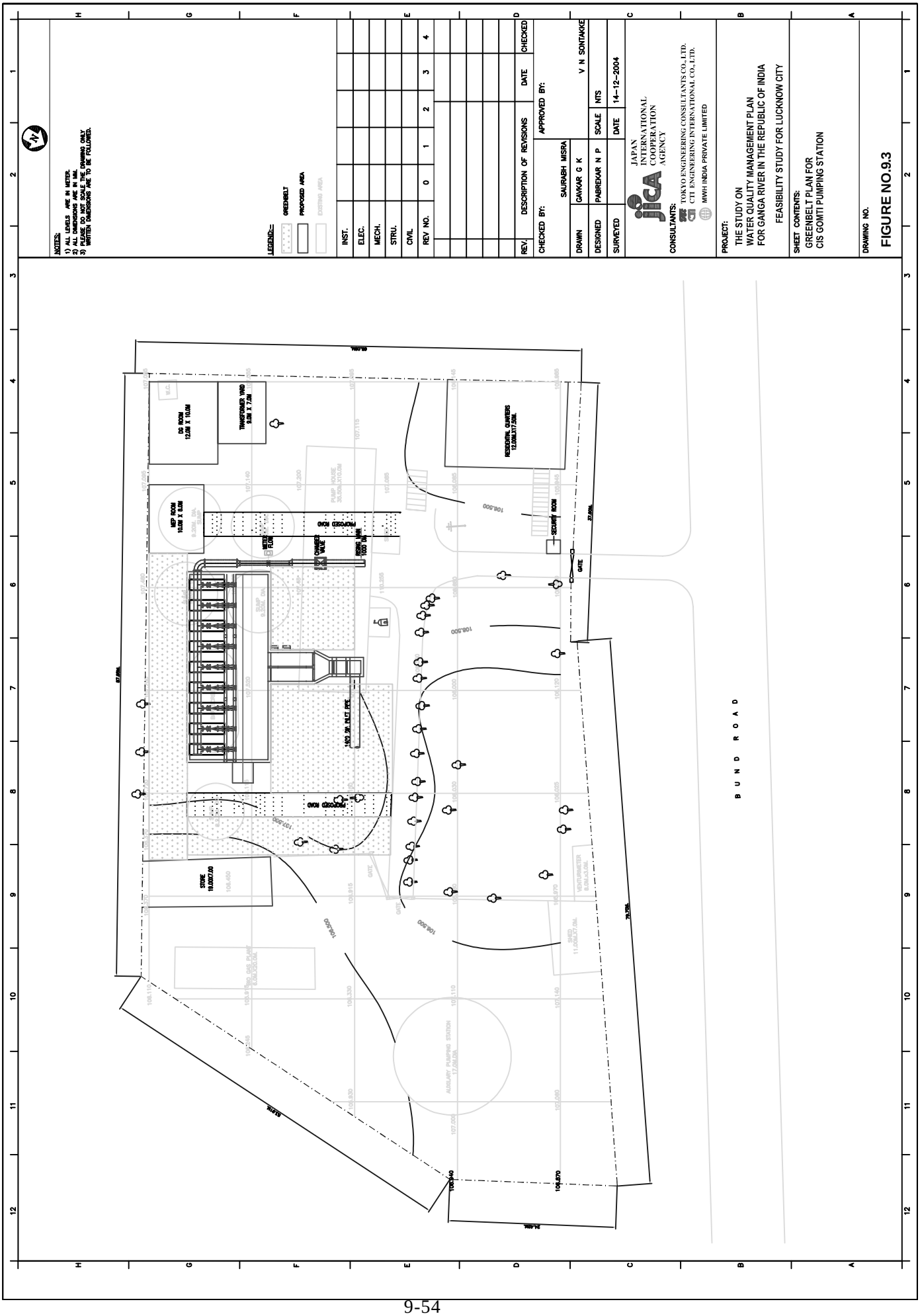
(3) Mitigation Measures for Sewerage

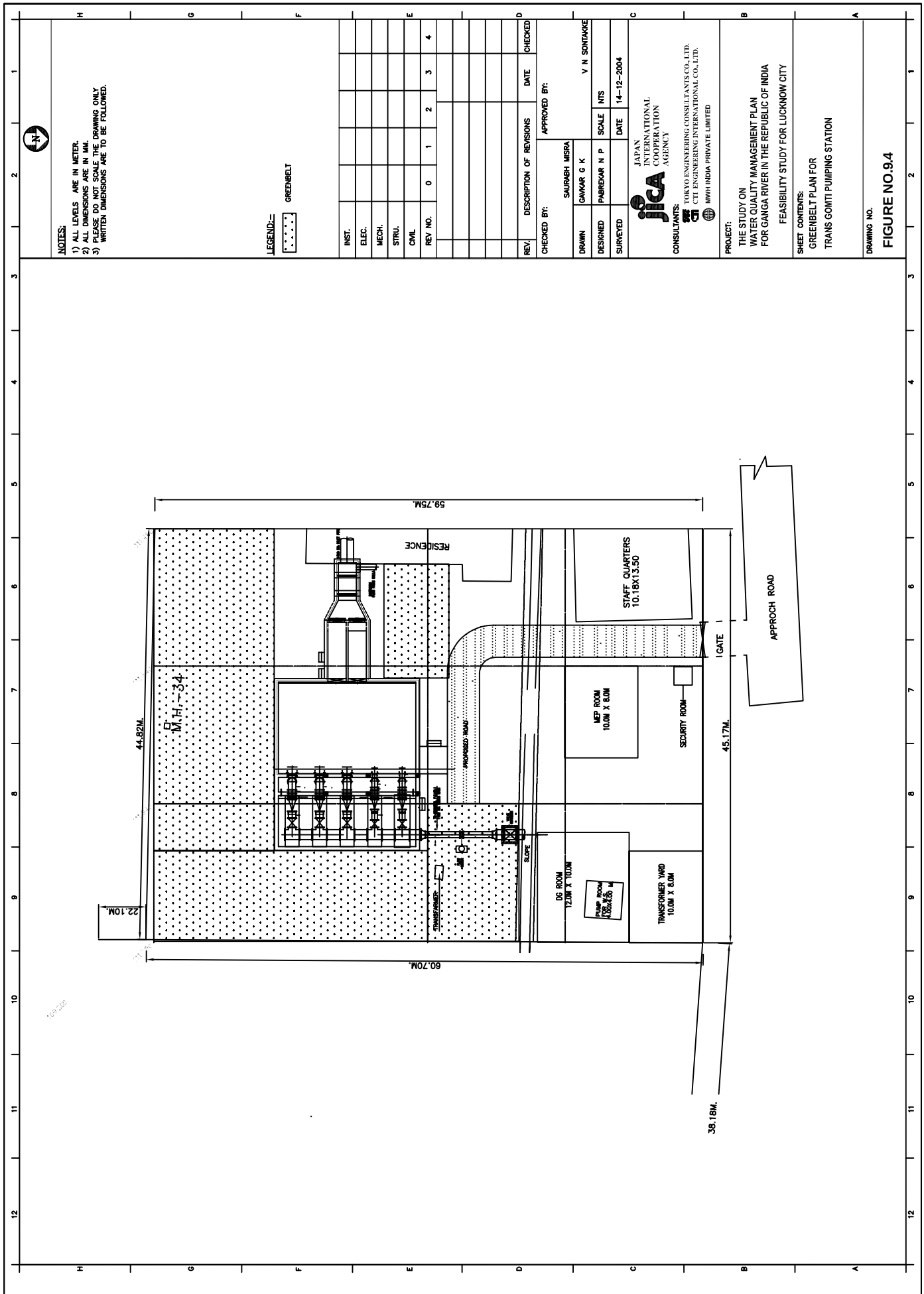
Selection of route for sewers is one of the most important activities in the pre-construction phase. In order to minimise adverse environmental impacts and land acquisitions, to avoid resettlement and rehabilitation problems and in general, from a social point of view, to minimise severance and other problems due to pipe laying activities, the sewers will be laid along the roads.

- Construction of the sewerage system will comprise: carrying the pipes to the site, excavation, laying the sewer pipeline, making good of the site after laying the pipeline, disposal of spoil/excavated material.
- All relevant codes of practice should be followed during detail engineering and construction phases to ensure pipelines safety and protection against corrosion.
- The risk of accidents should be minimized by taking all the proper precautions during the sewer laying activity.
- In some narrow roads and busy crossings, care must be taken for proper diversions of the traffic

with the help of the traffic police.

- Care should also be taken to avoid damaging existing infrastructure, telephone and power supply electric cabling, poles, etc. and minimizing the construction level impacts.


NOTES:
1) ALL LEVELS ARE IN METER.
2) ALL DIMENSIONS ARE IN MM.
3) FIGURE NOT TO SCALE. DRAWING ONLY. WRITTEN DIMENSIONS ARE TO BE FOLLOWED.
LEGEND:
GREENBELT
PROPOSED AREA
EXISTING AREA
REV. DESCRIPTION OF REVISIONS DATE CHECKED
CHECKED BY: SAURABH MISRA APPROVED BY: V N SONTAKKE
DRAWN GAVKAR G K
DESIGNED PABREKAR N P SCALE NTS
SURVEYED DATE 14-12-2004
JAPAN INTERNATIONAL COOPERATION AGENCY
CONSULTANTS: TOKYO ENGINEERING CONSULTANTS CO.,LTD. CTI ENGINEERING INTERNATIONAL CO.,LTD. MWH INDIA PRIVATE LIMITED
PROJECT: THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA
FEASIBILITY STUDY FOR LUCKNOW CITY
SHEET CONTENTS: GREENBELT PLAN FOR CIS GOMTI PUMPING STATION
DRAWING NO. FIGURE NO.9.3
DG ROOM 12.0M X 10.0M
TRANSFORMER YARD 9.0M X 7.0M
RESIDENTIAL QUARTERS 12.0MX137.0M
MEP ROOM 10.0M X 8.0M
SECURITY ROOM
GATE
STORE 18.0X07.00
BUND ROAD


NOTES:
1) ALL LEVELS ARE IN METER.
2) ALL DIMENSIONS ARE IN MM.
3) PLEASE DO NOT SCALE THE DRAWING ONLY WRITTEN DIMENSIONS ARE TO BE FOLLOWED.
LEGEND:-
GREENBELT
REV. DESCRIPTION OF REVISIONS DATE CHECKED
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CIVIL
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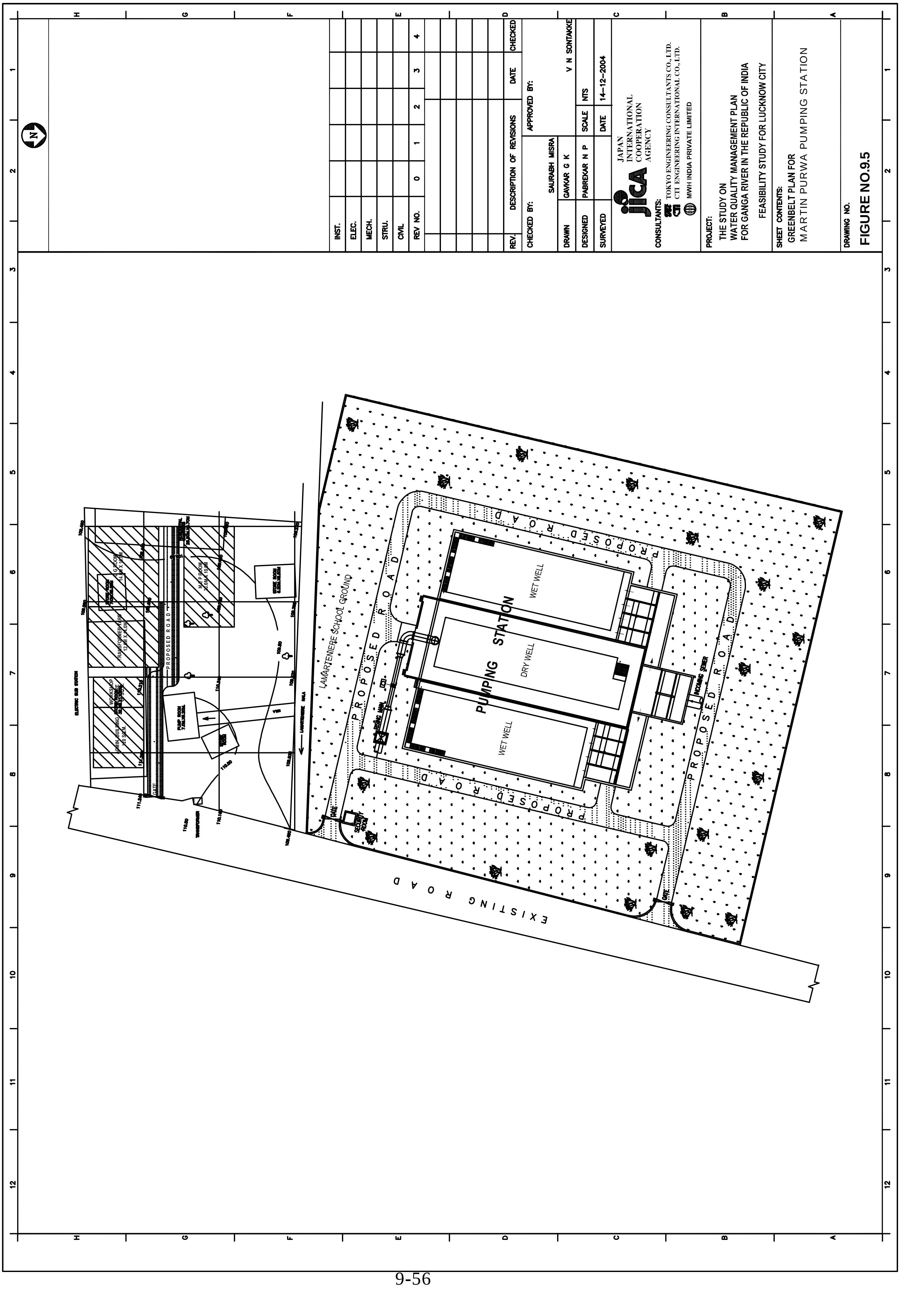
MECH.
ELEC.
INST.
CHECKED BY: SAURABH MISRA
APPROVED BY: V N SONTAKKE
DRAWN GAVKAR G K
DESIGNED PABREKAR N P
SURVEYED
SCALE NTS
DATE 14-12-2004
JICA JAPAN INTERNATIONAL COOPERATION AGENCY
CONSULTANTS:
TOKYO ENGINEERING CONSULTANTS CO.,LTD.
CTI ENGINEERING INTERNATIONAL CO.,LTD.
MWH INDIA PRIVATE LIMITED
PROJECT:
THE STUDY ON
WATER QUALITY MANAGEMENT PLAN
FOR GANGA RIVER IN THE REPUBLIC OF INDIA
FEASIBILITY STUDY FOR LUCKNOW CITY
SHEET CONTENTS:
GREENBELT PLAN FOR
TRANS GOMTI PUMPING STATION
DRAWING NO.
FIGURE NO.9.4
59.75M.
RESIDENCE
STAFF QUARTERS
10.18X13.50
APPROCH ROAD
GATE 1
M.H.-34
44.82M.
PROPOSED ROAD
MEP ROOM
10.0M X 8.0M
SECURITY ROOM
45.17M.
SLOPE
DG ROOM
12.0M X 10.0M
PUMP ROOM
TRANSFORMER YARD
10.0M X 8.0M
22.10M.
60.70M.
38.18M.


PUMPING STATION
WET WELL
DRY WELL
WET WELL
PROPOSED ROAD
EXISTING ROAD
LAMARTENIERE SCHOOL GROUND
INCOMING SEWER
GATE
REV. NO.
DESCRIPTION OF REVISIONS
DATE
CHECKED
CHECKED BY:
APPROVED BY:
SAURABH MISRA
V N SONTAKKE
DRAWN
GAYKAR G K
DESIGNED
PABREKAR N P
SCALE
NTS
SURVEYED
DATE
14-12-2004
JAPAN INTERNATIONAL COOPERATION AGENCY
CONSULTANTS:
TOKYO ENGINEERING CONSULTANTS CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.
MWH INDIA PRIVATE LIMITED
PROJECT:
THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA
FEASIBILITY STUDY FOR LUCKNOW CITY
SHEET CONTENTS:
GREENBELT PLAN FOR MARTIN PURWA PUMPING STATION
DRAWING NO.
FIGURE NO.9.5

(4) Mitigation Measures for Sewage Treatment Plant

Treated Water Quality

First and foremost, care should be taken to ensure adequate treatment to meet the discharge standards. Since it is recommended that the treated wastewater be reused for irrigation purposes, the treated wastewater should meet the required standards for irrigation re-use and be conveyed upstream of an area that can be irrigated.

Treated water quality should be monitored carefully so as to meet the discharge standards effectively. Figure 9.6 demonstrates the use of treated effluents for various purposes. However, in the case of Lucknow, the treated effluent will be used for agricultural irrigation and excess being disposed into the river.

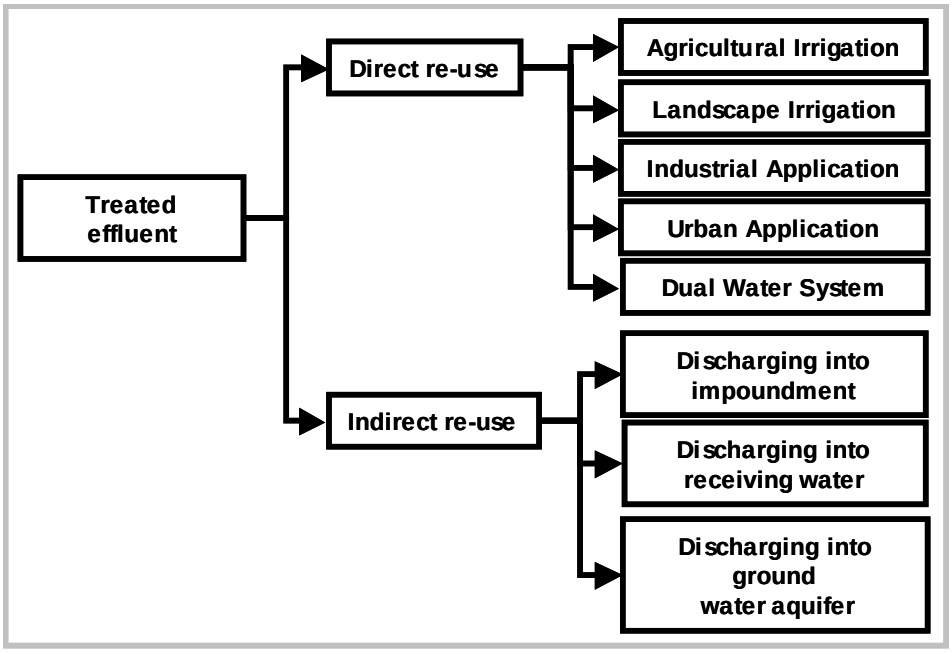


Figure 9.6 Direct and Indirect Use of Treated Effluent

Sludge Disposal

The sludge from the treatment plant should be disposed of in an environmentally acceptable manner. The sludge should be dewatered in sludge drying beds and the dried sludge is proposed to be used as fertiliser since it is biological in nature and has soil quality enhancing properties. However, the following precautions should be taken in the treatment, handling and disposal of the sludge:

- to rake the wet sludge frequently and remove dried sludge immediately,
- to facilitate proper drainage to avoid standing water leading to mosquito breeding,
- to store the dry sludge in a covered place before its distribution to farmers,
- to develop a green belt all around treatment plant,
- to take care that the operators handling the sludge are properly clothed with gloves and gum boots and will not handle the sludge with bare hands.

Workers' Health

The workers' health should be monitored with medical check-ups at the time of joining and thereafter

at regular intervals. In between, in case of any complaints, respiratory ailments, accidents, medical check-up should be conducted.

All the workers should be trained in first aid and emergency medical health should be available round the clock. It is also recommended from the safety point of view that one officer of the managerial cadre is available on duty at all times.

Land Acquisition

No relocation of people will take place during the project. Land will be acquired with appropriate compensation. Land is normally acquired under the provisions of the Land Acquisition Act, 1894 that is general and basic law in the country for the acquisition of land for public purposes and companies. This Act was comprehensively amended in the year 1984, taking into consideration the recommendations of the Law Commission, the Land Acquisition Review Committee.

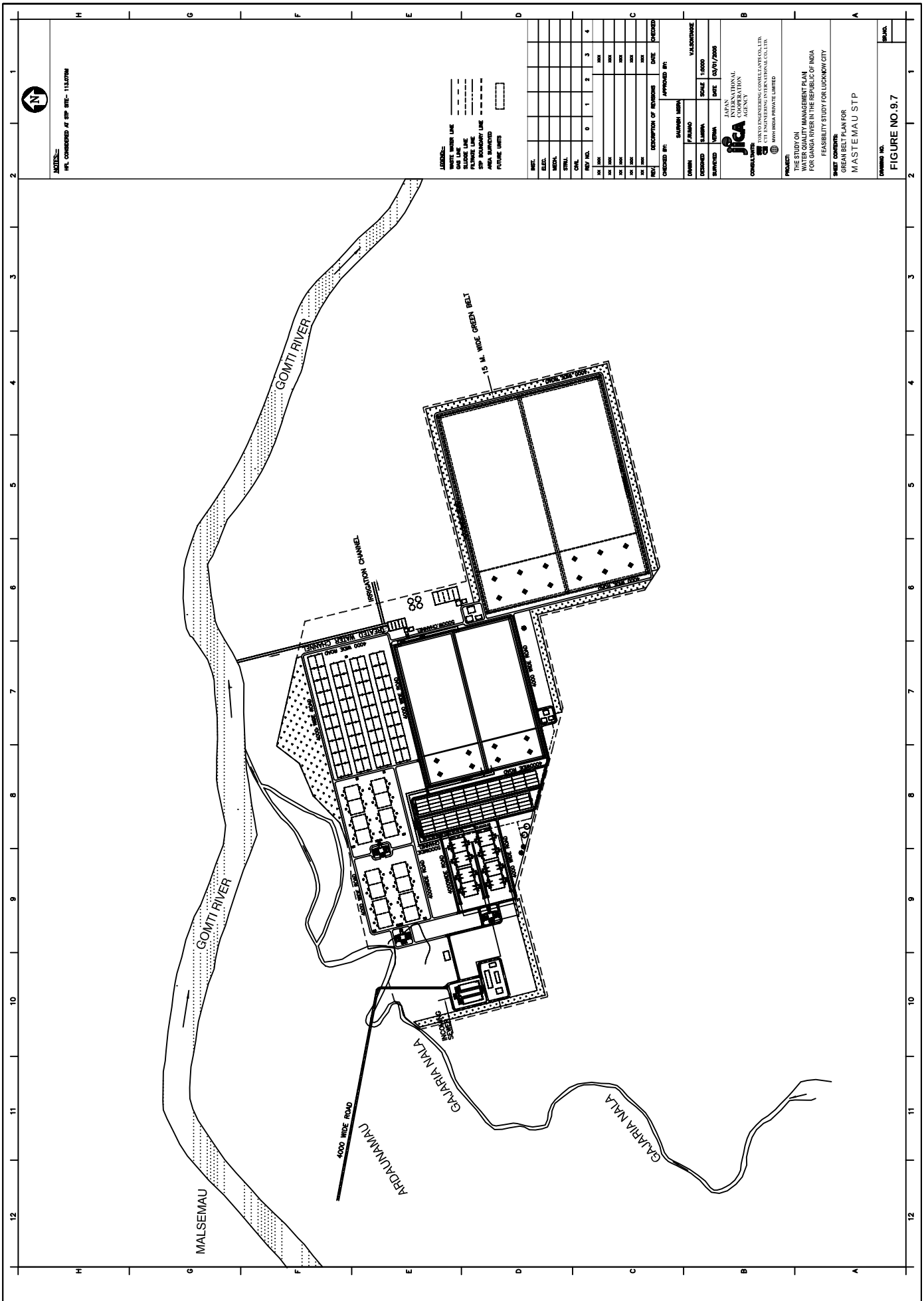
There are two types of compensation. Monetary compensation has to be provided to direct Project Affected Persons (PAPs) if their houses have to be acquired and demolished. It has to be provided also to indirect PAPs for their agricultural land to be acquired. Alternate land has to be provided to displaced persons for their resettlement. If land for resettlement can not be provided or PAPs are not willing to resettle in the new resettlement site, then monetary compensation has to be provided to direct PAPs for their homestead (i.e. residential) land to be acquired.

This will ensure that the farmers selling their land will not be affected.

Greenbelt Plantation

A 15 m greenbelt all along the plant boundary is proposed. Even within the plant premises, vacant land will be used to plant trees. The species should be selected considering the local flora and species. Development of green belt will minimise the noise levels to the outside of the plant boundary and filter the odour levels to a considerable extent. Greenbelt will also give an aesthetic cover to the plot area and the activities going on within the plant will not pose any disturbance to the local people outside.

The greenbelt area for the proposed STP site is given in Figure 9.7


NOTES:-
HFL CONSIDERED AT STP SITE= 113.07M
LEGEND:-
WATER WATER LINE
GAS LINE
SLUDGE LINE
POWER LINE
STP BOUNDARY LINE
AREA SURVEYED
FUTURE UNITS
GOMTI RIVER
GREEN BELT 15 M. WIDE
IRRIGATION CHANNEL
GOMTI RIVER
MALSEMAU
4000 WIDE ROAD
ARDAUNAMAU
GAJARIA NALA
GAJARIA NALA
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO ENGINEERING CONSULTANTS CO.,LTD.
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GREEN BELT PLAN FOR
MASTEMAU STP
FIGURE NO.9.7

Table 9.37 Summary of Environmental Impacts and Environmental Mitigation Plan

Environmental Issues	Adverse Impact	Nature of Impact	Proposed Mitigation Measures	Implementing Authority
CONSTRUCTION PHASE				
Soil Quality	• Due to excavation and earthwork: soil erosion, loss of top soil, silting and blocking of drainage/ nalas, which can cause slush; damage to existing structures • Due to compacting: loss of original quality, reduction in fertility	Significant and Permanent	• Stabilise all slopes with provision of benches/pitching • Avoid earthwork during monsoon • Provide adequate cross drainage facilities • Restrict traffic movements and use low ground pressure machines • Preserve top soil to be replaced after the completion of construction activity; avoid wet soils • Dispose of surplus earth after raising levels and refilling trenches, in low lying areas with proper compacting and planting of surfaces • Plant shrubs/trees/grass on exposed slopes and surfaces	UPJN/ Contractor
Air Quality	• Localised increase in dust due to excavation & earthwork • Temporary increase in the levels of SO_2/NO_x, from construction equipment and vehicles	Significant and Temporary	• Dust control through sprinkling / washing of construction sites and access roads particularly in congested areas • Use of dust cover over construction material • Dust collectors should be used in all drilling operations • Unnecessary idling of trucks should be avoided • Construction material trucks to be covered to minimise spills • Preventive maintenance of construction equipment and vehicles to meet emission standards • Construction requiring heavy traffic street closing/ diversion to be carried out during night time	UPJN/ Contractor
Noise Pollution	• Increase in noise levels due to construction work, transport of construction materials, etc.	Significant and Temporary	• Equipment emitting noise over 90 dB should be avoided • Noise generating construction work should be carried out in day time only • Equipment maintenance strengthened to keep noise production low • Sound barriers should be installed if needed	UPJN/ Contractor

Environmental Issues	Adverse Impact	Nature of Impact	Proposed Mitigation Measures	Implementing Authority
CONSTRUCTION PHASE				
Water Quality/ Drainage	• Increase in turbidity affecting surface water quality • Sanitary pollution	Significant	• Ensure steps to prevent earth and stone from silting up the nalas and drainage systems • Control run off and soil erosion through proper drainage channels and structures; improve existing cross drainage and provide extra cross drainage works wherever necessary • Provide adequate sanitation facilities to construction site workers	UPJN/ Contractor
Loss of Natural Vegetation	• Loss of avenue trees and natural vegetation, especially in the clearance for treatment plant site	Significant and Permanent	• Replantation on treatment plant area, as well as around the periphery • Replantation of avenue trees and ensuring proper care for growth	UPJN/ Forest Department/ Contractor
Traffic	• Traffic jams, bottlenecks, delays and inconveniences to general public • Serious disruptions of vehicular traffic, pedestrian access and commerce	Significant and Temporary	• Co-ordinate and plan all activities in advance • Adequate actions to direct traffic in consultation with highway and traffic police • Minimise vehicle movements • Preference for unused or low traffic roads • Construction of temporary roads and diversion of traffic • Use of trenchless sewer technology to minimise the damage • Seek public co-operation through public awareness	UPJN/ Contractor/ Traffic Police
Social Disruptions	• Disruptions in utility services • Social hostility due to employment of outsiders on construction activities	Temporary	• Minimise interruptions to services through proper planning and scheduling of activities and strong inter-departmental co-ordination • Preference should be given to local labour/skilled persons during construction, operation and maintenance	UPJN
Risk of Accidents	• Endangering lives of people/workers during construction due to inadequate safety measures	Significant	• Adequate traffic control measures should be taken • Sign board warning presence of open sewer trench • Guard rails to protect pedestrians • Strong safety policy for workers; protective helmets to be provided	Contractor/ UPJN

Environmental Issues	Adverse Impact	Nature of Impact	Proposed Mitigation Measures	Implementing Authority
CONSTRUCTION PHASE				
Aesthetic Conditions	• Visually anaesthetic conditions due to cluttering of waste, and spoils, dug up roads and pavements	Significant and Temporary	• Enhance aesthetics through proper housekeeping of construction site • Disposal of construction wastes at the approved sites quickly • Repair pavements and roads after sewer laying work is completed • Completing the construction activity by removing all spoils	UPJN/ Contractor
Land Acquisition	• Inadequate compensation • Loss of Income	Significant and Permanent	• Advance realistic payments to be made to relocated (estimation for compensation for land and property should be made on the prevailing market rates)	UPJN
Existing Infrastructures	Site clearance and works: • Damage existing structures, • Affect electricity supply and telecommunication lines, • Clutter road sides with pipes, • Cause general nuisance to public.	Not Significant and temporary	• Minimum damage to existing structures, flora and fauna, avenue trees and other natural vegetation, electricity & telephone lines and other infrastructure services • Cleared earth and debris should be properly disposed off • Storage sites should be identified for stacking pipes so as not to clutter road sides	Contractor
Construction Camps	• Prevalence of unsanitary conditions and practices like open air defecation • Possibilities of public health problems • Piling of garbage from workers	Significant and Temporary	• Adequate measures such as provision of septic tanks/pit latrines around the construction camp sites • Provision of clean drinking water to potable water standards • Collection of garbage in garbage cans in fixed places and disposal of it regularly	Contractor
Public and Workers' Health	• Adverse health of workers due to unsanitary practices and spreading of diseases from vectors	Significant and Temporary	• Workers are the immediately affected people • Proper sanitation and drinking water should be provided • Medical facilities to be provided to prevent communicable diseases	Contractor/ UPJN

Environmental Issues	Adverse Impact	Nature of Impact	Proposed Mitigation Measures	Implementing Authority
OPERATION PHASE				
Air Quality	• Problems of bad odour from the treatment plant	Significant	• Some bad odour from sewage treatment plant is unavoidable; however, steps should be taken to minimise odour by proper maintenance and housekeeping of the treatment plant. • Greenbelt should be adequately maintained.	UPJN/LJS/ Operator
Noise Quality	• Noise from DG sets and dual fuel engines will be generated	Significant	• Noise generating equipments will be enclosed in double walled structures	UPJN/LJS/ Contractor
Water Quality	• Overflow of sewers and breakdown of treatment plant leading to failure in meeting the requisite standards • Poor performance will affect the proposed reuse for irrigation, and also the receiving water body	Significant	• Preventive maintenance of all components should be performed regularly • Relevant standby equipment and spare parts should be provided; standby power generation should be provided at pumping stations, if any • Proper response plan must be prepared and all workers must be trained to tackle emergencies	UPJN/LJS/ Operator
Sludge Treatment & Disposal	• Improper treatment of sludge could lead to putrefaction and other related problems such as bad odour, health effects, etc.	Significant	• Sludge should be treated properly and dewatered • Dried sludge should be disposed of in a specified landfill site with proper precautions or given for land application to farmers, if it can be handled properly by them	UPJN/LJS/ Operator
Aesthetic	• Pumping stations, treatment work site might pose an unaesthetic sight but it affects only close residents	Not significant	• Sewage plant should be located away from the densely populated residential areas • Plantation of trees in and around the pumping stations/treatment plant would improve the aesthetics	UPJN/LJS/ Operator
Public Health	• Mixing of sewage with drinking water • Outbreak of waterborne diseases • Unhealthy conditions: mosquito breeding over sludge drying beds, etc.	Significant	• Any such health risk to public should be minimised by proper maintenance and operation of sewers, pumping stations, treatment plant, etc. • In case of failure, inform relevant authorities to alert public at risk so that precautions might be taken	UPJN/LJS/ Operator

Environmental Issues	Adverse Impact	Nature of Impact	Proposed Mitigation Measures	Implementing Authority
OPERATION PHASE				
Workers Health & Safety	• Workers may be inflicted by endemic & other diseases such as malaria or respiratory ailments • Accidents and loss of lives may occur during sewer cleaning & maintenance • Non availability of emergency medical facilities at all times during day & night	Significant and Permanent	• Proper house keeping of the plant to prevent unsanitary conditions • Regular medical check ups and immediate treatment of affected workers • Maintenance personnel should not perform dangerous tasks when alone, enter the manholes without checking for gas and without proper protective clothing, enter the manholes without ropes and harnesses firmly tied • Manholes should not be left open especially in busy roads, near schools and residential areas	Operator/ LJS/ UPJN
Economically Weaker Sections	• Filthy, unaesthetic conditions in slums, open defecation, foul smells, piling of garbage, endemic and epidemic diseases of residents	Significant	• Provision of sanitation facility should be extended to slums; if possible, shallow sewers should be laid to drain these areas • In areas that cannot be sewered, on site sanitation facilities like pit latrines/community ablution blocks should be provided • The residents should be educated on personal hygiene practices and the importance of sanitation and public health	UPJN/ LJS
Social Disruptions	• Breaking of sewer lines by farmers for irrigation as sewage would be a continuous source of water for irrigation	Significant	• The sewers should be patrolled and any unauthorised human activity should be discouraged • Farmers should be educated on health effects of using untreated sewage for irrigation, especially the effect of sewage flooding due to breakage of sewers with risks of epidemics	UPJN/ LJS/ Operator

Table 9.38 Scoping Matrix for Project Component

Environmental Elements		**Social Environment**								**Natural Environment**							**Pollution**				
Development Scheme		Land Acquisition	Economic Activity	Traffic/Public Facilities	Cultural Properties	Water Right/Right of Common	Public Health Condition	Solid Waste	Risk	Topography and Geology	Soil Erosion	Groundwater	River Water Quality	Flora and Fauna	Local Meteorology	Landscape	Air Pollution	Water Pollution	Soil Contamination	Noise and Vibration	Odor
Sewage Treatment Plant	C	A -	A+	B -	D	C -	C -	B -		D	B -	D	C -	D	D	B -	B -	C -	D	A -	D
	O		A+	D	D	C -	B+	-	C -	D	D	D	A+	D	D	B -	D	-	D	C -	C -
Pumping Station	C	C -	A+	B -	D	C -	C -	B -		D	B -	D	C -	D	D	-	B -	C -	D	A -	D
	O		A+	D	D	C -	B+	-	C -	D	D	D	B+	D	D	B -	D	-	D	C -	C -
Installation of Main Trunk Sewer	C	D	C -	A -	D	D	C -	B -		D	B -	D	C -	D	D	D	B -	C -	D	A -	D
	O		C+	D	D	D	A+	-	C -	D	D	D	A+	D	D	D	D	-	D	D	D
Rehabilitation of Existing Trunk sewer	C	D	D	B -	D	D	C -	B -		D	D	D	D	D	D	D	B -	C -	D	A -	D
	O		D	D	D	D	B+	B+	C -	D	D	D	B+	D	D	D	D	-	D	D	D

Remarks:
C: Indicates construction (rehabilitation) stage. O: Indicates operation stage.
A+: Strong positive impact A -: Adverse negative impact
B+: Moderate positive impact B -: Moderate negative impact
C+: Low positive impact C -: Low negative impact
D: No impact forseen

Table 9.39 Analysis of Siting of the Mastemau Sewage Treatment Plant Drainage District IV – 137,500 m^3/d in 2015, 330,000 m^3/d in 2030

Issues	STP at Mastemau
NATURAL PARAMETERS	
Soil Quality	• Construction of plant at this site will not have major impact on soil quality which is already very low.
Air Quality	• Present location is away from the residential areas and outside (but not far from) the boundary of proposed development by LDA.
Water Quality	• Treated water will be used for irrigation purpose in the surrounding area. • The surplus water will be discharged into Gomti river passing near the village.
Ecologically Sensitive Area	• Present location is not in forest or ecologically sensitive area and is not likely to have any adverse effect on the existing flora and fauna of the project area. • A private plantation area is near to the proposed STP site and a water body (Gajaria nala) passes between STP site and the plantation area clearly demarking both the sites avoiding the interference of STP site activities with the green cover.
SOCIO-CULTURAL PARAMETERS	
Land Use Pattern	• The present location is undeveloped and a part of the proposed site used for irrigation purpose by farmers. • The project is not expected to alter the land use drastically as the area chosen is rather uneven and is criss-crossed by water channels. A part of the land where land is used by farmers for irrigation will have to be acquired.
Socio-Economic Condition	• Positive impact on socio-economic condition due to increase in employment opportunities during construction and operation and maintenance of the plant
Public Health	• Proper housekeeping and maintenance of the plant required to offset problems of mosquito breeding and other nuisances
Archaeological/ Historical area	• Present location does not affect any historical/ or archaeological heritage.
Aesthetic and Visual	• Present location does not pose such serious aesthetic and visual problems as it is away from dense residential areas.
PROJECT IMPLEMENTATION PARAMETERS	
Land Availability & Land Cost	• Location of treatment plant away from inhabited areas (70 ha required) • The present location is outside the boundary of expected development • Land cost would be cheapest here.
Sewage Collection	• Sewage from entire Cis-Gomti area can be brought to this site effectively.
Pumping	• Will involve 2 sewage pumping stations one at Martin purva and another at STP site
Treatment Plant	• Treatment plant consists of Primary Treatment, UASB reactors followed by Facultative type Aerated Lagoons and Chlorination.
Sludge Disposal	• Treated sludge is organic in nature; it can be used as manure for agriculture.
Reuse –Irrigation potential of Treated Sewage	• Treated water is proposed to be used for irrigation purpose. • The treated water meets discharge standards applicable for its use for agriculture. • Irrigation fields are surrounding the STP site and the owners are ready to accept the water.
Use of biogas	• Methane enriched biogas produced in UASB reactors can be supplied to nearby villages for cooking and for lighting. • Biogas will be generated at the rate of 2800 m^3/day. • Remaining biogas is proposed to be utilised for generation of electricity. • Coordination with LESA will be done for street lighting in Mastemau and Bakaas.

9.8 ENVIRONMENTAL MANAGEMENT, TRAINING, AND MONITORING PLAN

9.8.1 General

The success of the Environmental Mitigation Plan depends on the efficiency of the organisational set up responsible for the implementation of the programme.

For a sanitation project of this magnitude, the Environmental Management Plan needs to be entrusted, in both the construction and the operation phases, to an Environmental Management Cell. Regular monitoring of various environmental parameters is necessary to evaluate the effectiveness of the management programme so that necessary corrective measures could be taken in case of any drawbacks.

Thus, the Environmental Management Plan will consist of:

- setting up an Environmental Management Cell to implement the mitigation measures in operation phase;
- ensuring a proper operation and maintenance of the treatment works;
- ensuring a proper maintenance of the sludge drying beds and the disposal of dry chemical sludge in a proper landfill site;
- monitoring the wastewater and treated water quality;
- monitoring the built in pollution control equipment, for vehicles and equipment;
- maintaining tree plantations around the sewage pumping stations and the periphery of the sewage treatment plant.

Details of the Management Cell and the monitoring requirements needed to ensure that construction and operation follow best environmental practices are given in this section.

9.8.2 Environmental Management Cell

The Environmental Management Cell (EMC) will be part of the staff in charge of the operation and maintenance of the sewerage works, since the laboratory will be housed at the treatment plant site. But this staff will be in charge of the overall management of the environmental aspects of the Sanitation Project.

The staff will be provided by the operator of the treatment plant, in case the operation and maintenance of the treatment plant is subcontracted by UPJN.

Under the supervision of an Environmental Engineer, the EMC will comprise of an Environmental Scientist, a Chemist and a Biologist and three Assistants, as shown in the following organisation chart. The Environmental Engineer would report directly to the Top Management of UPJN.

The organisational chart is shown in Figure 9.8

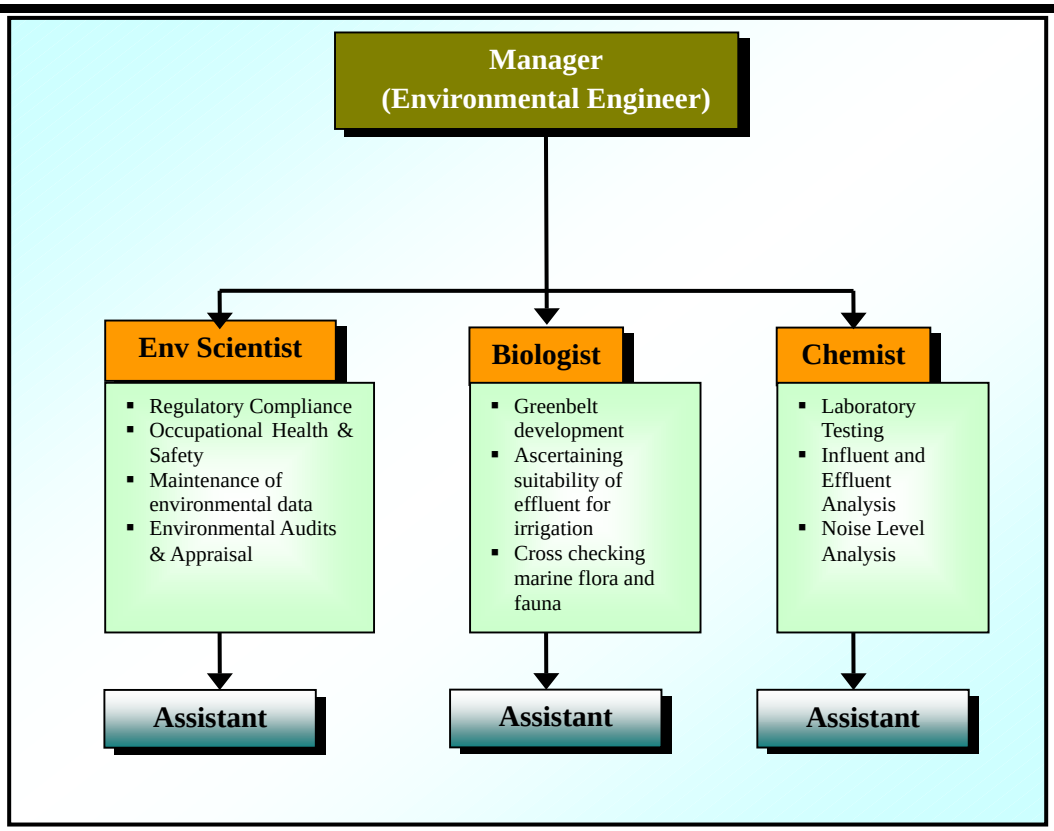

Figure 9.8 Environment Management Cell

The main functions of the EMC will be:

1. Collecting water, air, soil and sludge samples;
2. Analysing the samples collected or getting analysis done from outside sources;
3. Preparing and updating a database of environmental parameters;
4. Implementing the environmental control and protective measures;
5. Controlling the sludge treatment, disposal and re-use;
6. Collecting statistics of health of workers and the population of surrounding areas;
7. Ensuring the development and maintenance of the green belts;
8. Monitoring the progress of implementation of EMP;
9. Coordinating the environment related activities within the project as well as with outside agencies

9.8.3 Monitoring Plan

To evaluate the effectiveness of the EMP, regular monitoring of the important environmental parameters will be taken up by UPJN. The schedule duration and parameters to be monitored by the environmental team are described below and summarised in Table 9.42.

(1) Water Quality

The sampling of various inlets and outlets will be carried out for analysis of relevant parameters. The analysis will be carried out once in a month both at the inlet and outlet of the STP and at strategic locations within the plant. Some of the parameters will be tested daily. This practice would help UPJN evaluate the performance of individual units of the STP and take corrective measures if the results are not satisfactory.

(2) Air Quality

Ambient air quality should be monitored for SO_2, NO_x, SPM, etc. At the STP, H_2S and CH_4 should be monitored. Instruments like high volume air samplers and other monitoring kits should be used for the purpose of air quality monitoring. Monitoring points should be fixed in consultation with the UPPCB.

(3) Noise Monitoring

Noise levels should be monitored in working environment, main noise producing sources such as the DG sets, pumping stations, over the boundary and around the STP.

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(4) Green Belt and Compensatory Plantation

Greenbelt developed around the pumping stations and STP should be monitored and taken out regularly for its proper growth.

9.8.4 Environmental Testing Laboratory

A well equipped laboratory for routine analysis of raw sewage and treated wastewater as well as for ambient air quality and sludge analysis should be provided at the STP site. The biological testing facility should be provided in this laboratory in addition to chemical analysis of water. The record of analyses should be maintained at the plant site for all the parameters mentioned in the monitoring plan.

9.8.5 Environmental Training

The environmental monitoring plan will be successful only if it is implemented by trained and skilled staff. The training of the qualified staff should be necessary not only in day to day operation and maintenance of the STP, but also in environmental aspects.

It will be essential to involve the staff who will be responsible for the execution of the EMP, in the construction phase, as well as to train the staff in practicing the mitigation actions and the day to day monitoring programme during the operation phase of the project.

The training should include:

- Basic concepts of pollution control techniques in the various methods of sewage treatment,
- Operation and maintenance of the STP,
- Emergency preparedness to handle adverse situations,
- Principles of wastewater analysis,
- Other environmental monitoring techniques,
- Development of green belt and its maintenance,
- Sewage farming,
- Communication with farmers and general public.

This training is different from the mandatory training required for operation and maintenance of the STP.

9.8.6 Cost of EMP

The block and recurring costs for the implementation of the Environment Management Plan is given in Table 9.40 and 9.41, respectively.

Table 9.40 Block Costs for EMP

Components	Cost (in Rs.)
Establishment of EMC	500,000

Table 9.41 Recurring Costs for EMP

Components	Frequency	Costs (Rs./ year)
Waste water and Treated Water Quality	Quarterly	52,500
Groundwater	Quarterly	60,000
Surface Water (Receiving Water Body)	Quarterly	60,000
Ambient Air Quality	Quarterly	30,000
Ambient Noise	Quarterly	30,000
Environmental Audit	Once in year	200,000
Running Costs for EMC	Monthly	2,400,000
Total		2,832,500

Table 9.42 Environmental Monitoring Plan

Environmental Quality	Monitoring Parameters	Schedule and Duration of Monitoring
Waste and Treated Water Quality	• All physico-chemical and bacteriological parameters as per UPCB standards; pH, temperature, TDS, TSS, DO, BOD, COD, heavy metals and *E coli.*, etc.	• Quarterly Analysis • Monitoring point will be the inlet and outlet of the treatment plant • Technical criteria should be based on UPPCB standards/ guidelines
Ambient Groundwater	• pH, TDS, nitrates, fluorides, nitrites, and heavy metals	• Once in 4 months • At sewage treatment plant location near sludge drying beds • Technical criteria should be based on UPPCB standards/ guidelines
Ambient Water Quality of Receiving Body	• pH, TDS, TSS, BOD, COD, hardness, nitrates, heavy metals	• Quarterly • At discharge points according to the option selected • Technical criteria should be based on UPPCB standards/ guidelines
Ambient Air Quality	• SPM, NO_x, CO, SO_2, H_2S, CH_4	• Construction period: 3 times a year (January, May and September) Monitoring point will be near construction sites and residential areas • Operation period: 24 hour samples, for one week, quarterly; Monitoring points will be fixed in consultation with the UPPCB • Technical criteria should be based on UPPCB standards/ guidelines
Ambient Noise	• Noise level	• Operation period: Quarterly monitoring will be undertaken as appropriate; Monitoring points should be at pumping stations, near treatment plants • Technical criteria should be based on UPPCB standards/ guidelines

9.9 RISK ANALYSIS & CONTINGENCY PLAN

9.9.1 General

The sanitation project comprises sewer laying, construction of sewage treatment plants and their operation. The risk involved in laying the sewers is mainly for pipelines of DN 600 and larger, which require lifting by cranes. The risk of mechanical equipment failure and thereby occurrence of accidents cannot be overlooked.

Contingency measures plans have been prepared for:

1. sewage treatment works that could reasonably be expected to cause significant environmental impacts as a consequence of operational disruption (i.e. maintenance, etc. or breakdown);
2. accidents which may occur while laying sewers or during construction of the treatment works;
3. discharge of sub-standard wastewater into the environment from treatment plant which could cause a significant public health impact, and which therefore requires a continuous system of influent/effluent monitoring to identify potential problems as and when they arise.

In the preparation of the contingency measures:

- the most likely causes of process disruption/breakdown have been identified;
- the possible resultant environmental adverse impacts are presented;
- the recommended courses of action to minimise the severity of the impacts have been highlighted;
- the responsible agency that will act in case of emergencies has been indicated.

Table 9.43 gives the potential risks due to construction, operation and maintenance and corrective actions. The major risks that can result in breakdowns and disruptions are described below.

9.9.2 Power Supply

One of the main reasons for disruption during the operation phase of the treatment works is very likely to be power cuts due to a transmission line problem and/or energy shortage. Power cuts and the reasons for them should be monitored in advance so as to set a reliability analysis at the new treatment plant.

It is recommended that the new treatment plant influent pumping station is equipped with a branched connection to ensure continuity of operation in case one line remains out-of-order. It is also suggested that standby power generators are provided to ensure at least minimum services in case of prolonged power cuts.

Also the technology chosen should be able to survive short spells of power cuts.

9.9.3 E&M Equipment Disruptions

Operational disruption due to E&M equipment can be avoided by spare parts and stand-by provision available at site.

O&M instructions and manuals should be provided by the contractor of the treatment plant with training of the operation staff.

Table 9.43 Risk Assessment and Contingency Plan

	Works	Risks	Impact	Corrective Action Plan	Responsibility
1. ACCIDENTS RELATED TO CONSTRUCTION					
1.1	Sewerage	• Accidents due to pedestrians falling into the open trenches	Significant	• Excavated trenches should be provided with adequate barricades • Signboards in bold letters to be displayed in prominent places • Solid planks with guard rails should be provided across the trenches for crossing	Contractor/ UPJN
		• Accidents due to vehicular traffic and risk to pedestrians, workers, vehicle drivers	Significant	• Traffic diversions and signboards should be displayed prominently • Proper lighting should be provided at night time • Co-ordination with traffic police in managing traffic	Contractor/ UPJN
		• Accidents due to failure of machinery such as cranes	Significant	• Workers to be trained on contingency management • Emergency medical help should be available immediately • The contractor should have a proper safety policy issued to workers and should strictly comply with all the safety regulations	Contractor/ UPJN
		• Accidents due to carelessness of workers	Significant	• Workers should be provided with protective clothing and helmets • Workers should not be allowed to work when alone • Workers should be trained on first aid • Emergency medical help should be available immediately	Contractor/ UPJN
		• Breakages of water supply pipes and services connections	Significant	• Inform public in advance about works • Make temporary arrangements for not disturbing water supply in case some pipes have to be displaced	Contractor/ UPJN
1.2	Treatment Plant & Pumping Stations	• Risk of accidents	Significant	• During construction, effective safety and warning measures including all the above mentioned safety precautions should be followed by the contractor and UPJN should insist on compliance by contractor • Lighting of construction site and safety signs to be installed	Contractor/ UPJN

	Works	Risks	Impact	Corrective Action Plan	Responsibility
2. ACCIDENTS RELATED TO OPERATION & MAINTENANCE					
2.1	Sewers	• Accidents to operator/UPJN personnel	Significant	▪ Operators should not enter the manholes when alone • Operators should check for gases before entering the manholes • Operators should wear protective clothing, helmets and masks • Operators should enter the manhole by lowering themselves with a rope or a harness tied safely above • Manhole covers should be lifted using proper lifting keys • Emergency medical services should be available round the clock • At least one person of Management level should be on duty at all times	Operator/ UPJN/LJS
2.2	Treatment Plant	• Breakdown of wastewater treatment units (or overall poor condition)	Not Significant	• The treatment plant will require regular maintenance (preventive maintenance rather than reactive maintenance should be insisted upon)	Operator/ UPJN/LJS
		• Breakdown of mechanical equipment	Not Significant	• Adequate standby for pumps and motors should be provided • Adequate quantities of reliable spare parts should be available on site • Presence of mechanics to take corrective action • All standby equipment should be regularly checked to ensure full working order	Operator/ UPJN/LJS
		Maintenance of sludge drying beds: • risks of perpetuation of mosquitoes and other vectors • risk of bad odours • risk of groundwater pollution.	Not Significant	• Sludge drying should be maintained properly • Wet sludge should be raked frequently and dry sludge should be removed and stored/disposed off • Ensure proper drainage • Operator should ensure that there is no standing water on the SDB	Contractor/ UPJN / LJS
2.3	Treatment Plant (continued)	• Failure of biological process due to toxicity, poor maintenance, etc. (contamination of the effluent with toxic industrial effluents is the major reason for failure of biological treatment systems)	Significant	• The secondary biological treatment should be by passed and the water should be discharged after primary treatment only • All relevant authorities should be informed on potential health risk to public • The biological process should be revived	Contractor/ UPJN/LJS

	Works	Risks	Impact	Corrective Action Plan	Responsibility
				• Inoculation or addition of nutrients should be carried out, if needed	
2.4	Pumping Stations	• Breakdown of pumping stations leading to flooding and consequent public health problems as well as general nuisance to public	Significant	• Pumping stations should be avoided as far as possible and in cases where it is not possible, their numbers should be minimised • All pumps should be wear resistant • Standby pumps should be provided and they should be regularly checked to ensure full working condition when needed • Safety overflow should be provided at all pumping stations leading to a ditch or preferable a drain. These emergency overflows should be designed to ensure minimum environmental nuisance, in case of use	Operator/ UPJN/LJS
		• Power failure leading to flooding of sewage on streets and other problems	Significant	• Standby diesel generators should be provided to cater for a minimum of 1.5 times the average dry weather flow so as to avoid flooding • Emergency overflows as above, should also be provided along with the DG sets as a precaution	Operator/ UPJN/LJS

9.10 CONCLUSIONS

The objective of implementing the sewerage project in Lucknow is to stop the flow of sewage into the river Gomti and improve the water quality in Gomti along with the sanitary conditions of the city. A sewerage project with such an objective is associated with positive impacts. The most important of those are listed below:

- The collection and treatment of untreated wastewater before entering the river will improve water quality of Gomti.
- Those areas that are presently overflowing with sewage will improve as the sewage will be tapped and diverted through underground drainage systems.
- Risks due to water borne diseases will reduce since at many places the existing sewer lines will be rehabilitated. The contamination of the water supply line with the sewer will reduce considerably.
- Effective planning of sewage pumping stations and the treatment plant will ensure that wastewater does not percolate to sub surface layers of soil and contaminate the ground water.
- Treated effluent use in agriculture will help the farmers to enrich their soil fertility. Groundwater consumption will reduce.
- Sludge generated during the treatment process can be used as manure in nearby agricultural fields.
- Improvement in existing sewerage system will reduce the leakages and overflowing of sewage on the roads and streets.
- The construction activities will provide the local people with some employment.

9.10.1 Overall Impacts

The sewerage project to be implemented in Lucknow for improvement of the river water quality, although would improve the environmental condition of the city, there will be still some areas that would require more focus and attention.

- Many of the areas will still not be connected directly to the sewers and wastewater will continue flowing through the drains.
- Wherever lateral sewer networks and house to house sewer connections are not in place, indiscriminate sewage flow will continue to occur.
- If the implemented projects are not operated and maintained effectively, the purpose of the Project will not be achieved.
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9.10.2 Inference

Overall it can be concluded that the priority projects that will be implemented will have a positive effect on the improvement of the quality of the river. The mitigation measures, if followed correctly will not have any adverse impacts on the environment.

CHAPTER 10

COST ESTIMATION AND IMPLEMENTATION PROGRAMME

CHAPTER 10 COST ESTIMATION AND IMPLEMENTATION PROGRAMME

10.1 CAPITAL COST ESTIMATION OF THE PRIORITY PROJECTS

Cost estimates for various works are worked out on the basis of prevailing Schedule of Rates and market rates. Rates for land acquisition are obtained from Finance and Revenue Department, Govt. of Uttar Pradesh. All the figures are in Rs.

Unit prices for the estimate of capital costs are, in principle, derived from the list of prices provided by UPJN. However, prices not provided by UPJN are calculated using Lucknow rates on the basis of Delhi Schedule of Rates taking localities and deflator into account. Furthermore, prices of items such as sewer pipes, reinforcing steel bars, manhole covers and so on that are not found in UPJN Schedule or DSR are obtained by quotation. The following are cost estimation conditions.

1) The rates assumed for major civil works are based on UPJN Schedule of Rates for Lucknow and market rates.
   - To apply schedule of rates provided by UPJN in principle.
   - For rates of items not provided by UPJN, to use modified rates based on Delhi Schedule of Rates.
   - To use market prices for items not available in (1) and (2).
2) Costing of electrical equipment is based on the price list of standard suppliers.
3) Costing of the pump houses is based on actual quantities worked out from preliminary design.
4) Costing of pumps and motors is based on the price of reputed suppliers, and other facilities like screens, pipes, valves etc. are based on prevailing market rates.
5) Current market rates have been considered for pipes, reinforcement steel, structural steel and specialized items like geo-synthetics etc.
6) For STPs based on UASB technology, costs have been calculated on the basis of preliminary design of process units.
7) Physical contingencies: 5% of capital cost
8) Engineering costs (detailed design (6%) and project management (5%)): 11 % of capital cost
9) Project administration: 5 %, including the cost of "Environment Monitoring Plan", which is discussed in the section on Environmental Impact Assessment.

The capital costs of each component are provided in the relevant Chapters and the abstract of cost estimation is shown in Table 10.1.

10.2 IMPLEMENTATION PROGRAMME

In the F/S, a detailed list of the works identified for implementation of the priority projects has been provided.

The implementation programme (Table 10.2) for the priority projects in Lucknow has been prepared considering following assumptions.

1) Necessary technical and financial sanctions and inter government agreement (between Japanese Government and Indian Government) shall be finalised within 2005.
2) Process of appointment of Project Management Consultant for the project shall start by July 2006 by NRCD, Ministry of Environment and Forests, Government of India.
3) Appointment of consultants for detailed engineering and preparation of detailed project reports and tender documents for project component shall be completed within 2006.
4) Actual execution of various priority project components shall start from 2007.

5) During execution, various project components shall be executed in parallel.
6) UPJN, Lucknow, will acquire 100 % of the land required for construction of proposed sewage treatment plants and pumping stations before the commencement of tendering.

10.3 OPERATION & MAINTENANCE COST ESTIMATION

The following is the summary of the basis of preliminary estimation of operation & maintenance (O&M) cost for the proposed sewerage system.

(1) Estimation Conditions

i) Sewers and rising mains

- Annual maintenance cost of trunk sewers: @ 0.5% of capital cost (New & Replacement)
- Annual maintenance cost of rising mains: @ 0.25% of capital cost
- Annual maintenance cost of branch sewers: @ 0.5% of capital cost
- Annual operation cost: manpower cost
- Manpower cost - As per actual salaries and proposed staff requirement [*1]
- The capital cost of existing and sanctioned sewers is estimated based on unit cost of proposed facilities or Master Plan (M/P).

ii) Pumping stations

- Power cost (required power) - Rs. 3.25 per unit
- Diesel cost (for power cut) - As per market rate
- Annual power cost is estimated based on average flow
- Maintenance of civil works: @ 1.5% of capital cost of civil works
- Maintenance of mechanical & electrical (M&E) works: @ 3% of capital cost of M&E works
- Manpower cost - As per actual salaries and proposed staff requirement [*1]
- The capital cost of existing and sanctioned PSs is estimated based on unit cost of proposed facilities or M/P.

iii) Treatment plants

- Power cost (required power) - Rs. 3.25 per unit
- Gas power generator installed in the STP will be used during power cut
- Chemicals – actual cost
- Maintenance of civil works @ 1.5% of capital cost of civil works
- Maintenance of M&E works @ 3% of capital cost of M&E works
- Manpower cost - As per actual salaries and proposed staff requirement [*1]
- The capital cost of existing and sanctioned STPs is estimated based on unit cost of proposed facilities or M/P.

Note: [*1] The manpower requirement of O&M for sewers, pumping stations and treatment plants for 2015 is proposed and its cost is estimated in the PART IV of VOLUME IV-1, Institutional Development Programme.

(2) Facilities Considered for O&M Cost Estimation

The O&M costs of all facilities including existing, sanctioned and proposed facilities are estimated.

(3) Power Supply Conditions

The O&M costs in following two cases in terms of power supply conditions are estimated.

- Operation by power from grid (24 hours a day)
- Operation by power from grid (20 hours a day) and diesel (4 hours)

(4) Estimation Results

Table 10.3 presents annual O&M costs of all major facilities including existing, sanctioned and proposed facilities for 2015 and the following table summarises annual O&M costs for 2015.

Summary of Annual O&M Costs in 2015 (Lucknow)

(1,000 Rs./year)

Facility	Case-1 Grid Power Supply	Case-2 Grid Power Supply Supplemented by Diesel
(1) Sewers and Rising Mains	43,499	43,499
(2) Pumping Stations	192,253	281,269
(3) Sewage Treatment Plants	99,071	99,071
Total	334,823	423,839

Note: The O&M cost includes all major existing, sanctioned and proposed facilities.

Table 10.1 Abstract of Project Cost Estimation

	Sewerage District	Capital Cost (Rs.)	Contingencies 5%	Detailed Design 6%	Supervision 5%	Project Adminisrtation 5%	Total Cost (Rs.)	Land Acquisition (Rs.)	Total Project Cost (Rs.)
SEWERAGE SCHEMES									
Construction / Replacement of Trunk Sewer									
Trans Gomti Trunk Sewer	III	97,768,000	4,888,000	5,866,000	4,888,000	4,888,000	118,298,000		118,298,000
CIS Gomti Relief Trunk Sewer	IV	444,132,000	22,207,000	26,648,000	22,207,000	22,207,000	537,401,000		537,401,000
Sultanpur Road Trunk Sewer	IV	421,879,000	21,094,000	25,313,000	21,094,000	21,094,000	510,474,000		510,474,000
Construction of Sewerage Pumping Station					0				
Rising Main of Mohan Meakin SPS	III	13,709,000	685,000	823,000	685,000	685,000	16,587,000		16,587,000
Martin Purwa MPS and Rising Main	IV	200,977,000	10,049,000	12,059,000	10,049,000	10,049,000	243,183,000	34,000,000	277,183,000
TSPS at Mastemau STP	IV	372,532,000	18,627,000	22,352,000	18,627,000	18,627,000	450,765,000		450,765,000
Construction of Sewerage Treatment Plant					0				
Mastemau STP (include irrigation channel)	IV	453,075,000	22,654,000	27,185,000	22,654,000	22,654,000	548,222,000	173,320,000	721,542,000
Rehabilitation of CIS Gomti Trunk Sewer					0				
Desilting, Detailed Investigation	IV	74,760,000	3,738,000	4,486,000	3,738,000	3,738,000	90,460,000		90,460,000
Rehabilitation	IV	346,949,000	17,347,000	20,817,000	17,347,000	17,347,000	419,807,000		419,807,000
Rehabilitation of Existing Pumping Station					0				
Trans Gomti SPS	III	70,374,000	3,519,000	4,222,000	3,519,000	3,519,000	85,153,000		85,153,000
CIS Gomti SPS	IV	71,664,000	3,583,000	4,300,000	3,583,000	3,583,000	86,713,000		86,713,000
Total		2,567,819,000	128,391,000	154,071,000	128,391,000	128,391,000	3,107,063,000	207,320,000	3,314,383,000

Table 10.2 Implementation Schedule of Priority Projects (Lucknow)

(Unit:)Rs. (Unit: Rs.)

	Capital Cost	Detailed Design Cost	Total Project Cost	2007	2008	2009	2010	2011	2012
				Capital and Detailed Design Cost Schedule					
Construction of Trunk Sewer									
Trans Gomti Relief Sewer	97,768,000	5,866,000	118,298,000	5,866,000	19,554,000	19,554,000	19,554,000	29,330,000	9,776,000
CIS Gomti Relief Trunk Sewer	444,132,000	26,648,000	537,401,000	26,648,000	88,826,000	88,826,000	88,826,000	133,240,000	44,414,000
Sultanpur Road Trunk Sewer	421,879,000	25,313,000	510,474,000	25,313,000	84,376,000	84,376,000	84,376,000	126,564,000	42,187,000
Construction of Sewerage Pumping Station									
Rising Main of Mohan Meakin SPS	13,709,000	823,000	16,587,000				823,000	6,855,000	6,854,000
Martin Purwa MPS and Rising Main	200,977,000	12,059,000	277,183,000	12,059,000	40,195,000	40,195,000	40,195,000	60,293,000	20,099,000
TSPS at Mastemau STP	372,532,000	22,352,000	450,765,000	22,352,000	74,506,000	74,506,000	74,506,000	111,760,000	37,254,000
Construction of Sewerage Treatment Plant									
Mastemau STP	453,075,000	27,185,000	721,542,000	27,185,000	90,615,000	90,615,000	90,615,000	135,923,000	45,307,000
Rehabilitation of CIS Gomti Trunk Sewer									
Detailed Investigation	74,760,000	4,486,000	90,460,000	4,486,000	74,760,000				
Sewer desilting, flow diversion and rehabilitation	346,949,000	20,817,000	419,807,000			20,817,000	115,650,000	115,650,000	115,649,000
Rehabiltation of Existing Pumping Station									
Trans Gomti SPS	70,374,000	4,222,000	85,153,000	4,222,000	35,187,000	35,187,000			
CIS Gomti SPS	71,664,000	4,300,000	86,713,000	4,300,000	35,832,000	35,832,000			
Total	2,567,819,000	154,071,000	3,314,383,000	132,431,000	543,851,000	489,908,000	514,545,000	719,615,000	321,540,000

(Unit:million Rs.)

Items	Total Project Cost	2007	2008	2008	2009	2009	2010
Capital Cost	2,567.82	0.00	543.85	469.09	513.72	719.62	321.54
Detailed Design Cost	154.07	132.43	0.00	20.82	0.82	0.00	0.00
Contingencies	128.39	0.00	27.19	23.45	25.69	35.98	16.08
Supervision	128.39	0.00	27.19	23.45	25.69	35.98	16.08
ProjectAdmin	128.39	0.00	27.19	23.45	25.69	35.98	16.08
Total Cost	3,107.06	132.43	625.42	560.26	591.61	827.56	369.78
Land Acquisition	207.32	207.32	0.00	0.00	0.00	0.00	0.00
Total	3,314.38	339.75	625.42	560.26	591.61	827.56	369.78

Detaied Design
Construction Cost

Table 10.3 Operation and Maintenance Cost Estimation

	Status	Sewerage District	Ave. Capacity at 2015 (mld)	Diameter (mm)	Length (m)	Unit Cost (Rs./m)	Capital Cost (Thousand Rs.)	Power condition : Grid power supply (24 hours a day)					Power Condition : Grid power (20 hours a day) and diesel power (4 hours) supply						Assumptions and Conditions for Estimation	
								Staff Cost (Thousand Rs. /year)[3]			Maintenance Cost (Thousand Rs.)	Total O&M Cost (Thousand Rs. /year)	Staff Cost (Thousand Rs. /year)				Maintenance Cost (Thousand Rs.)	Total O&M Cost (Thousand Rs. /year)	Basis of Capital and Operation Cost	Basis of Maintenance Cost
1 Trunk Sewer																				
Existing (Trans Gomti Trunk Sewer)	E	III		900	3,350	see relevant part	38,626				193	193					193	193	MP Unit cost base	@ 0.5 %
Existing (Cis Gomti Trunk Sewer)	E	III		750-2100	7,177	see relevant part	208,358				1,042	1,042					1,042	1,042	MP Unit cost base	@ 0.5 %
Proposed (New Trans Gomti Trunk Sewer)	P	III		1300-1600	3,215		70,718				354	354					354	354	F/S estimate (except trenchless)	@ 0.5 %
Proposed (Cis Gomti Trunk Sewer)	P	IV			6,950		243,367				1,217	1,217					1,217	1,217	F/S estimate (except trenchless)	@ 0.5 %
Proposed (Sultanpur Road Trunk Sewer)	P	IV			7,450		409,724				2,049	2,049					2,049	2,049	F/S estimate (except trenchless)	@ 0.5 %
Sub Total					**28,142**		**970,793**				**4,854**	**4,854**					**4,854**	**4,854**		
2 Branch Sewer																	0			
District III		III	(10,018 ha x 70% x 385 m/ha)		2,699,851	1,000	2,699,851				13,499	13,499					13,499	13,499	Unit cost base	@ 0.5 %
District IV		IV	(13,692 ha x 60% x 385 m/ha)		3,162,852	1,000	3,162,852				15,814	15,814					15,814	15,814	Unit cost base	@ 0.5 %
Sub Total					**5,862,703**		**5,862,703**				**29,314**	**29,314**					**29,314**	**29,314**		
3 Rising Main																	0			
From Trans Gomti SPS	S	III		900	2,950	11,530	34,014				85	85					85	85	MP Unit cost base	@0.25%
From Kukrail No.1 SPS	S	III		1800	4,655	33,400	155,477				389	389					389	389	MP Unit cost base	@0.25%
From Guari MPS	S	III		2100	4,100	52,440	215,004				538	538					538	538	MP Unit cost base	@0.25%
From CIS Gomti SPS (Crossing Gomti river)	S	IV		1200	500	15,140	7,570				19	19					19	19	MP Unit cost base	@0.25%
From GH Canal SPS (Crossing Gomti river)	S	IV		1400	1,500	19,660	29,490				74	74					74	74	MP Unit cost base	@0.25%
From Mohan Meakin SPS	P	III		700	1,300		13,709				34	34					34	34	F/S estimate	@0.25%
From Martin Purwa MPS (Including trenchless)	P	IV		1200	900		19,897				50	50					50	50	F/S estimate	@0.25%
Sub Total					**15,905**		**475,161**				**1,188**	**1,188**					**1,188**	**1,188**		
Total					**5,906,750**		**7,308,656**				**35,355**	**35,355**					**35,355**	**35,355**		
								8,144				**43,499**	**8,144**					**43,499**	**See IDP report for staffsost**	

	Status	Sewerage District	Ave. Capacity at 2015 (mld)	Civil Cost (Thousand Rs.)	E & M Cost (Thousand Rs.)	Utility Cost (Thousand Rs.)	Total Capital Cost (Thousand Rs.)	Staff Cost (Thousand Rs. /year)[3]	Power Cost (Thousand Rs. /year)	Chemical Cost (Thousand Rs. /year)	Maintenance Cost (Thousand Rs. /year)	Total O&M Cost (Thousand Rs. /year)	Staff Cost (Thousand Rs. /year)	Power Cost (Thousand Rs. /year)	Chemical Cost (Thousand Rs. /year)	Diesel Cost (Thousand Rs. /year)	Maintenance Cost (Thousand Rs. /year)	Total O&M Cost (Thousand Rs. /year)	Basis of Capital and Operation Cost	Basis of Maintenance Cost
4 Pumping Station																				
Sarkata Nala SPS	E	I	36	53,974	27,512	0	81,486		3,082	-	1,635	4,717		2,568	-	2,986	1,635	7,189	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
Nagaria Nala SPS	E	I	6	8,996	4,585	0	13,581		514	-	272	786		428	-	498	272	1,198	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
Pata Nala SPS	E	IV	15	22,489	11,463	0	33,952		1,284	-	681	1,965		1,070	-	1,244	681	2,995	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
Wazirganj Nala SPS	E	IV	36	53,974	27,512	0	81,486		3,082	-	1,635	4,717		2,568	-	2,986	1,635	7,189	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
Ghasiyari Mandi SPS	E	IV	16	23,988	12,227	0	36,216		1,370	-	727	2,096		1,142	-	1,327	727	3,195	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
Gaughat Nala SPS	E	-	4	5,997	3,057	0	9,054		342	-	182	524		285	-	332	182	799	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
Mahanagar SPS	E	-	10	14,993	7,642	0	22,635		856		454	1,310		713		829	454	1,997	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
9 small existing PSs [1]	E	-	32	47,977	24,455	0	72,432		3,082	-	1,453	4,535		2,283	-	2,654	1,453	6,390	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
Trans Gomti SPS	E/R	III	60	89,957	45,853	0	135,809		5,137	-	2,725	7,862		4,281	-	4,976	2,725	11,982	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
CIS Gomti SPS	E/R	IV	50	74,964	38,211	0	113,174		4,281	-	2,271	6,551		3,567	-	4,147	2,271	9,985	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
Mohan Meakin SPS	S	III	28	41,980	21,398	0	63,378		2,397	-	1,272	3,669		1,998	-	2,322	1,272	5,592	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
Kukrail No.1 SPS	S	III	266	398,807	203,281	0	602,088		22,773	-	12,081	34,853		18,977	-	22,061	12,081	53,119	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
Daliganj No.1SPS	S	III	24	35,983	18,341	0	54,324		2,055		1,090	3,145		1,712		1,991	1,090	4,793	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
Guari MPS	S	III	398	596,711	304,157	0	900,868		34,074	-	18,075	52,149		28,395	-	33,009	18,075	79,479	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
GH Canal SPS	S	IV	133	199,404	101,640	0	301,044		11,386	-	6,040	17,427		9,489	-	11,031	6,040	26,560	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
8 small sanctioned PSs [2]	S	-	18	26,987	13,756	0	40,743		1,541	-	817	2,359		1,284	-	1,493	817	3,595	Martin Purwa PS F/S cost base	@1.5% of civil, 3.0% of E&M
Martin Purwa MPS	P	IV	80	119,942	61,137	0	181,079		6,849	-	3,633	10,482		5,708	-	6,635	3,633	15,976	F/S estimation	@1.5% of civil, 3.0% of E&M
TSPS at Mastemau STP	P	IV	100	139,237	232,070	0	371,307		7,646	-	9,051	16,696		6,372	-	7,406	9,051	22,828	F/S estimation	@1.5% of civil, 3.0% of E&M
Sub Total				**1,956,358**	**1,158,296**	**0**	**3,114,654**		**111,751**	**0**	**64,094**	**175,845**		**92,840**	**0**	**107,926**	**64,094**	**264,861**		
								16,408				**192,253**	**16,408**					**281,269**	**See IDP report for staff cost**	
5 Treatment Plant																				
Daulatganj STP (FAB)	E/A	I	56	103,040	154,560	0	257,600	4,039	10,770	-	6,182	20,991	4,039	10,770	-	-	6,182	20,991	MP cost base	@1.5% of civil, 3.0% of E&M
LDA Colony STP (UASB)	S	I	10	18,400	27,600	0	46,000	3,049	1,923	-	1,104	6,076	3,049	1,923	-	-	1,104	6,076	Daulantganj STP M/P cost base	@1.5% of civil, 3.0% of E&M
Kakraha STP (UASB)	S	III	345	908,620	239,685	414,804	1,563,109	9,623	17,440	5,037	20,820	52,920	9,623	17,440	5,037	-	20,820	52,920	Mastemau STP F/S cost base	@1.5% of civil, 3.0% of E&M
Mastemau STP (UASB)	P	IV	100	263,368	69,474	120,233	453,075	6,534	5,055	1,460	6,035	19,084	6,534	5,055	1,460	-	6,035	19,084	F/S estimate	@1.5% of civil, 3.0% of E&M
Sub Total				**1,293,428**	**491,319**	**535,037**	**2,319,784**	**23,245**	**35,188**	**6,497**	**34,141**	**99,071**	**23,245**	**35,188**	**6,497**	**0**	**34,141**	**99,071**		
Total				**3,249,786**	**1,649,615**	**535,037**	**5,434,438**	**39,653**	**146,939**	**6,497**	**98,235**	**291,324**	**23,245**	**128,028**	**6,497**	**107,926**	**98,235**	**380,340**		
Grand-Total							**12,743,094**	**47,797**	**146,939**	**6,497**	**133,591**	**334,823**	**31,389**	**128,028**	**6,497**	**107,926**	**133,591**	**423,839**		

Note:
(1) 9 small existing PSs: total capacity is 32 mld: Machhali Mohal, Daliganj No.2, Nishatganj, Rajaji Puram, Badshah Nagar, Vikas Nagar, Indira Nagar No.1, Indira Nagar No.2, Kursi Road
(2) 8 small sanctioned PSs: total capacity is 18 mld: NER D/S Nala, China Bazar Nala, Laplce Drain, Jopling Road Nala, Lamartenier and Jiamau Nala, Roop Pur Khadra Nala, Hanuman Setu Drain, Baba ka Purwa Nala
(3) See Institutional Development Programme (ID) report for Manpower (Staff) Cost.
E: Existing, S: Sanctioned, P: Proposed, A: Proposed augementation

407,431

Appendix A

Appendix A 3.1

Technical Evaluation for Selection of Pumps

Sewage pumps are used to lift liquid wastes from one level of the collection system to another (as in the case of intermediate pumping stations) or to the treatment plant for treatment (as in the case of main pumping stations).

At larger pumping installations, a large quantity of materials, such as rags, jute bags, fibre and plastic pouches is found in sewage. Proper efficient screening shall be done before the sewage enters into the wet well of the pumping station. A sewage pump shall be reliable, unchokable and accessible for quick maintenance, be robust and wear resisting. The type of pump to be installed at each pumping station shall be judged on its technical merits in relation to the rate of pumping, total head, physical composition of the sewage, septicity and requirement of preliminary treatment before pumping.

Pumps may be classified on the basis of the purpose or the application they serve, the material of construction, the liquids they handle, and orientation in the space. A more basic system of classification is to categorize the pumps on the principle by which the energy is supplied to the pump. Under this system, all pumps may be divided into two major categories.

Dynamic, in which energy is continuously added to increase the fluid velocities within the machine to values in excess of those occurring at the discharge such that subsequent velocity reduction within or beyond the pump produces a pressure increase.

Displacement, in which energy is periodically added by application of force to one or more movable boundaries of any desired number of enclosed, fluid containing volumes, resulting in a direct increase in pressure upto the value required to move the fluid through valves or ports into the discharge line.

Dynamic pumps may be further sub-divided into several categories of centrifugal pumps and other special-effect pumps, like jet pumps and hydraulic ram pumps etc. Displacement pumps are essentially divided into reciprocating pumps and rotary pumps.

Reciprocating pumps are suitable for applications where the required capacity is expected to be virtually constant over a wide range of system head variations. Another factor that has to be taken into consideration is that the output from the reciprocating pumps is pulsating. Where this is objectionable, rotary pumps are preferred over the reciprocating pumps. However, the application of rotary pumps is limited to low to medium pressure ranges.

In India, for sewage pumping application centrifugal pumps are in use. A centrifugal pump consists of a set of rotating vanes, enclosed within a housing or casing and used to impart energy to a fluid through centrifugal force. Thus, stripped of all the refinements, a centrifugal pump has two main parts.

- A rotating element, including an impeller and a shaft
- A stationary element made up of a casing, stuffing box, and bearings.

In this type of pump, the liquid is forced by atmospheric pressure or other pressure, into a set of rotating vanes. These vanes constitute an impeller, which discharges the liquid at its periphery at a higher velocity. This velocity is converted into pressure energy by means of a volute or by a set of stationary diffusion vanes surrounding the impeller periphery. Pumps with volute casings are called volute pumps, while those with diffusion vanes are called diffuser pumps.

Depending on the location of motor with respect to the pump, centrifugal pumps can be divided into two types, namely the conventional centrifugal pumps and the submersible centrifugal pumps. The broad classification of the commonly used pumps is shown in the following figure 3.1.

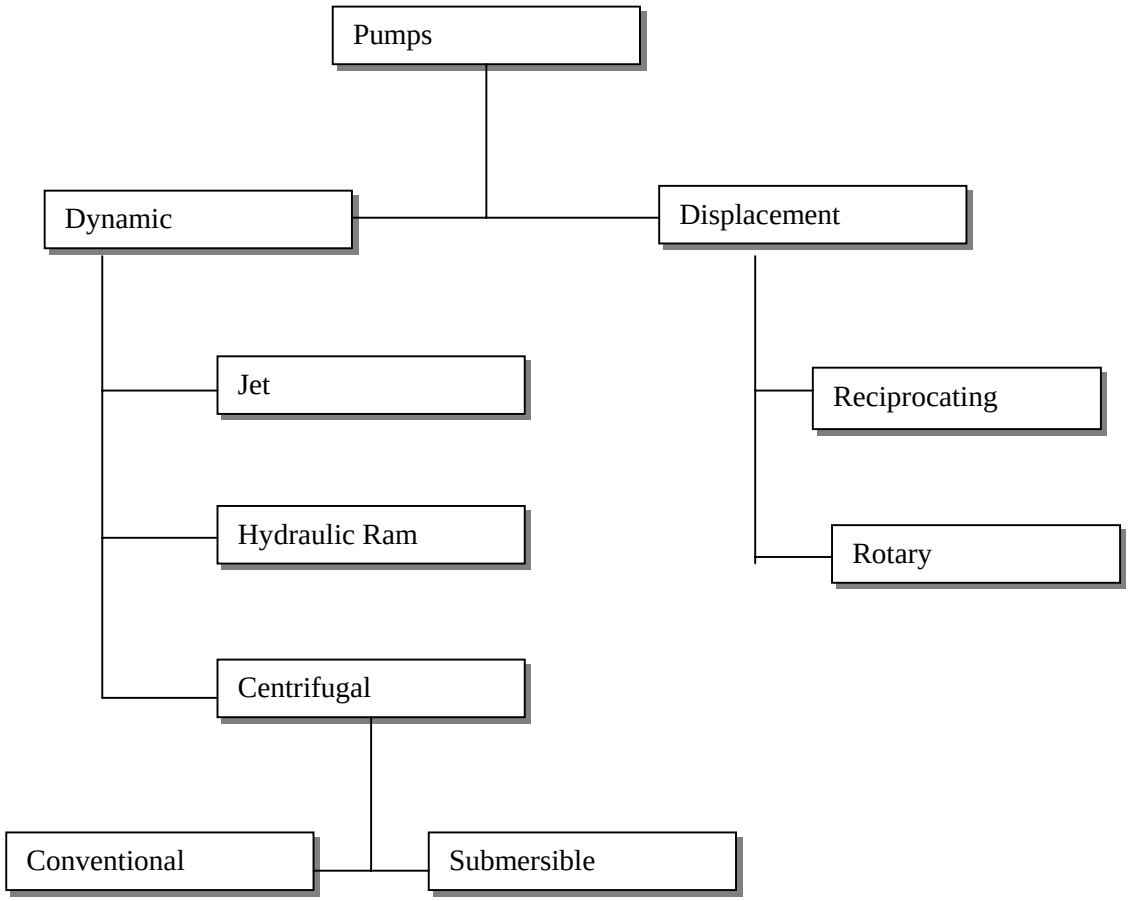

Figure 3.1: Pump Classification

3.1.1 Conventional Centrifugal Pumps

A conventional centrifugal pump is more specifically described as an end-suction, volute-type, with an overhung impeller of either the non-clog or the radial flow type or the mixed flow type pump.

The installation of conventional centrifugal pump requires considerable length of drive shafting. The addition of this shafting, of the many line bearings, and of an external lubrication system represents a major portion of the total installed cost. Furthermore, power losses increase rapidly due to elongation of shafts.

Conventional centrifugal pumps operate within a dry well adjacent to the wet well. The pumps are connected with the wet well through a suction line. One of the major drawbacks with these pumps is that they generally do not work with any suction lift. Instead they need a suction head or minimum submergence for trouble free pumping. Therefore, it is always advisable to install these pumps at such a level that the impeller or the volute of the pump is positioned below the low water level of the wet well to ensure a positive suction or prime.

3.1.2 Submersible Centrifugal Pumps

Submersible centrifugal pumps are based on modern developments and have integral motors with special seals suitable for operation below liquid level. The pump, along with the motor, is submerged into the wet well and does not need a dry well for installation. The pumps are fitted with semi-open type of impellers cutting and tearing contra-block system, which efficiently handles jute bag pieces, long fibres, plastic bags & pouches, cigarette buts, solid admixes, etc. which are generally present in sewage in India.

Submersible centrifugal pumps eliminate the need for extended shafting, shaft couplings, a stuffing box, a sub-surface motor stand, and an expensive dry well.

Submersible centrifugal pumps are available with closed coupled submersible motors. The pumps are supported by guide rails, which make it possible to lower and lift the pumps by means of a chain hoist. During this operation, the discharge is connected and disconnected without dewatering the wet well.

Motors for this type of pump are hermetically sealed, employing a double mechanically sealed oil chamber with moisture sensing probe to detect any influx or conductive liquid past the outer seal.

Due to their inherent advantages over conventional centrifugal pumps, submersible centrifugal pumps have been popular all over the world, for pumping municipal wastewater. Over the past ten years, the application of submersible centrifugal pumps has become very popular in India, for pumping municipal wastewater and is replacing conventional centrifugal pumps.

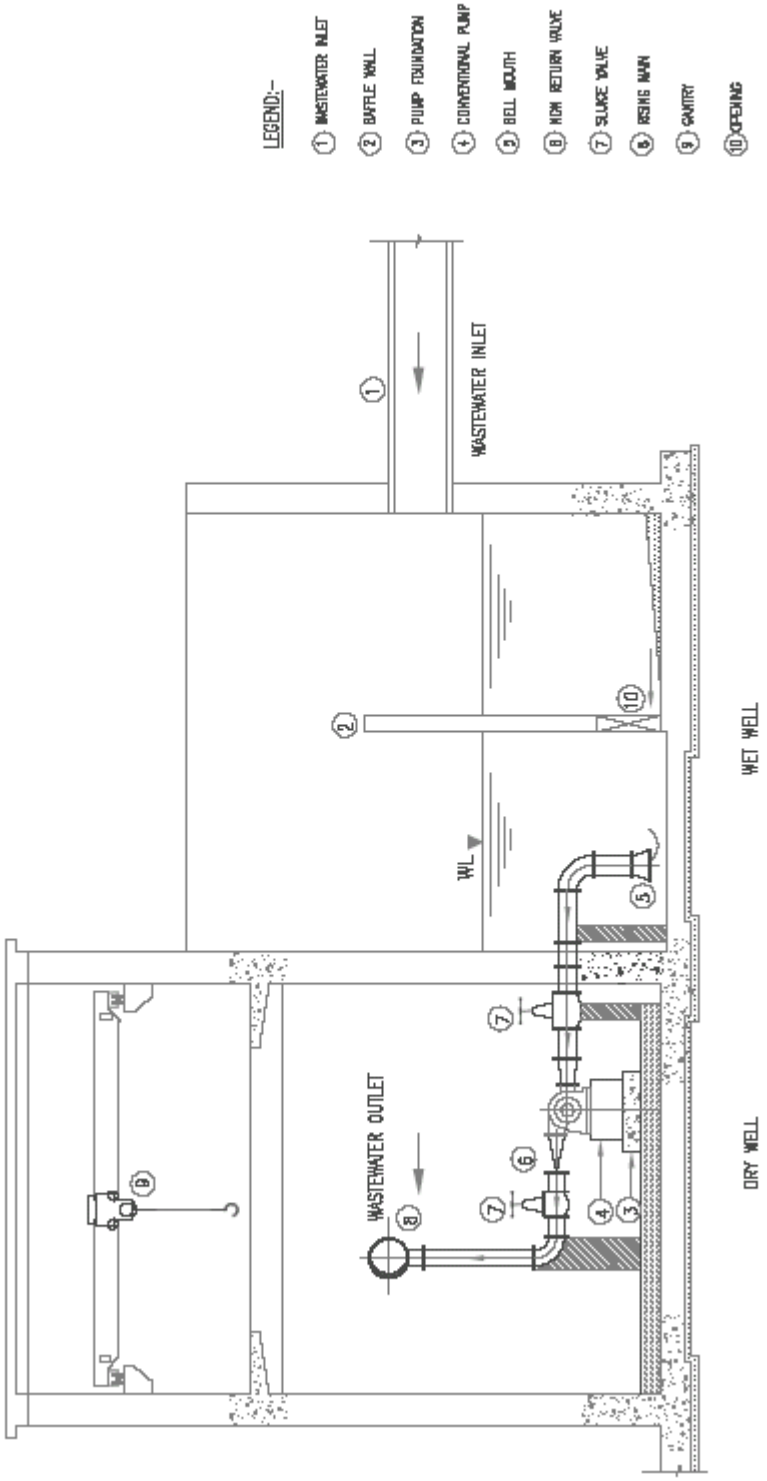

Figure 3.2 Schematic of Conventional Centrifugal Pump

Pump

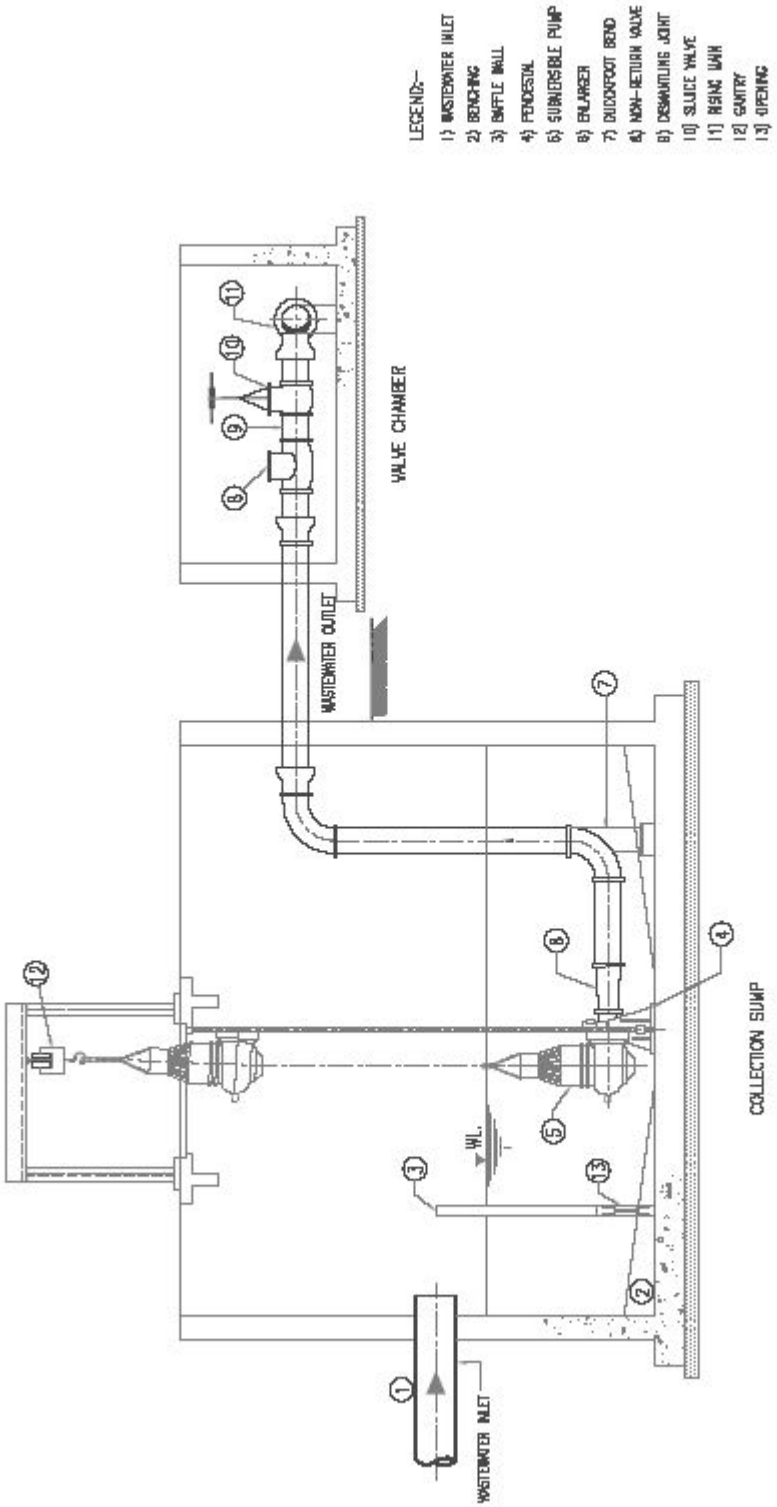

Figure 3.3 Schematic of Submersible Centrifugal Pump

A technical evaluation has been carried out for selection of pumps. For this purpose, conventional centrifugal pumps and submersible centrifugal pumps have been compared.

3.1.3 General Comparison of Conventional Centrifugal Pumps and Submersible Centrifugal Pumps

The conventional centrifugal pumps and submersible centrifugal pumps have their own advantages and disadvantages. The merits and demerits of both types can be summarized as given the following table:

Comparison between Conventional Centrifugal pump vs. Submersible Centrifugal pumps

Sr.	Parameter	Conventional Centrifugal Pumps	Submersible Centrifugal Pumps
1	Civil structure to house the pumps	Superstructure is needed for protection of motors and therefore these pumps require a dry well in conjunction with a wet well (sump). Sectional view of a pumping station with conventional centrifugal pumps has been given in Figure 3.2	Both pump and motor are installed in the wet well. This saves substantial space and brings about significant saving in the civil engineering costs. Sectional view of a pumping station with submersible centrifugal pumps has been given in Figure 3.3
2	Land requirements	Require more space	Require very little space
3.	Piping	Extended	Shorter
4	Column pipes	Required	Not required
5.	Suction pipes	Required	Not required
6.	Discharge pipes	Required	Required
7.	Delivery piping and common header	Require column assembly	The discharge pipes of all pumps can be terminated at the common header, which is installed in a shallow valve chamber just adjacent to the collection sump
8.	Solid handling capacity	Lower (80 mm)	Higher (100 mm and above)
9.	Weight of pumps	Heavy	Relatively much lighter
10.	Lubrication	Special attention is required for lubricating lines of intermediate bearing support and further design is required to check intermediate floor for bearing supports, etc.	No such attention required. Further, the supports required for the intermediate bush bearings is also not applicable
11	Vibrations and noise	Large column lengths always cause vibrations and motor mounted on top causes noise pollution. The vibrations are also due to their heavy weight	Submersible centrifugal pump being a mechanically robust mono-block unit where impeller is mounted on the motor shaft which is supported by two sturdy bearing, ensures a mechanically

Sr.	Parameter	Conventional Centrifugal Pumps	Submersible Centrifugal Pumps
			robust design which in turn results in vibration free performance of the pump and further whatever vibrations that still remain, are damped because the pump is submerged in sewage
12.	Starts and stops	Capable of less stops and starts per hour (4 to 5) and hence requires more hydraulic retention time (5 minutes at peak flow) for wet well	Capable of relatively more starts and stops per hour (8 to 10). This results in reducing the hydraulic retention time (3.75 minutes at peak flow) of the sump, ensuring the compactness of wet well.
13.	Impeller	Closed impeller having both front and back shrouds. This type of impeller is not suitable for Indian sewage, which has solids like plastic bags & pouches and jute fibre. Choking and clogging of impeller is quite frequent	Fitted with specially designed and specially shaped single/double vane impeller of open type with contra-block cutting system. These two combined features make this pump truly non-clogging and therefore substantially more reliable under Indian conditions
14.	Motor	Squirrel cage induction motor is the prime mover, which is coupled with the pump by means of a rigid or flexible coupling	Squirrel cage motor is an integral part of the pump and fitted with an aluminium die cast rotor. This totally enclosed motor is equipped with sealing features to permit operation while submerged in a specified medium at a specified depth.
15.	Electrical cabling and control panels	Since conventional centrifugal pumps offer substantially reduced kilowatt consumption, the ampere consumption also reduces, resulting in reduction in size of motor cabling, length of cabling, reduction in capacity of transformer and generator set.	Cabling and control cabling is extended.
16.	Installation and removal	Installation and removal is cumbersome since the assembly is on a foundation and each pump has to be specially removed and then lifted	The pump installation and removal are automatic, without having to enter into the sewage pit. Guide rail system and guide pipe are provided to facilitate the automatic coupling of the pump

3.1.4 Operation and Maintenance Aspects

Operation and maintenance is an important aspect to be considered while selecting the type of pumps. It is therefore, necessary to consider ease of installation and removal, materials of construction, safety features and frequency of lubrication etc. as important parameters.

In case of conventional centrifugal pumps, frequent clogging of impeller are more due to its closed type design and lower solid handling capacity. Also, due to presence of line shaft bearings, there is a need of frequent lubrication. There is more wear and tear of glands and other parts due to extended shafts. It is not easy to install and remove these pumps because of their heavy weight and manual fixing onto the foundation.

In case of submersible centrifugal pumps, due to their semi-open type impeller, clogging is less frequent. Furthermore, the special contra-block cutting and tearing system provides on the suction side of the pump facilitates disposing off soft materials like plastic pouches, small jute pieces, which is very typical of sewage in India. Pump bearings are of anti-friction type and are maintenance free and are grease lubricated for long life. The bearings are capable of taking normal thrust loads due to unbalanced hydraulic loads on the impellers.

The maintenance of submersible centrifugal pumps is comparatively less because there are no line shaft bearings, which need reliable lubrication and periodic replacement. Only mechanical seal of this type of pump may need replacement after certain working hours, thereby reducing the maintenance cost substantially.

Selecting a pump with less moving parts and low RPM reduces wear and tear of parts and ensures trouble and maintenance free operations. Submersible pumps offer state of the art technology in pump protection ensuring trouble free operation in toughest applications.

The salient operation and maintenance features of conventional centrifugal pumps and submersible centrifugal pumps are given in the following table.

Salient Operation and Maintenance Aspects of Conventional Centrifugal Pumps and Submersible Centrifugal Pumps

Sr.	Conventional Centrifugal pumps	Submersible Centrifugal Pumps
1.	-	Thermistor sensors for motor protection
2.	-	Bearing monitors for trouble free and smooth operation
3.	-	Mechanical seal health monitors for ensuring an enhanced pump life
4.	Periodic greasing required	Lubricated for life bearings
5.	Absence of warning system results in abrupt failure giving no time for planning not allows selective maintenance	Early warning system allows ample planning time and selective maintenance
6.	More moving parts	Less moving parts
7.	Design incorporating multiple shafts, resulting in frequent alignment problems.	Compact design on single shaft.

With reference to the technical comparison between conventional centrifugal pumps and submersible centrifugal pumps it can be concluded that the submersible centrifugal pumps is based on modern developments in the technology of centrifugal pumps for sewage pumping applications. Development in impeller design like semi-open type with contra-block system, steel material of construction, better solid handling capacity, better design due to direct mounting of motor shaft on impeller, better design

of motor stator rotor (aluminium die cast) makes the submersible centrifugal pumps technically more superior. The facility of guides rail system and automatic coupling facilitate better operation and maintenance. Also the submersible centrifugal pumps offering better safety and construction features ensure reliability and trouble free operation. However, availability of submersible pumps is limited to a specified capacity (usually a maximum of 300 HP) in India.

Based on the above technical evaluation, considering advantages, disadvantages, and also the past experiences of UPJN officials on existing installations, it was decided and recommended that for sewage pumping stations in Lucknow, submersible pumps shall be opted only upto 150 HP capacity and horizontal centrifugal pumps shall be opted for higher (>150 HP) capacities.

Appendix A 4.1

4.1 Laying of Sewers Using Trenchless Technology

4.1.1 Trenchless Options for Trunk Sewer

The selection of a trenchless option for the construction of a part of the proposed relief trunk sewer will avoid much of the disruption associated with traditional open cut construction. Trenchless construction involves access to the construction works at discrete points along the pipeline route rather than the disruption of a continuous corridor along the route with the requirement for temporary reinstatement and pavement patching. Site management of trenchless process involves the delivery of essential materials to these discrete intervention points in a timely fashion as opposed to the stringing out along the route of pipe and pipe bedding materials. Similarly, the removal of spoil material can be managed in a timely fashion with the attendant avoidance of disruption. However, it should be mentioned here that site management is the key to successful trenchless construction; a poorly organized site and bad practice can be immensely disruptive and damaging to the public interest causing damage to the perception of the implementing authority in a magnitude not dissimilar to open cut construction.

The selection of access points through specially constructed access shafts is important to minimize public disturbance, these access points can be 100-250 mm apart and the adjacent working areas if well managed can be minimized to the order of 30-70 square meters. Damage to adjacent buried infrastructure such as other utility services is always a risk. Careful survey and attention to local information can minimize this risk. Cooperation with other utility providers and the traffic authorities is an important contribution to successful installation. Careful selection of appropriate technology and materials will minimize future maintenance requirements. Trenchless methods can be expected to deliver better built quality for the most part, free from settlement and reinstatement problems.

There are a number of practical problems in the delivery of the trenchless option. Amongst the most important of these is the requirement for specialist product and equipment, much of which is not currently, available in India. Accordingly planning and selection place special burdens on the client, consultant and contractor. Sufficient time for detailed planning, discussion and programming is essential, detailed method statements and specifications are useful to the achievement of an understanding of all the key issues between the parties. This section of the report seeks to set out key issues for consideration to inform the selection process.

The proposed relief trunk sewer involves both trenched and trenchless components; the section identified for trenchless construction, presented in Table 4.9, is ideally suited being a deep sewer 3-10m to invert, located under a busy road where trenched construction would be enormously disruptive. The trenched component is also deep where connecting to the trenchless section; special measures should be taken here and for most of the trenched reaches to use modern practice of closed sheeting or trench boxes to minimize trench width and ensure worker safety.

Open cut construction can be accomplished with reduced disruption using a trench box or drag box method so that regardless of the depth to formation, that is, below the pipe bedding the trench can be excavated safely without battering back the trench sides, to a minimum width. Close sheeting can also be used to control trench width and maintain safe working conditions but is more time consuming to install and requires closer supervision; the trench sheets are liable to damage and may be regarded as project consumables whereas trench or drag boxes can be regarded as capital items and maintained as such. Careful use of a trench box not only restricts the width of the trench and hence the work site but also the length of pipeline open at any one time to about 6-8 metres. Temporary reinstatement of the pavement after backfill and consolidation can minimize the length of road closure necessary.

With good site management the activity zone of the narrow trench construction outlined above can approximate to the scale of a pipe-jacking site, though the site footprint is larger and cannot be selected at optimum points along the pipeline for minimum disruption. Traditional trenching practice usually involves the temporary storage of excavated material and pipe bedding on site, although this inevitably makes the site area larger and more disruptive. Coordinated truck movement to ship in bedding and product pipe can minimize the area required.

4.1.2 The Microtunnelling Option

There is a wide range of pipe jacking and microtunnelling processes and system providers from Japan, Europe and the US are working internationally. Pipe jacking, pipe ramming and microtunnelling methods have been used in India since about 1997 in Mumbai. Generally, in India the companies working in this sector have developed their own machinery and import specialist items on a project by project basis.

Pipe jacking is defined in the ISTT guidelines as a system for directly installing pipes behind a shield machine by hydraulic jacking from a drive shaft such that the pipes form a continuous string in the ground'. Typically pipe jacking can achieve tolerances of 75mm on line and 50mm on level. Microtunnelling is defined by ISTT as steerable remote control pipe jacking to install pipes of internal diameter less than that permissible for man entry. Microtunnelling was developed from pipe jacking by the Japanese in the early 1980's by the miniaturization of tunnel boring machines (TBMs) and the development of earth pressure balance and slurry microtunnelling machines. Introduced into Germany in the mid 80's the technology was extended by the development of auger machines suited to the sand, silt and clay soils in the Hamburg region. Microtunnelling is now used worldwide to construct 10-20% of new sewer lines. Typically microtunnelling can achieve tolerances of +/- 25 - 50mm on line and level depending on the procedure use.

For a detailed consideration of microtunnelling and selection of the most appropriate process the following basic factors should be reviewed:

- The diameter range of pipe, which can be installed - most machines can be used for a small range (2-3 times the standard size) by changing the cutting head or shield body.

- The type of pipe, which can be installed - pipe compressive strength and surface friction are important factors in determining the length of drive.

- The type of ground, which can be traversed, and the maximum hydrostatic head to be withstood - this will determine the cutting head, the spoil removal system and the need to counterbalance ground water.

- Machine accessibility - in the event of mechanical failure or unforeseen conditions or obstacles.

- The location of access points (drive and receiving shafts) - with respect to achievable drive length, drive shafts are generally larger and more costly than receiving shafts and consideration should be given to driving in both directions.

- The accuracy of alignment achievable - gravity sewers require a very accurate grade whereas pressure mains and casings can tolerate lesser accuracy.

- Sizes of shafts and access thereto - this will depend on the type of microtunnelling machine, hydraulic rams (single or double acting) and pipe length, access is important to operating efficiency and time is critical to avoid the build up of pipe friction.

- Lack of disruption and associated cost benefit - microtunnelling is a capital intensive process and often more costly than open cut pipeline construction at shallow laying depth. Evident reduction of disruption can be expressed as an engineering or social cost saving to justify the use of the procedure.

- Traffic patterns may influence the selection and number of access points, storage areas and support locations are also affected.

In respect of these basic criteria, microtunnelling appears to be appropriate technology for relief trunk sewer. With the wide range of sizes of pipe (1200mm –2400mm) required by flow capacity analysis; a decision shall be taken to rationalize construction to just two sizes to improve the viability of the microtunnelling option so that there is a minimum of disruption to the construction schedule. However, in this report the actual diameter is considered for further detailing. With use of high strength pipes and advanced microtunnelling technology access shafts can be at 200-300 meter centers; such drive lengths are readily achievable with good quality concrete. The route, for the most part could accommodate excavation to access the machine, in the event that this is required. However, there are some sections along the route, for example adjacent to the rail under bridges and in the vicinity of the nala crossing where construction of access shafts should be avoided to the extent possible to minimize disruption and technical problems. Accuracy of +/- 25-50mm is achievable with a variety of machines in drives of length up to 300m consistent with the grade tolerances for the gravity sewer. There are limitations on shaft size evident along the identified route; in the vicinity of the rail under bridge there is barely sufficient space to construct a reasonable sized shaft without significant disruption and concern must be raised about the extent of the footings and foundations for these engineering structures. The route is heavily trafficked and runs through both densely populated areas - the disruption of open trenching would generate a major public nuisance and substantial social costs.

4.1.3 Installation Options

Microtunnelling machines are generally classified in two groups according to the method of spoil removal

- Auger systems where spoil is transferred from the cutting head to the drive shaft by a system of auger flights located in the casing or product pipeline. A full face cutting head may be used to apply an earth pressure balance to support for the cutting face. Ground water can be controlled to a limited extent by earth pressure balanced by the cutting head; this may be supplemented with compressed air. Auger machines are ideally suited to working in cohesive silts and clays and can accommodate ground water pressure of up to 3m. Auger machines are limited by the torque they can apply, drives of about 130m are possible. The maximum size for auger machines is about 1 m diameter.

- Slurry systems where the spoil is mixed with water at the cutting head for transportation in a discharge pipe back to the surface. Settlement tanks and other separation devices allow the water to be recycled and solid waste is transported away. Use of a slurry system can balance high ground water head up to 30m. Slurry systems are suited to working in saturated sand and gravel strata.

- Cutting heads have been designed for working in rock. Such heads may incorporate a modified cone crusher to break up rocks and boulders up to 30% of the face size. The jacking arrangement will consist of a sturdy frame rigid enough to apply the required force through an arrangement of 2-6 hydraulic cylinders each capable of about 100-300 tons force.

Further classification arises from the operating procedures microtunnelling may involve

- A single stage process where the machine is propelled through the ground by jacking product pipes immediately behind the machine.

- A two stage process where special protective pipes are used to drive the machine the full length to the reception pit; product pipes are then jacked through the completed bore displacing the protective pipes which are recovered for re-use. This procedure reduces substantially the load on the product pipe. The annular space between the product pipe and the bore must be grouted.

- A pilot bore where an initial bore of small diameter is reamed out so that the product pipes can be inserted.

The system selected should fulfill the following requirements:

- The shield must be cylindrical to a fine tolerance - eccentricity or damage from prior use will affect steering capability.

- The jacking frame must be sufficiently robust to withstand the weight of the shield and pipes and not deflect during jacking.

- The cutter head and shield must be suitable for the prevailing ground conditions and ground water head.

- If needed face support should be maintained by earth or slurry pressure.

- It should be capable of dealing with rock or rubble included in the spoil up to 30% of the casing or product pipe diameter.

- The cutter head should be steerable with automatic control capable of programming to the appropriate alignment.

- The hydraulic jacks should apply the required jacking force slowly and evenly through a thrust ring, relief valves should prevent overload.

- It should include a data-logging device to display key parameters such as jacking force, jacking speed, earth or slurry pressure, machine deviation, steering roll and gradient in real time.

- It should be capable of installing a 200-300m pipeline to within +/-50mm of level.

- Addition of product pipe and adjustment of hose and cable lengths in the drive shaft must be readily accomplished.

Subject to confirmation that the soil type is essentially silt and sand, essentially free from larger rocky inclusions and that problems with ground water can be anticipated at the burial depths required, it seems likely that slurry shield type machine may be required. Even though serious ground water is less likely at the shallower depths where a 1200mm pipe (rising main) will be installed, the torque requirements for long length jacking will probably exceed machine capability for the auger type. Access shafts could be either rectangular or circular caisson type; the caisson type is probably well suited to the soil type but rectangular may minimize the width of carriageway required for the larger pipes on this scheme. Accordingly the potential for disruption along the proposed route is minimized.

4.1.4 Product Pipe Options

Product pipes are subjected to high compressive loads during jacking and microtunnelling. Pipe wall thickness and compressive strength determine drive length; drive length capability, normally 130-200m may be extended by use of lubrication and intermediate jacking stations. Long distance jacking methods combining highest grade pipe and highly developed methodologies can achieve drives in

excess of 400m. Japanese researchers are reported to be aiming for 1000m. However, for the present purposes consideration is given to methods comfortably associated with drives up to 130m. Depending on the selection and size of the shaft and installation equipment, short pipes (1.2 - 2.0m) may be required.

a) Concrete pipes

The vast majority of jacking pipes in use worldwide are manufactured from concrete to accepted standards such as BS EN 5911 pt120, DIN4035, JSWAS A2 or similar. The high compressive strength (70-90N/mm2) and the smooth low friction exterior surface required support centrifugal spinning as the preferred method of manufacture. This method has lost some popularity in recent years as high speed vibrated methods have been widely adopted for the production of inexpensive concrete pipe for laying in trench. However in the main jacking pipe markets, Japan and Germany spun pipe production remains popular. Where jacking pipe is made by contractors, wet cast molded methods can provide smooth pipe at low volume consistent with construction rate. Jacking pipe are furnished with butt ended joints with coupling rings of steel, stainless steel or GRP, of external diameter slightly smaller than the pipe outside diameter; the joint rings may be loose or bonded into molded rebated joint surfaces. Butt joints provide the maximum area for load transfer. Elastomeric seals are used between the joint ring and the pipe spigot. Modern jacking pipe joints usually employ seals that combine compression seal and lip seal characteristics. Jacking pipes are supplied with load transfer rings usually of particle board, plywood or plastic bonded onto the pipe at the socket end; squareness of ends is critical, a key element of the pipe specification. Vertical cast pipe are demoulded green and air cured, they may be subject to some distortion of ends due to differential drying shrinkage. Concrete pipes are vulnerable to acid attack, which can be a problem where septicity is permitted to develop in the sewer; high ambient temperature, long retention times and shallow grade can be contributory factors. Concrete pipe may be protected by addition of PVC or HDPE lining.

b) Clay pipes

Stoneware pipes are manufactured in diameters up to DN 1200. Recognised standards include DIN 1230 or BS EN 295 pt 7. Stoneware pipes possess particularly high compressive strength. They are manufactured in the UK, Germany and the USA. Stoneware pipes are resistant to all substances found in sewage or soil and have excellent wear resistance. The joint profiles and butt ends are machined to a high standard. The majority of jacking pipes in the range DN200-600 are of vitrified clay. Hybrid clay lined concrete pipes are made in Japan and Germany. Clay pipes are not available for the 2400 mm sizes required at Lucknow.

c) GRP Pipes

GRP pipes such as Hobas are also used for pipe jacking, the sandwich construction of their composite wall providing sufficient wall thickness for a modest end load capability. They are also chemically resistant. Hobas pipe is the dominant pipe used for microtunnelling in the USA.

d) Polymer Concrete Pipes

Polymer concrete pipes were developed in Germany in the early 1990's, they combine the strength and wall thickness of concrete (90 N/mm^2) with the chemical resistance of clay or GRP. A manufacturing unit has recently been established in Malaysia.

e) Steel pipes

Steel Pipes have outstanding strength and toughness; this coupled with their weldability makes them attractive for use as casings or carrier pipes installed by pipe jacking or microtunnelling. However, they have low corrosion resistance and for this reason they have never been widely used in the sewage sector though they are commonly used for water and gas mains often with polymer coatings and

cathodic protection. Steel pipes are often used where a dynamic process such as pipe ramming is used for construction and where a two stage process like auger boring may be used to install other product pipes such as concrete inside the steel carrier pipe.

Centrifugally spun concrete pipe have been made in India for many years, it is expected that manufacture of such pipe designed according to overseas standards can be reinstated to meet the demands. Wet cast concrete pipe have also been made by pipe jacking contractors.

The process of pipe jacking or microtunnelling subjects the external surface of the pipe to significant abrasion as the pipe is pushed through the ground, the extent of abrasion

Depending on the strata, the length of drive and the lubrication. Even in strata free from rock, the paint or other coating on the tunneling machine may be damaged or removed altogether. Very high surface stress is induced in pipes during jacking, particularly when steering or correcting deviations from line or level, pipes are subject to a severe combination of compressive and transverse loads during installation, such stress may also damage the coatings applied to GRP or steel pipes and prejudice their durability.

Concrete, clay or polymer concrete pipe are preferred for medium and long distance jacking. The jacking pipe share of the overall pipe market is relatively small, generally less than 10%. Accordingly jacking pipes are specialty items with higher coat, due to low volume production and the provision of steel or plastic collars. However, the basic pipe cost is a small fraction of the pipeline construction cost, typically 15-20%. Pipe quality should not be compromised, the pipe is a vital component in the performance of the installation and in the subsequent utility and longevity of the installed asset. The pipe, once installed by pipe jacking or microtunnelling will be competently jointed and free from the soil settlement induced in trench construction; it can be expected to perform satisfactorily throughout its working life.

For the relief trunk sewer concrete pipe are recommended. They offer outstanding quality as jacking pipes from the installation perspective. Microtunnelling contractors worked in Mumbai have facilities to make their own pipes by wet casting.

The need for protection from H_2S corrosion is debatable. Instances of failure due to corrosion may vary from place to place and good operational practice may be sufficient to minimize acid attack.

4.1.5 Working Area Requirements

A limited space is required to stage a microtunnelling project, typically 350-500 m^2 – the largest space required will be at the drive shaft, receiving shafts are generally smaller. At the drive shaft additional space will be required for the processing and disposal of spoil; this may involve settlement tanks for slurry machine, a crane, a control cabin, pipe storage, vehicle access and support facilities like power generation and lubricant processing. A crane or gantry is used for lowering the machinery and product pipe into the drive shaft and for spoil removal. Overhead cables, buildings or trees should not restrict movement of the crane. The size of drive pit/shaft will depend on the size of the machinery employed, the length of pipe and the method of working. For a 1200 mm pipe a pit of 4 m x 7 m or shaft of diameter 4 m should be adequate, the receiving shaft used to recover the machine may be smaller say 4 m x 6 m. The DNH 2400 pipe may require a wider shaft 6 m x 8 m or 7 m diameter.

The drive/receiving pit may be constructed by sheet piling, by use of concrete caisson unit, by construction of a diaphragm walled shaft or a shotcreted shaft. The pit may be converted on completion to function as a manhole. In Europe, the use of pre-case caissons has become popular, standardizing shaft dimensions and influencing pipe and manhole design. Fabrication of similar pre-cast products in India should present no problem. Careful positioning and installation of the caisson shafts is required. The caisson becomes in effect the foundation stone of the new pipeline. Caisson units are designed with water proof seals and are bolted together in position and sunk as the spoil is

excavated. It is important to ensure that the caisson is truly vertical during the early stages of installation. The caisson must be designed to accommodate the thrust reaction force. The floor of the shaft must be sealed to the caisson and the structure prevented from floating or otherwise moving due to changes in ground water level.

For longer distance jacking a substantial thrust wall or thrust block will be necessary. Consideration must be given to lubricating pipes through injection point along the length of the drive by injection through the pipe wall. Intermediate jacking points enabling the full length of the drive to be move forward in sections will also be helpful to lengthen the drive, special interjack pipes with modified steel collars will be required for these stations. Limited numbers of drive pits/shaft, offsite pipe storage and coordinated spoil removal will significantly limit the congestion caused by site operation.

4.1.6 Ground Water

The ground water table in the proposed stretches ranges from 2.5 m to 10 m, thus ground water control will certainly be necessary and a gland wall seal or entry and exist lock arrangements will be needed when launching the machine. Furthermore, the probable ground water table will certainly be in the vicinity of the nala crossing, there will be ground water to deal with. Various dewatering options are available – sump drainage, ground water lowering and ground water damming by closed sheeting, caisson sheeting or other form of prefabricated sheeting. Ground water lowering by use of well pointing use of compressed air or other means should only be temporary measure because it can endanger shaft stability and adjacent structures; it can be used for example when placing the drive pit bottom or inserting or removing the machine.

4.1.7 Traffic Considerations

Inevitably there will be problems associated with traffic routing at the rail under bridge, Hazratganj junction, in front of the civil hospital (park road) and in the trenched reached. Some diversions and route planning will be necessary if working areas and access pits/shafts compromise traffic flow. However irksome this may be it will be significantly better than the disruption inevitable with open cut working, the impact of the working area being finite, temporary and minimal. Permits must be obtained in connection with working in the highway. Smooth progress with regard to the issue of such permits is essential to the execution of the micro-tunneling operations. It is customary practice for the client, in this case UPJN, to take responsibility for the grant of such permits as may be necessary. Permits will be needed for driving the sewer under the railway that bisects the proposed route; negotiations with the railway authority are understood to be particularly difficult and should be undertaken by UPJN by interaction between the agencies.

4.1.8 Contractor Experience

There is some pipe jacking and micro tunneling experience in India, particularly in Mumbai at this time, but local contractors wishing to bid for the relief trunk sewer will need to collaborate with overseas suppliers and equipment specialists to get the slurry shield microtunnelling machinery. A number of competent collaborators are either already active in marketing and the execution of initial projects but additional candidates from the Japan and US could be encouraged. It is however essential that the credentials of collaborative contractor teams are thoroughly checked and that the "experienced" staff is available at all critical times from planning through execution. The qualifications of staff must be properly documented giving full details of training and experience on similar projects and preferably in developing markets. Microtunnelling is a highly specialized skill; usually an engineer from the machine manufacturer can be available to ensure that local staff is properly trained, that equipment is properly used and maintained. Equipment suppliers providing training should be required to certify trainee competence after training and periods of supervised site experience. Technical visits by the product pipe manufacturer are also helpful particularly during product inspection and testing. These requirements could be written into the project bid documents.

4.1.9 Client Experience

Successful implementation of microtunnelling and other trenchless technologies and the establishment of an effective partnership between the UPJN and its suppliers depend upon an effective dialogue between the contractors and suppliers of technology and the Jal Nigam engineers. This dialogue is essential because there are few internationally recognized specifications available for trenchless technologies and the parties will have to develop a shared vision of the issues rather than fallback on a prescriptive relationship. A period of training is recommended for the executing engineering staff at all levels. A number of training organisations such as the UK's WTI and other specialist small consultants offer training packages, some leading to formal qualifications, other being simply familiarisation with the technologies. The depth of such courses is a function of the time and money invested by all parties concerned but they are nonetheless valuable if they can skill the engineers to interact with their contractors and particularly their overseas collaborators in regards to the operational issues thrown up by implementation of these technologies.

4.1.10 Programming

Sufficient time must be allocated for all essential operations, equipment and product supply and approval, sinking of shafts and caissons and machine maintenance and overhaul. Microtunnelling is a dynamic process, the transverse loads experienced by the pipe are time dependent, that is to say the pipe friction develops as the ground locks onto the pipe. For optimum working, every phase of the process must be conducted on schedule lest the machine or product pipeline still causing the contractor to abort the drive, construct an emergency shaft and excavate the machine. Delays due to breakdown or intermittent delivery of product pipe cannot be tolerated. The drive once commenced should be continuous until the machine arrives in the receiving shaft. This continuity of operation usually involves shifts working round the clock.

4.1.11 Method Statement

There are relatively few process and product standards available for the trenchless installation of pipelines and those that exist are limited in scope and inevitably are dated in respect to developing technology. Accordingly installation by trenchless means rely heavily on understanding between the supplier / contractor and the client or the clients the managing consultant. For the avoidance of doubt and the clarity of understanding the required to equitably resolve and adjudicate problems as they arise, clear documentation of the aims and objectives, goals and outcomes, and expectation of the parties is valuable at the precontractor stage. The client can reasonably be expected to have a simple and clear concept of expectation, for example a sewer line installed to line and level with specified performance characteristic. The contractor on the other hand as an understanding of the capability of the staff and their abilities to utilize their equipment to meet the clients needs in a specific environment, chosen by the client but unknown in detail to both parties. To facilitate this improvement dialogue, detail method statement and working procedures will be called for at the tender stage for discussion during bid evaluation.

4.1.12 Calculations

The contractor will be expected to submit calculations showing the maximum expected jacking force taking in to account the method face support, pipe frictional resistance, pipe weight, lubrication measures and the cutter characteristics, degree of over cut, soil type, groundwater, depth of cover, rate of advance, deviation from the line and level and steering measures. The pipe selected should be capable of carrying 300 to 400 % of this force without distress and thrust wall or caisson must also be capable of supporting this load with normal margins of safety. Jacking force should be monitored at all times: modern equipment has an automatic recording capability, at no time should the 80 % safe working load on the pipe be exceeded.

Appendix A 6.1 STP Design Spec

6.1 DESIGN SPECIFICATIONS FOR STP

6.1.1 Civil Works

Natural ground level of the treatment site is more or less flat with a moderate slope towards south i.e. Pandu river. Land area available at the western side of the identified plot is utilised for the proposed STP for Phase I.

(1) Design Loads

1) Dead Loads

Dead loads (D) shall mean the total weight of the structural components and/or foundations, all architectural appurtenances incorporated in the structure and all permanent externally applied loads.
The unit weight of materials in general, shall be in accordance with IS:875. Also, the following unit weights shall be considered for the purpose of design.

- 6 mm thick chequered plate = 55 kg/sq.m
- 25 mm thick grating = 40 kg/sq.m
- Hand rail = 15 kg/sq.m

2) Live Loads

Live loads (L) shall mean, the total weight of moving or movable external loads on structures, buildings and/or foundations, produced by people, tools, furnishings of buildings, etc. which are not permanently fixed thereto.
However, weight for small equipments and miscellaneous facilities like following, which may be permanently fixed there to, shall be included in live loads.

- Local lighting facilities,
- Local instrumentation and electrical facilities and cables, and
- Local small pipings.

(2) Live loads on locations other than roofs

The design live loads shall be those appropriate to the actual situations but shall not be less than the following values.

Location	**Live Loads**
Office	400 kg/sq.m
Operating floors	500 kg/sq.m
Storage	750 kg/sq.m
Work shop light duty	500 kg/sq.m
Work shop medium duty	700 kg/sq.m
Work shop heavy duty	1,000 kg/sq.m
Platform	500 kg/sq.m
Staircase	500 kg/sq.m
Corridors	500 kg/sq.m
Walkways	500 kg/sq.m
Floor under conveyors	300 kg/sq.m
Kitchen, toilet	200 kg/sq.m

(3) Live Loads on Roof

i)	Flat roof, sloping roof with slope	<	10^o
a)	With access	:	150 kg/sq.m
b)	Without access except for maintenance	:	75 kg/sq.m
ii)	Sloping roof with slope	>	10^o

A	For roof membrane sheet or purlins	75 kg/sq.m less 2 kg/sq.m for every degree increase in slope over 10 degrees subject to minimum of 40 kg/sq.m
B	For member supporting the roof purlins such as trusses, beams and girders, etc.	2/3 of the load calculated in (ii) - (a)

(4) Wind Load

Wind loads (W) on plant buildings/structures shall be calculated in accordance with IS 875.
Reference : IS : 875 Part 3

(5) Seismic Load (S)

1)	Reference	:	IS : 1893
2)	Seismic zone	:	III
3)	Basic seismic coefficient ( )	:	0.04
4)	Importance factor (I)	:	1.5
5)	Seismic coefficient method (αh)	:	β I αo
	where αh	:	Horizontal seismic coefficient
	β	:	Soil foundation factor

(6) Equipment Loads

Equipment loads shall be defined as per the following three cases, according to the governing conditions of erection, operation and testing.

1) Equipment Loads for Erection

Equipment loads for erection (Ee) shall mean the weight of equipment during erection and exclude, the weight of internals, fluids and solids within the equipment, platforms, insulations and piping attached to the equipment.

2) Equipment Loads for Operation

Equipment loads for operation (Eo) shall mean the load of equipment during normal operating conditions, including the weight of internals, fluids and solids within the equipment and all materials permanently attached to the equipment, such as platforms, insulation and piping.

Vibration caused by operation of equipment shall be considered separately as vibration loads.

3) Equipment Loads for Testing

Equipment loads for testing (Et) shall mean the load of equipment during hydrostatic testing after erection/installation, including the weight of water within the equipment, piping and all materials permanently attached to the equipment, such as platforms, insulation and pipings.

(7) Piping Loads

Piping load (P) shall mean the weights of pipes, fittings, valves, insulations and the fluid contents of piping including the weight of cable ducts wherever installed.

Piping loads shall be assumed as the equivalent loads considering the pipe diameter and piping arrangement.

(8) Handling Device Loads

Handling device loads (H) shall mean the loads of cranes, hoists and lifts including the lifted weight in the normal operation

Handling device loads shall be increased with the following percentages to include adequate allowance for the following impact conditions.

1) Vertical Impact Loads

Frames supporting lifts and hoists	:	100%
Foundations supporting lifts and hoisting apparatus	:	40%
Vertical loads for electrical overhead cranes	:	25%
Hand operated cranes	:	10%

2) Horizontal Impact Loads

a. Overhead Cranes

Horizontal loads transverse to rails	10% of the maximum wheel loads of the crane applied at the top of rail
Horizontal loads along the rails	5% of all static wheel loads

b. Monorails

a) Transverse load : 20% of the lifted load
b) Longitudinal load : 10% of the lifted load, hoist and trolley

(9) Vibration Loads

Vibration loads (V) shall mean the vibration forces caused by heavy vibrating equipment or machinery and dynamic forces caused by fluids in the normal operation.

Frames, structures and foundations for machinery or equipment causing vibration shall be designed to limit vibrations to an acceptable level.

It shall be designed such that whether they are independent or part of the building, it shall not only safely carry the loads for such items, but also prevent resonance. Natural frequencies of frames, structures and foundations must differ by more than 30% from that of the machinery under operating conditions.

In the design of structures and/or foundations for the equipment and machinery with dynamic loads, the loads indicated by vendor in his documents shall be used. However, in the absence of such vendor data, the following loads shall be assumed as the equivalent static loads when the dynamic analysis is not carried out.

1) Reciprocating and Rotating (Centrifugal) Type

a)	Vertical direction	0.5 times the weight of equipment or machinery
b)	Horizontal direction	
i)	Along direction of rotation (perpendicular to centre line of shaft)	0.25 times the weight of equipment or machinery
ii)	Along direction of shaft axis	0.1 times the weight of equipment or machinery

(10) Thermal Loads

1. Thermal loads (T) shall mean, the forces caused by the thermal expansion or contraction of vessel or piping on the supporting structures and / or foundations. When the thermal expansion or contraction results in friction between the equipment and its support, the friction force shall be calculated in accordance with the following friction coefficients.

- Steel to steel : 0.3
- Steel to concrete : 0.4
- Concrete to soil : 0.5

2. Pipe anchor points on pipe racks shall be designed in accordance with the actual anchor forces. These anchor forces shall be transferred to the appropriate resisting frames/bracing and foundations.
3. In the design of pipe supporting beams, the horizontal frictional forces exerted by expanding or contracting pipe or pipe racks shall be assumed by the 30% of the piping loads on the beams. These frictional forces shall not be transferred to the columns and foundations

(11) Earth Pressure

1. Earth pressure (Ep) shall mean pressure of the soil acting on the underground structures and / or foundations retaining walls, dikes etc.
2. Earth pressure at rest, acting on basement, trenches and pit shall be calculated from the following equations :

a) Above ground water level

$Pv = y\ ho + q$ (T/sq.m)

$Ph = Ko\ Pv$ (T/sq.m)

b) Below ground water level

$Pv = yH1 + q + y1\ (ho-H1) + yw\ (ho-H1)$ (T/sq.m)

$Ph = Ko\ (yH1 + 1 + y1\ (ho - H1)) + yw\ (ho-H1)$ (T/sq.m)

where

Pv = Vertical soil pressure (T/sq.m)
Ph = Horizontal soil pressure (T/sq.m)
y = Unit weight of soil (T/sq.m)
ho = Soil depth from grade surface (m)
q = Distributed load on ground surface (T/sq.m)
H1 = Underground water level from grade surface (m)
y1 = Submerged weight of soil in water (T/sq.m)
yw = Unit weight of water (T/sq.m)
Ko = Ratio of horizontal to vertical pressure = $\tan^2 (45^o - Ø/2)$
Ø = Internal friction angle of soil = 30^o

3. Active and passive earth pressure acting on retaining wall shall be calculated from Coulomb's or Rankine's earth pressure equation.

(12) Liquid Pressure (LP)

1. Liquid pressure shall mean the pressure of liquid acting on the pit / basin structures
2. Liquid pressure shall be calculated by using the following equation

P1 = y x h1 (T/sq.m)

where

P1 = Liquid pressure (T/sq.m)
h1 = Depth from liquid surface (m)
y = Unit weight of liquid T/sq.m

(13) Traffic Loads

Traffic loads for plant engineering and construction shall be defined according to the governing condition at the time construction. Unless otherwise specified, appropriate IRC (Indian Road Congress) loading shall be applied to the design of road crossing constructions such as drainage pipes and cable trench.

(14) Combination of Loads

1) Types of Loads

Unless otherwise specified, all loads listed herein, shall be considered in the design
D = Dead loads
L = Live loads
W = Wind loads
S = Seismic loads
Equipment loads (Ee, Eo, Et)
Ee = On erection condition
Eo = On operation condition
Et = On test condition
P = Piping loads
H = Handling device loads
V = Vibration loads
T = Thermal loads
Ep = Earth pressure
Lp = Liquid pressure

(15) Loading Combinations

Buildings, structures, foundations, and all structural components shall generally be designed for the following load combinations

Sr.	**Load Combinations**	**Category of Loading Combinations**
1)	Loading combinations for buildings	
	D + L + H	A
	D + L + H* + W	B
	D + L + H* + S	B
	D + W	B
2)	Loading combinations for equipment supporting structures **	
	D + L + Eo + P + H + T	A
	D + l + Eo + P + H* + R + W	B
	D + l + Eo + P + H* + R + S	B

Sr.	Load Combinations	Category of Loading Combinations
	D + Ee + W	B
	D + L + Et + P + H*	A
3)	Loading combinations for pipe racks	
	D + L + P + T	A
	D + L + P + T + W	B
	D + L + P + T + S	B
4)	Loading combinations for equipment foundations	
	D + Eo + T	A
	D + Eo + T + W	B
	D + Eo + T + S	B
	D + Ee + W	B
	D + Et + 25% Wind	A
5)	Loading combinations for machine foundations	
	D + Eo + P	A
	D + Eo + P + V	A
6)	Loading combinations for sleeper and local support foundations	
	D + P + T	A
7)	Loading combinations for dykes, trenches and underground pits (***)	
	D + L + Ep + Lp	A

1) Notes

- A - Basic combination and no increase of allowable values shall be considered
- B - Combination considering wind loads/seismic forces or considering temporary erection. maintenance conditions
- (*) - Only dead load of handling device shall be considered in the design
- (**) - When the structural effect of the vibration loads are significant they shall be considered in the design.
- (***) - Traffic loads shall be considered, where required

(16) Load Factors for Limit State Design

Loads	**Item**	**Buildings (1)**				**Equipment Supporting Structures (2)**				
		Normal	**Wind**	**Eo**	**Stability**	**Normal**	**Wind**	**Eo**	**Erection**	**Test**
Dead loads	D	1.5	1.2	1.2	0.9/ ϕ 1.5	1.5	1.2	1.2	0.9 / ϕ 1.5	1.5
Live loads	L	1.5	1.2	1.2		1.5	1.2	1.2		1.5
Wind loads	W		1.2		1.5		1.2			
Seismic loads	S			1.2				1.2		
Equipment loads										
On erection condition	Ee								0.9 / ϕ 1.5	
On operation condition	Eo					1.5	1.2	1.2		
On test condition	Et									1.5
Piping loads	P					1.5	1.2	1.2		1.5
Handling device loads	H	1.5	1.2	1.2		1.5	1.2	1.2		1.5
Vibration loads	V									
Thermal loads	T					1.5	1.2	1.2		
Earth pressure	Ep									
Liquid pressure	Lp									

ϕ Value of 0.9 to be considered when stability against overturning of stress reversal is critical.

Loads	**Item**	**Pipe Racks (3)**			**Equipment Foundations (2)**				
		Normal	**Wind**	**Eo**	**Normal**	**Wind**	**Eo**	**Erection**	**Test**
Dead loads	D	1.5	1.2	1.2	1.5	1.2	1.2	1.2	1.5
Live loads	L	1.5	1.2	1.2					
Wind loads	W		1.2			1.2		1.2	1.5
Seismic loads	S			1.2			1.2		
Equipment loads									
On erection condition	Ee							1.2	
On operation condition	Eo				1.5	1.2	1.2		
On test condition	Et								1.5
Piping loads	P	1.5	1.2	1.2					
Handling device loads	H								
Vibration loads	V								
Thermal loads	T	1.5	1.2	1.2	1.5	1.2	1.2		
Earth pressure	Ep								
Liquid pressure	Lp								

Loads	**Item**	**Machine FDN (5)**		**Local FDN (6)**	**Dykes Trenches & U/G Pits (7)**
		Normal	**Vibration**	**Normal**	**Normal**
Dead loads	D	1.5	1.5	1.5	1.5
Live loads	L				1.5
Wind loads	W				
Seismic loads	S				
Equipment loads					
On erection condition	Ee				
On operation condition	Eo	1.5	1.5		
On test condition	Et				
Piping loads	P	1.5	1.5	1.5	
Handling device loads	H				
Vibration loads	V		1.5		
Thermal loads	T			1.5	
Earth pressure	Ep				1.5
Liquid pressure	Lp				1.5

(17) Safety Factors for Stability

All buildings, structures and foundations shall be designed, such that the safety factor shall not be less than the values mentioned before in any condition

Overturning : 1.5 during erection
: 1.5 during operation and testing
Sliding : 1.5
Buoyancy : 1.2

(18) Materials – Concrete

1) General

Unless otherwise specified in the drawings, material specifications shall conform to the following.

2) Cement

Cement used for all concrete works both above and below ground shall be ordinary Portland cement conforming to IS : 8112.

3) Aggregates

Aggregates used in the concrete works shall be locally available gravel or crushed stone conforming to IS : 383.

Unless otherwise specified, the maximum size of aggregates shall be as follows:

For large foundations and mass concrete	40 mm graded down (provided the pitch of reinforcement is more than 100 mm)
For others	20 mm graded down

4) Reinforcement

Reinforcement shall be high strength deformed bars and shall conform to IS: 1786.

5) Anchor Bolts

Anchor bolts shall be of structural steel quality conforming to IS: 2062.

6) Insert Plates

Insert plates shall be of structural steel quality conforming to IS: 2062 and shall be provided with mild steel lugs as per drawings/ standards.
Mild steel bars shall conform to IS: 432.

(19) Design Strength of Concrete

Unless otherwise specified, the design compressive strength of Cast-in-situ concrete at 28 days (conforming to IS: 456) shall be as follows:

Structural concrete (M 20)	200 kg/sq.cm
Liquid retaining structures (M 20)	200 kg/sq.cm
Paving (M 20)	200 kg/sq.cm
Grade slab (M 15)	150 kg/sq.cm
Leveling concrete (M 10)	100 kg/sq.cm
Filling / mass/ plum concrete (M 5)	50 kg/sq.cm

(20) Design Basis

1) Design Loads

1. Design loadings shall be as per design loads and shall be applied to the following
   - Design loads
   - Loading combinations
   - Safety factors for stability
   - Load factors for required strength
2. The calculation of stability and soil contact pressure of foundation shall be carried out on the basis of working load and allowable soil bearing capacity.
3. The resisting lateral force against the sliding of foundation shall generally be based on the friction force between the foundation and its supporting subsoil within factor of 0.5

2) Foundation Design Criteria

The foundation design criteria such as foundation depths, allowable soil bearing capacities, foundation settlement and soil design parameters shall be in accordance with relevant IS Codes and geotechnical survey report.

(21) Design Basis and Requirements

1. Framing systems shall be arranged so that the stiffness of structure can be well balanced and the structural stability can be secured
2. Expansion joints for the structure shall be provided every 45 to 50 meters in the longitudinal direction.
3. Structural analysis and section design shall be made in accordance with the applicable codes, standards and specifications and by using the authorised and approved methods.

4. In case of heavy and/or tall equipments installed on the reinforced concrete structure, the floor and beam arrangement shall be planned so that the firm anchoring and structural stability shall be assured.
5. Pits and basins shall be designed to withstand the water pressure, earth pressure, buoyancy and surcharge where required.

Pits and basins containing liquids shall be designed for both full and empty conditions and partition walls between compartments shall be designed for alternative liquid pressure on either side.

Dikes shall be designed to withstand the pressure of containing liquid for both full and empty conditions.

Liquid retaining structures shall be designed as per IS: 3370, with crack width criteria of 0.1 mm.

(22) Minimum Dimensions of Members

Member sizes shall be as per design requirements. However, minimum dimensions of structural members shall be as given below:

Grade slabs	150 mm thick
Floor slab (Non suspended)	150 mm thick
Floor slab (Suspended)	120 mm thick
Footings	200 mm thick
Underground pit/drain walls	150 mm thick
Water retaining walls	150 mm thick
Water retaining slabs (non suspended)	150 mm thick
Water retaining slabs (suspended)	120 mm thick
Columns and pedestals	230 mm width. 230 mm length
Beams	150 mm width. 300 mm depth
Insert plate	10 mm thick
Corner angle	8 mm thick

(23) Minimum Height of Plinth and Pedestals above Finished Grade Level

Building plinth	500 mm
Pedestals for structural columns	300 mm
Stair pedestals	200 mm
Ladder pedestals	200 mm
Equipment including pump etc.	300 mm

(24) Minimum Cover to Main Reinforcement

Reinforcement shall have concrete cover not less than twice the diameter of bar end. Minimum cover to main bar shall be:

1)	Slab	: Free face	25 mm
		: Face in contact with earth	30 mm
2)	Beam	: Top/Bottom	40 mm
		: Side	30 mm
		: Face in contact with earth	40 mm
3)	Column and pedestal	:Super structure	40 mm

		Face in contact with earth	40 mm
4)	Retaining wall	:Face in contact with earth	40 mm
	Basement and pit wall	:Free face	40 mm
5)	Liquid Retaining	:Face in contact with liquid	40 mm
	Structure :Face in contact with earth		40 mm
	Free face		40 mm
6)	Plinth beam	:Top and side	30 mm
		:Bottom	40 mm
7)	Foundation:	Bottom	50 mm
		:Top	50 mm

8) The above requirements shall not be applied to concrete construction of trench, local foundation, minor platform foundation, sump pit/manhole, paving and other miscellaneous concrete construction, for which minimum cover shall be 25 mm.

9) Minimum Bar Diameter

Major foundation	10 mm
Block foundation – main bars	10 mm
Block foundation – tie bars	8 mm
Minor foundation (local foundation etc.)	8 mm
Column, pedestal – main bars	12 mm
Column, pedestal – ties	8 mm
Beam – main bars	12 mm
Beam – anchor bars	10 mm
Beam – stirrups	8 mm
Slab – main bars	8 mm
Slab – distribution bars	8 mm
Wall – main bars	8 mm
Wall – distribution bars	8 mm
Minor elements such as chajjas, lintel beams etc.	8 mm

10) Bar Spacing[1]

	Minimum	**Maximum**
Foundations	125 mm	200 mm
Slabs	100 mm	300 mm
Stirrups for beams	100 mm	300 mm
Ties for columns, pedestals	100 mm	300 mm
Walls	100 mm	300 mm

(25) Foundations

1. Foundation shall be proportioned in such a way that the allowable soil bearing capacity is not exceeded and the resulting settlement is within the acceptable limit.
2. All major foundations shall be placed below the natural ground level even in places filled up during the site preparation.
3. Foundation sizes and depths shall be planned considering subsurface conditions and surrounding underground constructions such as adjacent foundations, underground pipes and cables, trenches, pits, roads as well as the slope of ground.

[1] Bar Spacing shall be provided in multiples of 25 mm

4. Isolated footing shall be planned for each foundation. However, where adjacent footings interfere with each other, combined footing may be provided.
5. Where applicable the elevation of foundation top shall be in accordance with the process, mechanical and piping requirements.

1) Foundations *for Rotating and Reciprocating Equipment*

1. Foundation for rotating and reciprocating equipment such as turbines, engines, compressors and generators shall be designed to secure the dynamic stability of the foundation system, as well as the static stability.
2. Dynamic stability for foundation supporting heavy vibrating equipment like the following shall be secured by dynamic analysis in general :
   - Heavy vibrating equipment
   - Equipment sensitive to vibration
   - Equipment causing large dynamic force

Unless otherwise specified foundation design shall follow general criteria indicated below :

Criteria		**Application**	
Dynamic analysis	Allowance amplitude2	Rotating	: P ≥ 400 kW
	Natural frequency of foundation	Reciprocating	: P ≥ 100 kW
	Natural frequency of foundation	Rotating	: P ≥ 100 kW
		Reciprocating	: P ≥ 40 kW
Foundation weight control	More than 3 x equip. Weight	Rotating	: P < 100 kW
	More than 5 x equip. Weight	Reciprocating	: P < 40 kW

P = Rated Power output of equipment (unit kW)

(26) General Requirements for Design

Following requirements shall be taken into account for foundation design in principle:

1. Foundation for heavy vibrating equipment shall be kept independent of building floors/foundations and other adjacent foundations.
2. Foundation weight shall be at least three times the weight of the rotating equipment and five times the weight of the reciprocating equipment
3. Foundation shall be of uniform rectangular/square shape.
4. Beams and columns of foundations shall be of uniform rectangular/square shape.
5. The horizontal eccentricity, in any direction, between the center of gravity of the machine - foundation system and the center of base contact area, shall be within 5%.
6. The geometric layout of the foundation and structure shall be basically symmetric with respect to the vertical plane passing through the rotational axis of the equipment.

(27) Dynamic Analysis

1) General

Dynamic analysis shall be performed by suitable and approved method so that dynamic features can be evaluated correctly.
The following effects shall be taken into account:

[2] If the Suppliers requirement is available, it shall be considered

- Dynamic features of subsoil
- Dynamic features of supporting foundation system
- Dynamic effect of the foundation system
- Dynamic forces of equipment

Data of dynamic load to be used for the dynamic analysis, shall be supplied by equipment supplier and shall state unbalanced force due to :

- Eccentricity of dynamic mass of rotating equipment
- Different crank arrangement of reciprocating equipment

2) Evaluation of Dynamic Analysis

Frequency Ratio
Wherever possible the natural frequency of the foundation soil-system shall be higher that the highest disturbing frequency and the frequency ratios shall be less than 0.7. Where this is not possible, the natural frequency of the foundation soil system shall be kept lower than the lowest disturbing frequency. The frequency ratio in such cases shall not be lower than 1.50. While the above criteria shall be applied to all possible modes of vibration, it may be permitted to operate machines closer to the resonance in certain modes of vibration provided the resulting amplitudes do not exceed the permissible limit.

3) Allowable Amplitude Due To Dynamic Load

Amplitude of the foundation systems for vibrating equipment shall be calculated through dynamic analysis by using dynamic analysis by using dynamic load supplied by supplier and the allowable amplitude shall conform to supplier's requirement.
If supplier's requirements on amplitude are not specified, following criteria shall be applied. The amplitude of vibration of the foundation in any direction, at any point in the foundation of structure shall be such that, it will fall down the zone ACC' for the specific exciting frequency.

(28) Design Details

1) Anchor Bolts

1. In case of no tension load in the anchor bolts of equipment such as small towers, tanks, heat exchangers, pumps, blowers, compressors, etc. Anchor bolts shall generally be set in anchor boxes unless embedment is required. Minimum distance between the inside surfaces of the anchor boxes and the outside surface of the foundation shall be 75 mm.
2. In general, anchor bolts for structural steel columns are embedded into the pedestal.
3. Anchor bolts for heavy towers, which are subject to pull out force, shall be embedded into the foundation at the time of placing concrete using templates.

2) Grouting

i) Unless otherwise specified by equipment manufacturers, top of foundations except for local foundations shall be provided with an allowance for grouting as specified below:
   a) Foundation for large heavy duty compressors, generator, etc. 50 mm
   b) Foundation for big towers (>20 m) 50 mm
   c) Other foundations 30 mm
ii) All grout shall bee composed of one part cement and two parts clean sand. Grout material for heavy rotating machines shall be used in accordance with manufacturer's requirement where required.

(29) Foundation for Steel Structure

1. Generally tops of all foundations except for local foundation shall be provided with grouting of 30 mm thickness
2. All grout shall be composed of one part cement and two parts clean sand unless otherwise specified.

(30) Covering for Pit/Basins

1. Open pits and basins without roofing or covering shall have safety railings. Stepladders shall also be provided for the pits and basins having a depth of more than 1.0m.
2. The minimum 600 mm diameter cover for access, shall be provided for Pits and Basins.

(31) Materials - Structural Steel

1) Design Basis and Requirements

1. Framing and bracing shall be planned so that the stiffness of the structure can be well balanced with the loads and the structural stability can be secured.
2. Vertical and horizontal bracings shall be arranged properly, considering the following requirements :
   - Plant layout
   - Equipment
   - Piping arrangement
   - Structural layout/construction, operation & maintenance requirement

   The vertical bracings furnished for lateral stability of structure may be knee braced, diagonal or "V" type and shall satisfy clearance and rigidity requirements.
3. Expansion joints for the structure shall be provided every 45 to 50 meters in the longitudinal direction
4. Structural analysis and members selections shall bee made in accordance with the applicable codes, standards and specifications and by using the authorised and approved methods

2) Bolt Holes

Bolt holes for structure bolts shall be as follows, unless otherwise specified on drawings.

a) Ordinary bolts : D + 2 mm
b) Anchor bolts : D + 5 mm

Where D = Nominal bolt diameter

3) Minimum Size of Structural Members

Columns, framing beams	:	ISMB 150, ISMC 150.
Bracing members	:	ISA 50 x 50 x 6
Column base plate		
For major structure	:	16 mm thick
For minor structure	:	12 mm thick

4) Gusset Plate

Thickness of gusset plate shall be a maximum of the followings:

a) Thickness required by design
b) mm

5) Connections

Unless otherwise specified.

1. Shop connections shall be welded and all welds shall be continuous structural welds. Where galvanizing is specified, seal welding is required at all shop connections prior to hot-dip galvanizing.
2. Field connections shall be bolted connections for all main framing and bracing members.
3. Field connection for ladder, handrails, post, stair stringers, removable members, platform framing members shall be made with black colts.
4. Bolted connection for structural members shall be made, with at least two bolts except for lacing bolts, where it may be with single bolt.
5. High tensile friction grip bolts shall be used for connections subjected to repetitive cycles of loadings.

6) Stopper to Hoist Beams

Removable stoppers, fixed with ordinary black bolts shall be provided on both sides of hoist beams.

7) Column Base

Steel column bases shall be designed to transfer all loads to the foundations or to the supporting reinforced concrete structure.

8) Deflection

Pipe Rack and Equipment Supporting Structure
Allowable deflection of beams and columns, to support pipe and / or equipment directly during normal operation, shall be as stated below, in fraction of the supported span of the beam.

i. Pipe rack beams : 1/325 or less but not more than 30 mm
ii. Equipment supporting structure
Equipment supporting beams : 1/400 or less but not more than 30 mm
Other beams : 1/325 or less but more than 30 mm
iii. Horizontal sway at top of column of each storey
For open framed structures : Height 1/200
For cladded structures : Height 1/400
iv. Cantilevers : 1/250 but more than 20 mm at end

Crane Girders
Allowable vertical and horizontal deflection of girders for traveling cranes during normal operation, depending on types, shall be as stated below, in fraction of the supported span of the girders.

i) Hand operated crane : 1/500
ii) Electric overhead traveling crane upto 50 T : 1/750
iii) Electric overhead traveling crane over 50 T : 1/ 1000
iv) Other moving loads such as charging cars : 1/ 600
v) Monorails and hoist beams : 1/500
vi) Joist : 1/ 325
vii) Purlins, furring strips : 1/200

(32) Floors, platforms and walkways

a) Platform and walkways shall be minimum 900 mm wide and shall be made of chequered plate flooring or grating flooring as specified in the drawings.
b) The minimum clear headroom over platforms and walkways shall be 2100 mm to the lowest point of overhead structural framing or equipment. This clearance may be reduced to 1800 mm locally for Support beams when structurally required.

c) Chequered plates shall be 6 mm thick.
d) Floor gratings shall typically be pressure locked or pressure welded type steel grating with bearing bars 25 x 5 mm x 30 centers with secondary cross bars 12 x 5 mm x 75 mm centers. Serrated style grating shall be used for stair treads. Landing and stair treads shall have full width chequered round nosing plates.
e) Openings more than 200 mm diameter on the floors, shall be guarded by surrounding toe plates of flat bar 100 x 6 mm.
f) Drip holes having 10 mm diameter shall be properly arranged on the chequered plate flooring of outdoor platforms and walkways.
g) High elevation platform and walkways around equipments (towers, tanks, etc.) shall be described in vessel standard and/or other engineering specifications.

(33) Staircases

a) Staircase shall be minimum 900 mm wide and shall be made of channel stringers with grating treads.
b) Unless otherwise specified, staircase shall have risers of not more than 200 mm and treads not less than 250 mm.
c) The vertical rise of stairs shall not exceed 4.0 m for the single unbroken flight.
d) The minimum length of landings shall be 900 mm in the direction of stairs.
e) The vertical clear headroom over stairs shall be 2100 mm.

(34) Ladders

a) Ladders shall be minimum 450 mm wide and shall be made of stringers with 20 mm diameters. MS rungs at 300 mm intervals.
b) The flight of Ladder without the intermediate platform shall not exceed 9 m.
c) Ladders over 4.0 m in height or originated from a point, which is 4.0 m or more above grade, shall be provided with safety cages, originating 2.1 m from the bottom.
d) Ladder access openings shall be provided with the safety chain.

(35) Hand Rails

a) Platform, walkways and stairs located 1 m above grade or floor shall be provided with handrails consisting of top rails, posts, mid-bars and toe plates.
b) Handrails shall be 1025 mm high.
c) All projecting cut edges on top rails be rounded to smooth finish

(36) Geotechnical Information

Five numbers of boreholes were taken at the identified site of Panka STP. The same data is used in the design of foundations.

(37) Reference

a) IS: 456 – 2000 : Code of practice for plain and reinforcement concrete (Incor. amendment no.1) (third revision)
b) IS:3370 – 1967 (Parts I to IV) Code of practice for concrete structures for the Storage of liquids
c) IS:269 – 1979 Specification for ordinary, rapid hardening and low heat Portland cement.
d) IS:875 – 1987 Code of practice of design load for building and structures (parts I to IV)
e) IS:1786 – 1979 Specifications for high yield deformed bars
f) IS:1893 – 1984 Criteria for earthquake resistant design of structures (fourth revision)

g) IS:4236 – 1993	Specification for earthquake resistant construction of building (second revision)
h) IS:1904 – 1986	Specification for design and construction of foundation in soils
i) IS:800 – 1984	Specification for general construction in steel
j) IS:2974 – 1979	Specification for design and construction of machine foundations
k) IS:13920 – 1993	Ductile detailing of reinforced concrete structures subjected to seismic forces
l) SP:34 (S&T)-1987	Handbook on concrete reinforcement and detailing
m) SP:16(S&T)-1980	Design aids for reinforcement concrete to IS:456 – 1978
n) SP:24-1983	Explanatory handbook on IS:456 – 1978
o) C.E.Reynolds	Reinforced concrete designer's handbook by J.C.Steedman
p) Jai Krishna	Plain and reinforced concrete Volume I & II – O.P Jain

6.1.2 Mechanical Works

The mechanical equipment consists of screens, grit removal mechanism, aerators, pumps, etc. The equipment is selected to suit the performance requirements and the prevailing site conditions. The requirements of mechanical equipment are described here under.

(1) Aluminium Gates

For the control of the flow and for maintenance of the mechanically raked screens, rising spindle aluminum gates are provided. The gates shall be single faced, rising spindle, flush bottom closing, wall mounted flange back frame. Aluminum sluice gates suitable for seating water head of 1.5m and mounting on the flat face of a wall, water sealing at two vertical sides, top an bottom side of gate frame by means of neoprene rubber seal fitted in gate aperture and having forced contact with gate slide, to be provided with aluminum frame and shutter, SS 304 spindle to suit distances as specified in the bill of quantities. All fasteners shall be in SS 304 and anchor bolts, EPDM rubber seals, SS 304 rubber seal retainer bars, CI stem guide bracket, SS 304 coupling, CI manually operated head stock.

(2) Screens

At STP, there will be six screen channels, each of 1800 mm width and 1000 mm liquid depth. Four channels are working which are provided with mechanical screens and two channels are standby which have manual screens. The mechanical screens will have 6mm clear opening and manual screens will have 12 mm clear openings.

1) Specifications of Mechanical Screens

Each mechanical screen shall mainly consist of the screen surface (bar screens), rotor arm (raking arrangement), chute and a drive system.

The frame is rigidly framed on all ends and anchored to the RCC channel top surface and to the bottom of the channel. The frame is curved in shape the curvature radius will match the rotor arm tip radius. The entire channel width and depth will be covered by the screen surface.
The rotor arm assembly will be placed on the inlet side of the screen. The rotor consists of two main Bearing Blocks having an axle running in their journals across the channel. Two rake arms at 180 degrees to each other, fixed to the axle, shall carry the retriever combs made of cast steel. The outer radius of the combs shall match the radius of the screen surface and the combs will engage into the bars to carry the trapped screenings to the top end of the screen. The bearing blocks are anchored to the RCC channel, parallel to the screen surface.

The cleaning rake will be revolving rake type with four steel combs. The rake will be suitably sized for heavy duty and shaped to effectively clean the bar screen. The sprocket chain will be split type. The screenings is to be dropped on conveyor about 600 mm above the top of the screen channel.

The chute shall be placed on the outlet side of the screen surface, near the top end and shall receive the screenings through an interceptor plate from the rotor arms combs. The client shall have to either place a conveyor belt to receive the screenings or have a mobile trolley under the chute.
The drive system operates the axle and correspondingly the rotor arms. The system consists of a motor of required HP driving a reduction gearbox, which in turn drives another gearbox through chain and sprocket transmission to obtain the desired RPM on the rotor. The system is assembled over a base frame that is anchored to the RCC channel top near the rotor.

The drive machinery includes TEFC motor, speed reducer, head shaft, etc. All fasteners will be of SS 316. All the steel structures shall be sand/ball blasted to near white and painted with two coats of zinc rich primer followed with two coats of epoxy paint.

The bar screens are fabricated from 50 mm x 10 mm mild steel flats spaced at required clear opening as mentioned above and fixed at an inclination of 75° to the structural steel frame work such that all bars project on upstream side and teeth of the rake engages within the clearances of the bars without hindrance.

A dead plate of not less than 6 mm thick is provided from top of the bar screen to prevent falling of screenings in the channel. It shall have pivot plate at the bottom for preventing jamming of bottom shaft. The complete unit above the floor will be totally enclosed with hinged clean out and inspection doors.

2) Conveyor

A common conveyor is provided for collecting screenings from four mechanised fine screens and will drop the screening in a trolley type container kept at one end of the conveyor for taking out the screening for disposal. The conveyor will also cover manually cleaned screen channel. The screening from manual screens will be put on conveyor manually.

Each assembly of conveyor will consist of two pulleys with their shaft and bearings for driving the belt and idler pulleys for supporting the belt. The upper level idler pulleys will have three roll twenty degree roughing idlers. The bottom level idlers for belt return will be flat roll-type.
At the end of the belt drive, an adjustable scrapper is provided on the screening hopper for diverting the screening through hopper to the container

The belt material will be two - ply nylon or equivalent with 3 mm neoprene covering on carrying side and 0.75 mm neoprene covering on pulley side. The speed of the belt will be between 25 m to 30 m per minutes. The width of the belt will be 750 mm

The power transmission will be by means of TEFC motor coupled to the reduction gears. The gears will have service factor of 2.

The whole conveyor will be supported on steel structure over the screen channel.

(3) Grit Chamber

Two grit chambers are provided for grit removal. It has a rotating grit scraping mechanism, adjustable influent deflector, reciprocating rake mechanism to remove the grit and organic return pump. The grit scraping mechanism shall have fixed bridge with rotating scrapper arms. The scrapper arms will have adjustable squeezes, which will scrap the grit to the grit sump. An overload alarm is provided. This arrangement will trip the machine in case of overload.

Suitable classifier mechanism along with the organic return pump will be provided. The reciprocating rake mechanism will lift the grit up. The reciprocating rake mechanism will be installed at about 35^{o}

inclination. Chute is located at the top, through chute grit will fall to the ground/container, for further disposal. A grit cleaning arrangement is provided to remove organic particles from the grit and is pumped back to the inlet by an organic pump.

(4) Sludge Pumps

There will be two sludge pumping stations to pump out the sludge to sludge drying beds. Each sludge pumping station will have two pumps, one working and one standby. The required capacity of these pumps is 50 cum/hr so that sludge withdrawal from all reactors is completed during general shift of eight hours, with sufficient safety in operating time. The operating head of the pump will be 10.0 m. The sludge volume to be withdrawn from UASB reactors is approximately 563 cum/day.

The sludge pumps will be of centrifugal, non-clog submersible cavity type. The specifications are mentioned in the following table.

1	Liquid	Sludge
2	Capacity	50 cum/hour
3	Head	10.0 m
4	Solids size	40mm hard, incompressible 80mm soft, compressible
5	Temperature	Ambient
6	Specific gravity	1.1
7	Installation type	Fixed
8	Casing material	2.0 - 2.5% Ni CI
9	Impeller material	CF 8M
10	Motor body	CI IS 210 Gr FG 260
11	Seal cover	CI IS 210 Gr FG 260
12	Shaft	AISI 410
13	Guide pipe and chain	SS 304
14	Top cover	CI IS 210 Gr FG 260
15	Motor rating	30 kW
16	Motor RPM	Less than 980
17	Rated voltage	415 V
18	Frequency	50 Hz

The pump will have automatic coupling arrangement at discharge end for removal and refixing of the pump from top. A guide pipe/wire rope will be provided for smooth removal and lowering of pumps.

(5) Floating Type Aerators

8 nos. of 50 HP aerators are provided in the first compartment of facultative type of aerated lagoon. The purpose of aeration is for removal of anerobicity of the effluent and also for removal of residual BOD and sulphides present in the effluent from UASB reactor. These aerators will be of slow speed. The aerators will have minimum capacity of 1.5 kg oxygen/kWh oxygen transfer under field condition. The aerator will be fabricated from mild steel sheets of not less than 3 mm. The aerators will be dynamically balanced. The gears will be helical-type with service factor not less than 2.

The motors will be with TEFC enclosure. The aerators will be sand/ball blasted and will be epoxy painted after applying zinc rich primer.

Aerator are provided with helical gear box with a service factor of 2, casing in horizontal split condition with integrally cast mounting blocks with casing to facilitate 150mm adjustment of aerator

cone in water. Also, aerators are provided with dry well arrangement on output shaft to make the output end of gear box leak proof.

Mounting studs with lock nuts and fasteners shall be in SS304

Rectangular/circular floats shall be in MS duly FRP coated with 4mm FRP lining thickness, hydraulically tested with mounting platform and handrails. The floats will be filled with polyurethane foam and will have ballast compartment at both ends to fill the ballast made up of RCC cubes to stabilise the floating aerator operation in water.

Mooring arrangement of nylon rope of sufficient length to secure floating aerator with RCC column shall be provided. Each float will be provided with lifting hooks and hooks for connecting mooring arrangement.

(6) Monorail Trolley and Chain Pulley Block

Monorail trolley and the chain pulley block will be provided for lifting of sludge pump. The trolley and the chain pulley block will be hand driven. The capacity of trolley and chain pulley block is 1 tonne, which is sufficient to remove complete pump set.

The trolley will be gear-less and will have four wheels to run on the lower flange of the rolled steel joist. The wheels will be of carbon steel casting. The trolley will have arrangement to fix the chain pulley block.
The chain pulley block will have spur type gears, load sheave, brake unit, hand chain wheel, loan chain wheel and hooks for suspension on monorail trolley and load.

(7) Biogas Holder

The biogas produced is to be utilised for power generation using fuel engine generator. The expected maximum gas generation will be about 1000 m^3/day. The capacity of biogas holder is provided for its storage for 6 hrs of retention time. The generation will depend on ambient temperature. To have uniform supply of required gas for power generation a gasholder has been included. Provision has been made for flaring of gas if there is excess.

The gas produced in the UASB reactors is to be led to the gasholder through a moisture trap and gas flow meter. The tap-offs are provided after the gas pipe enters the gasholder, one going to the generator room for supply to dual fuel engines and the other to the gas flaring equipment.

The biogas holder will be of the wet type with a sealing of water. The biogas holder would be a RCC circular structure. The gas dome would be fabricated from mild steel plate having minimum 6 mm thickness. Guide rails embedded in RCC structure facilitate the vertical movement of the gas dome. The gas dome surface shall be coated with 350-micron thickness.

One pressure release valve will be provided at the top of the dome, which will open out when the level reaches 100% value. One high-level limit switch will be provided at 95% to give an audible alarm signal in the control room.
At low-level, say 20%, the running engines will be shut off and the biogas holder will be allowed to rise again. However, in case of heavy leakage, or otherwise, if the level goes to a very low level of say 5%, the vacuum breaking glass will break and will prevent the biogas holder from any damages due to vacuum condition.

(8) Chlorine Mixer

Mechanical chlorine mixers suitable for a tank of size of 7.5m x 7.5m x 2.5m SWD are required. These mixers shall comprise of a suitable reduction gear box of worm wheel type driven by a 5 HP motor. It shall have turbine type impeller in SS 304 with output speed of 36 RPM.

(9) Gas Scrubber Unit and Gas Blowers

The biogas produced from the reactors contains corrosive gas H_2S at about 1% concentration and is at a very low pressuring (100 to 250 mm water column).
The biogas has to be supplied at 0.4 kg/sq.cm to the gas engine. H_2S content in the biogas shall be less than 0.1%. Thus the biogas needs to be pressurised and H_2S is to be reduced to less than 0.1%. The biogas consumption is about 135 cum/hr at full load. The gas scrubber and blower system is designed for 135 cum/hr.

First, H_2S is removed in scrubber. In the scrubber, the H_2S containing gas is contacted in counter current mode with a scrubbing liquid. Absorption of H_2S occurs in the scrubber under certain specific conditions and a chemical reaction with metal ions takes place.
H_2S when dissolved in aqueous medium is ionized to H+ and S^{2-}. The sulfur ions can be oxidized by polyvalent metal ions, such as those irons, which can exist in ferric (Fe^{3+}) or Ferrous (Fe^{2+}) form. When sulphide ion comes in contact with ferric ion, it is oxidized to elemental sulfur and gets precipitated. The ferric ion is in turn reduced to ferrous form. This reaction can be written as

$$2Fe^{3} + S^{2-}$$
$$= \quad 2\,Fe^{2+} + S$$

The ferrous ions can later be oxidized to ferric ions by reaction with oxygen in the atmosphere air. The oxidation of ferrous ion can be written as

$$4\,Fe^{2+} + O_2 + 4\,H^{+} = 4\,Fe^{3+} + 2\,H_2O$$

A root type blower has been considered to increase the pressure and since the engine may run at different times the biogas pressure is raised upto 1 kg/sq.cm and stored in a pressure vessel. The blower will operate on pressure switches and will be generally operated when biogas pressure in the pressure vessel drops below 0.6 kg/sq.cm and will stop as soon as the pressure develops to 1 kg/sq.cm. Since raising of gas pressure increases the temperature of the gas, an after cooler is provided. The cooling of the blower and after cooler will have cooling tower and cooling water pump.

(10) Biogas Flaring System

Gas flaring system will be installed to burn excess biogas generated at the STP. The burning capacity of the flare will be 250 cum/hr. The biogas flaring system will consist of the following:

- Moisture separator
- Flame arresters on pilot and main gas burner
- Non-return valve
- Pressure relief valve
- Flare gas burner (6m height from ground level)
- Pilot gas burner with push button ignition complete with ignition electrode
- Fusion plug

(11) Pure Gas Engine

1) Working Principal

A pure gas engine is has a conversion kit to run the engine with biogas. Gaseous fuel is added to the air, which is included at air intake manifold or before turbocharger. This mixture of air and gas is compressed in the cylinder just as air compressed in normal IC engine.

2) Components for Pure Gas Engines

- Gas engine
- Governor
- Direct coupling between alternator and the engine
- Air filtration
- All mountings shall be anti vibration type
- Gas train consisting of solenoid valve, regulator, low/high pressure switch, and filter
- All necessary safety measures
- Necessary accessories
- Alternator of required rating
- Fabrication of gas piping between regulator and gas control valve and air intake connection

The following aspects on auxiliary and utility system shall be taken into consideration for gas utilisation systems:

- Inlet air system,
- Filter or duplex filter to be located at an elevated position to prevent ingress of dust,
- Air inlet silencer, and
- All piping, ducting, supports, instrumentation and control.

3) Exhaust Gas System

Ducting with thickness 6mm, expansion joints upstream and down stream of turbocharger (if provided), silencer insulation etc. stack leading outside the building at safe height from ground level.

4) Safety Requirement

1. Anti vibration mounting for engine and alternators.
2. Enclosure ventilation/ cooling fans with drives.
3. Enclosure lighting
4. Inspection opening in the frame to permit easy inspection of the driving gear, lube oil pump, bearing etc.
5. Gas and fire detection system.
6. Explosion valve in DG room maintenance doors.
7. Crank case explosion relief valve.
8. Compression relief valve.

5) Cooling Water System

The cooling water system shall consist of the following:

1. Primary and secondary cooling water system (closed cycle) for engine cooling, lube oil cooling (if applicable) start up air compressor cooling (if applicable) etc.
2. For primary circuit, one CW pump shall be engine driven. During standby conditions, the engine jacket water shall be kept warm by means of thermostatically controlled electric heaters.

(12) Fire Fighting

Suitable number of portable extinguishers CO_2 and dry powder type shall be provided for all pump house, gas engine room, electrical and control room at strategic locations as per Indian tariff, advisor committee rules/ NFPA standards.

(13) Maintenance of Crane/ Hoists

Composite hoist double girder electrically operated overhead crane shall be provided for gas engine room.

(14) Ventilation Fans

Suitable number of ventilation fans shall be provided in gas engine room.

(15) Lube Oil System

- Motor driven pre-lube pump
- Duplex lube oil filter.
- Oil mist pipe leading to atmosphere at safe height.
- Lube oil centrifuges if necessary.
-

(16) Specific Requirements

1. All equipment and plant shall conform to the provision of statutory and other regulations in force in India and/ or in the state of Uttar Pradesh and local municipal authority such as Indian electricity act., Indian explosives act., Indian electricity rules, Environmental rules, obtaining of all permissions and approvals from the statutory authorities shall be the responsibility of the contractor.
2. All electrical and instruments in fuel gas and fuel oil system shall be flame proof/ intrinsically safe type/ increased safety type as per statutory rule prevailing in India.
3. All gas vent/ relief valve discharge shall be led to atmosphere at safe height.
4. Suitable drain and vents with valve shall be provided at lowest and highest points as per site layout.
5. All high temperature piping and ducting shall be insulated to keep outside surface temperature at $60^{o}C$ (worst ambient temp).
6. Level switches shall be provided in gasholder for automatic operation of gas burners.
7. All gas vent line shall be provided with flame arrestor.
8. Cooling tower shall be provided for cooling and shall be designed for total load arising from charge air cooling, lube oil cooling and engine cooling, booster compressor and re-circulation gas compressor cooling (if applicable).
9. The power generation plant shall be designed so that quality of liquid effluent if any shall meet the requirement of IS :2490.
10. All controls (electrical/ pneumatic devices) have failed safe features with redundancy as per good engineering practice.
11. All atmospheric tanks shall be designed to IS:803 or equivalent.
12. All pressure vessels shall be designed as per ASME SEC-VIII or IS-2825 or equivalent.
13. Pure gas engine alternator shall be packaged skid mounted type.
14. Generator plant shall be continuously rated and shall be suitable for black start. In particular the engine set shall be capable of start-up and running without water supply system for a minimum period of three (3) minutes for achieving black start.
15. All pumps in power generation package shall have 50% or minimum one stand by.
16. Generator shall be able to start when room temperature is 4 deg cel.
17. All valves in fuel oil shall be of welded construction. All drain and vent valves in lube oil line shall be lockable type. Lube oil lines after filters upto bearings shall be of stainless steel. Oil cooler tubes shall be of stainless steel.

(17) Instrumentation and control

Each generator unit shall be provided with complete instrumentation and control system for safe and reliable operation. The standard instrumentation and control system shall include the following relay based control

1. Pressure and temperature gauge for lube oil, primary and secondary CW, fuel oil, fuel gas, inlet and out let of engine, heat exchangers/ coolers, exhaust gas temp. outlet from cylinder and turbo charger (if applicable), pressure gauge for each pump discharge.
2. Gas flow meter inlet to engine.
3. Fault detectors with pressure and temperature switches for status indication, alarm and trip for high CW temperature, low lube oil pressure, high lube oil temp., high charge air temp. (if applicable) high and low fuel oil level in service tank, gas pressure low, low fuel oil pressure, makeup/ expansion water level low, pre lube oil pressure, high charge air temp., fire alarm, gas detection, air starting OK, vibration detection, over speed , over voltage , control air, pressure low, crankcase pressure abnormal starting fault, engine exhaust temperature - high and low etc.
4. Engine speed, running hour meter, watt meter etc,
5. Emergency stop-push button, auto manual selector switch.
6. Differential pressure gauge across lube oil and fuel oil strainer.
7. All tanks shall be provided with level gauge. Level switches shall be provided for fuel oil tanks.
8. Emergency shutdown provision acting on signal from gas detection equipment.
9. Thermostatic control in lube oil and CW system, charge air circuit by-pass shall be provided to control lube oil and jacket water temp.

(18) Layout

Layout of the powerhouse shall be developed to ensure operability maintainability and conformity to good engineering practice and suitable for future expansion. Suitable lay down area shall be provided for maintenance in powerhouse at one end. Necessary statutory clearance shall be observed while locating HT equipment and fuel oil installation.

Suitable platforms, walkways, stairs and handrails shall be provided for access and walk space for operation. Separate electrical room annex in engine room shall be provided for housing electrical equipment and panels. Space for office shall be provided adjacent to electrical room.

Necessary access to all on base equipment i.e. lubes oil console, fuel oil tanks, CW console etc. shall be provided. Space will be required for all heat exchangers.

Space provision in electrical equipment placement shall envisage safety clearances as per factory rules and IS rules as well as adequacy of same for maintenance, testing and data logging for panel boards, generators transformers and cabling.

6.1.3 Electrical & Instrumentation Works

The electrical system design for STP is based on electrical load requirements, i.e. connected load and peak load for functional and lighting requirements in various areas of the plant. The basic equipments are aerators, coarse & fine screens, grit removal mechanism, sewage pumps, aerators, chlorine mixer, chlorination system, sludge pumps, air compressors system and gas scrubbers etc. The utilities are administrative building with laboratory, panel room, plant area lighting, staff quarters etc.

The power distribution system to the plant has been considered based on the peak load requirements and captive power available from pure gas engine.

From installation and operation point of view, two main load centres are proposed, one for TSPS and one for STP. The installations for TSPS have been discussed in the earlier section.

The STP shall have one outdoor substation for receiving power from UPSEB. The power from UPSEB metering panel shall be fed to HT vacuum circuit breaker (VCB) panel with outgoing transformer feeder. HP power from VCB panel shall be fed to the transformer installed in the same substation. One main electrical panel shall be installed in the electrical panel room.

One pure gas engine is proposed which shall be installed in the gas engine room. The power form pure gas engine panel shall be fed to aerators and other panels installed in a room near to the aeration tanks. This panel shall have two supplies, one from pure gas engine and other from local electric supply company - Uttar Pradesh State Electricity Board (UPSEB), which can be switched on in case of failure of the pure gas engine or insufficient availability of biogas. Power produced from pure gas engine will be supplied only to this panel (for aerators and chemical house & chlorination system load), as the generated power is sufficient only to take care of this load only. Since synchronising of captive generator and UPSEB's supply is not considered, as it is normally not permitted, interlocking provision is made between two supplies, so that only one supply can be put on at a time. The complete load of this load centre shall be generally on pure gas engine supply. In case of non-availability of pure gas engine power supply, this load centre shall be switched over to UPSEB power. The biogas produced from the reactors will be utilised for the pure gas engine.

The electrical system incorporates all safety requirements as per I.E. rules and all the components considered be as per relevant IS standards. The single line diagram, as enclosed, provides general requirements of various units of electrical distribution system.

The various equipments and panels considered at STP are :

a) Main electrical panel
b) Aerator and chlorine house panels
c) Fine screen & grit chamber panel
d) Compressor panel
e) Gas scrubber panel
f) Sludge pump panels
g) Filtrate pump panels
h) Main lighting panel
i) Sub lighting panels
j) Administrative block cum laboratory power distribution board
k) Staff quarter power distribution board

(1) Power Supply

The electrical supply system for the STP will be as given hereunder:-

1) Normal Power Supply

UPSEB power for the TSPS & STP is proposed to get from the nearby UPSEB switchyard. It is presumed that power from the nearby UPSEB switchyard shall be released at 33kV by laying an overhead transmission line up to the TSPS site. Cost of this transmission line is covered under costing of TSPS. This power from the UPSEB metering panel to be installed at the point of supply in the TSPS, shall be received at the 33kV VCB panel proposed to feed 33kV power to TSPS as well as STP transformers.

In STP, 33 kV UPSEB power shall be fed from the main 33 kV VCB panel at TSPS. 33 kV power from this VCB panel at TSPS shall be transmitted to STP site by laying overhead transmission line. Power from transmission line shall be received at 33 kV outdoor isolator proposed to be installed near MEP room at STP. One 33 kV VCB panel shall be installed in MEP room which will receive power from outdoor isolator and will feed this power to transformers. Two numbers of transformers are

proposed for each STP. Each transformer shall be rated to run the entire plant load. Power stepped down to 0.433 kV shall be fed to MEP by laying 1.1 kV 3.5 core cable.

The entire plant will be operated on 415 V, 3-Phase, 50 c/s 3 wire/4 wire system for which, one main electrical panel will be provided. The variation in the voltage is considered as ±10% and frequency as ±10% and combined voltage and frequency variation ± 3%.

Power for entire plant equipments and utilities shall be distributed from this panel.

2) Gas Engine Supply

The proposed STP will have its own generation system utilising the produced biogas with pure gas engine. One pure gas engine is proposed in STP area, which shall be capable of taking the entire load of aeration and chlorine house panel.

Both the supplies will operate independently and no paralleling will be done at any time.

6.1.4 Utilities

(1) Administration Building

Administrative block cum laboratory building of built-up area of 240 sqm is proposed at Panka STP. The proposed administrative block is a double storey structure. The laboratory is also provided in the same administrative building.

The laboratory along with rooms for plant manager and the supporting staff are provided in the administrative block. A storeroom for storing the chemicals and other materials is also provided. The office block is also equipped with a kitchen and sanitation facility.

(2) Laboratory

Laboratory for analysing the wastewater and sludge samples is proposed at the STP. It is located in the ground floor. The laboratory will be equipped with the required equipment so as to analyse the following parameters:

- pH,
- Bio-chemical oxygen demand (BOD),
- Chemical oxygen demand (COD),
- Total suspended solids (TSS),
- Total dissolved solids (TDS),
- Total solids (TS),
- Volatile suspended solids (VSS),
- Volatile fatty acids (VFA),
- Alkalinity,
- Sulphates,
- Sulphides,
- Nitrates,
- Sludge stability,
- Gases (CH_4, H_2S etc.)
- Fecal coliform count.

The working platforms in the laboratory are provided with glazed white tiles. Mosaic flooring is proposed in the laboratory. Sinks with water taps are proposed for cleaning of the glassware and other equipment. The list of laboratory equipment is presented in Table no. 6.4.

Table 6.4 : List of Laboratory Apparatus and Equipment

Sr.	Particular	Nos.
A	**Instrument**	
1	Oil free diaphragm type vacuum cum pressure pump	1
2	Laboratory hot air oven	1
3	Muffle furnace	1
4	Digital fully automatic electronically controlled BOD incubator	1
5	Electronically controlled incubator, 37 Degree Celsius	1
6	Specific ion electrodes of Orion USA make, Model-901. 1. Cyanide, 2. Chromium, 3. Copper, 4. Arsenic, 5. Mercury, 6. Boron, 7. Manganese, 8. Nickel, 9. Lead, 10. Cadmium, 11. Sulphide, 12. Silver, 13. Selenium.	1 each
7	Autoclave (vertical) working pressure 5.2 lb.psi 750 x 500 mm with SS basket, inner chamber SS, 6 kW with pedal lifting, pressure and temperature gauges and water level indicator with insulated radial locking arrangement	1
8	COD apparatus with 6 hot plates	1
9	Colony counter	1
10	Gas analyzer for CH_4, H_{2S}	1
11	UV-VS Spectrophotometer with personal computer	1
12	Gas chromatograph with thermal detector	1
13	Electron detector with printer, gas column	1
14	Refrigerator	1
15	Electronic single pan balance	1
B	**Air conditioning for laboratory and office building**	
1	1.5 tonne capacity room air conditioner	1
2	Air cooler for office	3
3	Personal computer and printer for data analysis and plant monitoring	2

(3) Water Supply

The STP is provided with water from the proposed tube well station. This tube well will also take care of the water requirement for the gardening, fire hydrant and other miscellaneous uses as well.
The water distribution will be done by means of 100 mm AC pipes for the administrative and staff quarters. Hydrants with valves are provided for cleaning and flushing of the units. Sufficient residual pressure will be available for cleaning purposes.

(4) Waste Collection and Disposal

Liquid Wastes

Liquid waste, generated at within the STP premises, is storm water as well as the sewage from the utility of the STP. Open drains of 230 mm x 300 mm depth are provided to take care of the water logging at STP. Sanitation facilities are provided for the proposed administrative building and the staff quarters. The sewage from the administrative block and staff quarters will be discharged into the sump well of main pumping station within the STP premises.

Solid Wastes

The solid waste generated within the treatment plant will be from the following units:

Screen Chamber

Large amount of floating materials and other inert material like cloth, plastic, wood etc will be there in the raw sewage. Screens are used to stop these materials into the treatment plant units. Two screens, one of 12 mm clear opening alongwith 25 x 25 mm aluminum wire mesh is provided. The screenings collected will be transferred to the conveyor belt and thus into a chute. The screenings will be transported to the disposal site by means of trucks/trailers.

Grit Chambers

Grit will be removed from the grit chamber by mechanical means. The grit removed from the tank will be taken to the near by landfill sites by means of wheelbarrows.

Staff Quarters and Office Building

The domestic solid waste from the administrative building and the staff quarters will be collected in the dust bins. Staff quarters will be provided with masonry dust bins of 1.5 x 1.5 x 1.25m depth, at the place of transporting points. The waste, which arises by street sweepings, will be transferred to the transporting points. The solid waste from the transporting points will be transferred to the disposal site by means of trucks or trailers.

(5) Security Room

Security will be provided to guard against vandalism of the STP property. The security staff is provided with a room at the gate for giving shelter against the vagrancy of the nature. The shelter will be made of brick masonry with RCC roof. The shelter will have the necessary electrical and mechanical furnishings as deemed necessary.

(6) Staff Quarters

Staff quarter will be provided at the treatment plant site for the operating and maintenance staff. The costs for providing the same have been included in the cost estimates of the treatment plants. Based on the NRCD guidelines, staff quarters are provided only for the staff at the operating level.

Table 6.5: Type and Size of Proposed Staff Quarters

Sr.	Designation	Type of Quarters	Plinth Area (sq.m)	Number of Quarters
1	Watchmen, gardeners and sweepers	A	34.2	4 (double storey)
2	Chemist & operator	B	45.6	7 (single storey)
3	Junior engineer	C	62.7	1 (single storey)
4	Sub-divisional engineer	D	86	1 (single storey)

(7) Internal Roads

The various units as well as facilities of the treatment plant are provided with a 4.0 meter wide asphalt road for comfortable movement of men and material within the plant premises. At places where vehicular traffic is not expected, particularly above underground/surface pipes or insufficient space for laying of roads, brick pavement having a width of 1.0 meter are proposed so that there is access from the 4.0 meter road to the destination.

(8) Plant Lighting

Sodium vapour lamps mounted on 9 m height steel/aluminium tubular pole are provided at every 30.0 m interval on the road for sufficient illumination and provide the treatment plant personnel with a smooth, glare and accident free environment due to bad illumination.

(9) Green Belt

There will be a green belt zone all around the treatment plant. The green belt will have various trees at every 20 meter interval, as they act as air purifiers. This will help in circumventing to some extent the odour problem in the eventuality of an improper operation of the treatment plant. Besides, a green belt will act as natural screen against the outside populace.

(10) Bypass Arrangement

A bypass arrangement has been considered for the STP in case of breakdowns. This is provided from downstream of grit chamber to downstream of UASB reactors. Here onwards, two different bypass arrangements shall be provided where one will connect to the facultative aerated lagoon and the other one will connect directly to the treated effluent channel.

Appendix A 9.1

SOIL ANALYSIS REPORT

Sl. No.	Parameters / Tests		La Martienierie Pumping Station / Power House	Cis Gomti Sewage Pumping Station	Mastemau site sample
			I	II	III
	Physico-Chemical & Metals				
1.	pH (Electrode method)		8.26	8.39	9.81
2.	Conductivity	μS/cm	228.0	79.0	225.0
3.	Moisture Content	%	2.66	4.34	20.0
4.	Bulk Density	g/c.cm	1.32	1.22	1.19
5.	Organic Carbon	%	0.26	0.25	0.19
6.	Chloride as Cl^- (ILC)	μg/gm	188.5	48.25	60.15
7.	Sulphate as SO_4^{-2} (ILC)	μg/gm	290.25	54.6	97.4
8.	Nitrate as NO_3 (ILC)	μg/gm	181.25	39.3	38.1
9.	Fluoride (ILC)	μg/gm	17.85	9.15	12.87
10.	Phosphate as P (ILC)	μg/gm	2.48	10.17	1.97
11.	Iron as Fe (AAS)	μg/gm	22976.35	17307.5	28348.8
12.	Calcium as Ca (AAS)	μg/gm	3594.65	4284.65	4994.65
13.	Sodium as Na (ILC)	μg/gm	782.94	339.4	1526.0
14.	Potassium as K (ILC)	μg/gm	15.47	25.27	14.5

Appendix A9.2

RESULTS OF PRIMARY GROUNDWATER SURVEY

Sr. No.	Sampling Point	Date	Color	Odor	pH	Conductivity msm-1	Hardness mg/l	Calcium mg/l	Turbidity NTU	Chloride NH_3	Alkalinity mg/l	TDS mg/l
1.	Borewell water Mr. Hira Lal Yadav	23.11.04	Colorless	Odorless	7.62	1.48	200.0	190.0	18.2	22.0	292.0	154.0
2.	Borewell water Mr. J.O. Sharma Farm	23.11.04	Colorless	Odorless	7.72	0.77	190.0	170.0	20.0	55.0	290.0	128.0
3.	Martinpura borewell water UPPCL Power House	23.11.04	Colorless	Odorless	7.63	0.76	148.0	126.0	22.0	21.0	384.0	112.0
4.	Pipra Ghat Vasahat Near 2/2 Railway Phatak bore well water	23.11.04	Colorless	Odorless	6.54	0.76	130.0	116.0	18.0	14.0	408.0	122.0
5.	Cis Gomti sewage pumping station borewell water	23.11.04	Colorless	Odorless	7.97	1.13	120.0	78.0	22.0	46.0	400.0	148.0
6.	Shri Ram Verma bore well water Sikandar Nagar	23.11.04	Colorless	Odorless	7.37	0.88	208.0	110.0	104.0	35.0	418.0	133.0

HEAVY METAL ANALYSIS

Sr. No.	Sampling Point	Date	Copper mg/l	Chromium mg/l	Zinc mg/l	Lead mg/l	*Cadmium mg/l	*Iron mg/l
1.	Borewell water Mr. Hira Lal Yadav	23.11.04	0.02	Nil	0.092	Nil	-	-
2.	Borewell water Mr. J.O. Sharma Farm	23.11.04	0.13	Nil	0.865	Nil	-	-
3.	Martinpura borewell water UPPCL Power House	23.11.04	0.16	Nil		Nil	-	-
4.	Pipra Ghat Vasahat Near 2/2 Railway Phatak bore well water	23.11.04	0.21	Nil	0.454	Nil	-	-
5.	Cis Gomti sewage pumping station borewell water	23.11.04	0.24	Nil	0.422	Nil	-	-
6.	Shri Ram Verma bore well water Sikandar Nagar	23.11.04	0.02	Nil	0.704	Nil	-	-

- Was not analysed due to problem in Lamp

Appendix A9-3 List of Plot Owners at Proposed STP Site (Mastemau)

Sr.	Gata No.	Area (ha)	Owner Name
1	1	0.013	Gaya Prasad etc.
2	2	0.076	Ramkumar Shivkumar, etc.
3	3	0.307	Gaya Prasad, etc
4	4	1.345	N.P
5	5	0.291	Kamladevi, etc.
6	6	0.565	Rambarose, etc
7	7	1.220	Ramsevak, etc
8	8	0.721	Dayaram Pardin, etc
9	9	0.679	Rampal, etc
10	10	0.354	Gaya Prasad, etc
11	11	0.291	Ishwardeep, etc.
12	12	0.714	Ramavatar, etc
13	13	0.326	Shravankumar, etc
14	14	0.329	Manjupande, etc
15	15	0.253	Jagatnarayan, etc
16	18	0.342	Ramprasad, etc
17	19	0.141	Thakurji Radhakrishna, etc
18	20	0.468	Harishankar, etc
19	22	0.516	Ramlakhan, etc
20	23	0.506	Radhakrishna, etc
21	24	0.496	Malilram Verma, etc
22	25	0.493	Malilram Verma, etc
23	26	0.509	Shravankumar, etc
24	27	0.114	Shravankumar, etc
25	28	0.164	Shravankumar, etc
26	29	0.506	Sarochiskumar, etc.
27	30	0.114	Ramadhar, etc
28	31	0.335	Jagatnarayan, etc
29	32	0.269	Ramesh Naresh, etc
30	33	0.474	Bhanjar
31	34	0.316	Vinod Kumar Singh, etc.
32	35	0.360	Ramdulal Munshilal, etc
33	36	1.024	Dayashankar Ramdayal, etc.
34	37	0.506	Vinod Kumar Singh, etc.
35	38	0.506	Durgaprasad, etc.
36	39	0.139	Ramsharan, etc
37	40	0.158	Ramsharan, etc
38	41	0.135	Anilkumar, etc
39	42	0.114	Anilkumar, etc
40	43	0.297	Radhakrishna, etc
41	44	0.211	Maikulal, etc.
42	45	0.218	Ramesh Rajesh Ramadevi, etc.
43	46	0.347	Sunil Kumar, etc.
44	47	0.202	Sunil Kumar, etc.
45	48	0.329	Ramgopal Paunchilal, etc.
46	49	0.076	Navmilal, etc.
47	50	0.063	Ramjanki Thakur, etc.
48	51	0.057	Ramjanki Thakur, etc.
49	52	0.069	Ramjanki Thakur, etc.
50	53	0.110	Ramesh Rajesh Ramadevi, etc.
51	54	0.417	Sunil Kumar, etc.
52	55	0.193	Rajankumar Misra, etc.
53	56	0.449	Shambahadur Singh, etc
54	57	0.493	Dayashankar Ramdayal, etc.
55	58	0.610	Dayashankar Ramdayal, etc.
56	59	0.155	Dayashankar Ramdayal, etc.

Sr.	Gata No.	Area (ha)	Owner Name
57	60	0.397	Dayashankar Ramdayal, etc.
58	61	0.379	Shivpal Mukesh Kumar, etc.
59	62	1.594	Dayashankar Ramdayal, etc.
60	63	0.879	Radheshyam Ramvilas, etc
61	68	0.091	Rampal, etc.
62	69	0.092	Rampal Pujari, etc
63	70	0.092	Mahavir, etc
64	71	0.093	Gurudeep, etc.
65	73	0.177	Ramjanki Thakur, etc.
66	75	0.020	Nalla
67	76	0.772	Purvidin, etc.
68	77	1.096	Manju Pandey, etc.
69	78	0.008	Nalla
70	79	0.350	Banshilal Bihari, etc.
71	80	0.350	Sunderlal Bihari, etc
72	81	0.035	Nalla
73	82	0.380	Shivshankar
74	83	0.670	Shivraj Roopchand, etc.
75	84	0.834	Kalawati
76	86	0.783	Ramesh, Naresh
77	87	0.520	Road
78	88	0.783	Ramadhar, etc
79	89	0.532	Ramsevak, etc
80	90	0.212	Shivpal Mukesh Kumar, etc.
81	91	0.691	Jagatnarayan, etc
82	92	0.055	Road
83	93	0.024	Drain (Gram sabha)
84	94	0.514	Nankau
85	95	0.553	Shivkumar Avasti, etc.
86	96	0.699	Shivprasad, etc
87	97	1.256	Durgaprasad, etc.
88	98	0.573	Babulal Mohanlal, etc.
89	99	0.633	Pratap Yadav, etc
90	100	0.019	Chackmarg (Gram sabha)
91	101	0.017	Drain (Gram sabha)
92	102	0.550	Shri Radhakrishna Thakur
93	103	1.252	Navipati, etc.
94	104	0.237	Satayanarayan Lalaram, etc.
95	105	0.253	Ramnath, etc.
96	106	1.477	Keshan Nanhe, etc
97	107	0.005	Drain (Gram sabha)
98	110	0.278	Vijay Kumar / Sravan Kumar
99	111	0.240	Jagatnarayan, etc
100	112	0.253	Sunil Kumar, etc.
101	113	0.088	Nalla
102	114	1.115	Ramnath
103	115	0.402	Uma Dutt / Hanumant
104	116	0.221	Kishore
105	117	0.031	Chackmarg (Gram sabha)
106	118	0.813	lalu
107	119	0.859	Gaya Prasad
108	120	0.021	Nalla
109	121	0.870	Kalicharan
110	122	0.781	Ram Gulam / Munshi Lal etc.
111	123	1.099	Gaya Prasad
112	124/1, 124/2	0.353, 0.354	Umesh Kumar / Ashok Kumar
113	125	0.722	Mayaram
114	126	0.152	Road

Sr.	Gata No.	Area (ha)	Owner Name
115	127	0.503	Kuntilal, etc
116	163	0.431	Ram Charan
117	207	0.020	Nalla
118	210	0.459	Ram Janki/Thakurdwara Truct, Raghurai
119	211	0.038	Navmilal, etc.
120	213	0.147	Road
121	214	0.312	Babadin
122	215	0.443	Gaya Prasad
123	216	0.316	Dayaram Nanhe, etc
124	217	0.208	Dayashankar Ramdayal, etc.
125	218	0.350	Dayashankar Ramdayal, etc.
126	219	0.219	Mansharam, etc.
127	220	0.251	Ramadhar
128	221	0.010	Nalla
129	222	0.041	Road
130	223	0.347	Ramgopal Rajeshkumar, etc.
131	224	0.025	Road
132	225	0.347	Ram Narayan
133	226	0.061	Kuldeep / Pradeep Kumar
134	227	0.961	Sripal / Satau etc.
135	228	0.420	Dayashankar Ramdayal, etc.
136	229	0.506	Puttilal / Shivraj
137	279	6.552	Tarai / Gram Panchayat
138	100	0.022	Main Road
139	101	0.030	Nalla
140	107	0.043	Nalla
141	108	0.058	Main Road
142	109	0.038	Road
143	77	1.096	Manjupande, etc
144	86	0.783	Ramesh Naresh, etc
145	10./1207	1.265	Ramgulam Munshilal, etc.
			Village - Bakkas
146	1	0.588	Gomti River
147	2	0.474	Ram Bilas s/o Bhola etc.
148	3/1, 3/2	0.101	Smt Aparna Watal C/o 2- lakh
149	4	0.287	Arjun Singh s/o Sitaram, etc., C. H. Singh s/o Sitaram, Jai
150	5	0.519	Arjun Singh s/o Sitaram, etc., C. H. Singh s/o Sitaram, Jai
151	6	0.338	Sarju Gajraj Shivprasad c/o Govind Raju Rajesh Rajjha
152	7	0.259	Pyaralal Ram Sanjivan Prem Madanlal Virendra c/o
153	8	0.123	Vikram Ramadhar, Smt. Ishwardevi
154	9	0.699	Smt. Vishundevi w/o Babu
155	10	0.253	Sriram s/o Kallu
156	11	0.531	Cheda s/o Sushma
157	13	0.506	Rajeshwar kumar, Sunil Kumar, Ravimohan, Nirmaldevi,
158	14	0.060	Rajesh, etc.
159	15	0.519	Rajesh, etc.
160	16/1, 16/2	0.117 , 1.379	Shripal Chandrapal s/o Parikshit Hedakant, s/o Smt
161	17	0.651	Bhagwant Manoharlal
162	18	0.439	Tripal etc.
163	19	0.481	Arjun Singh, etc.
164	20	0.341	Vikram etc. s/o Baijnath
165	21	0.379	Smt. Vishundevi w/o Babu
166	22	0.054	Prem etc. Ramchandra Lalla
167	23	0.506	Natha Singh s/o Maikulal
168	24	0.215	Santlal etc. s/o Bhagwandas
169	25	0.412	Gomti Prasad s/o Jagdeo
170	26	0.159	Gomti Prasad. Etc.
171	27	0.173	Gomti Prasad. Etc.

Sr.	Gata No.	Area (ha)	Owner Name
172	28	0.142	Ram kumar, etc.
173	29	0.948	Ram Sevak etc.
174	30	0.114	Ragunath Prasad, etc.
175	31	0.477	Ragunath Prasad, etc.
176	32	0.417	Rampal s/o Totaram
177	33 - 1, 2, 3, 4	1.011	Ram Chandra, etc.
178	34	0.114	Smr. Gauri etc.
179	35	0.367	Ram Sewak s/o Dheerandas, etc.
180	36	0.278	Smt. Aparna Vatal
181	37	0.699	Ramnaresh, etc.
182	38	0.095	Nadi Gomti
183	39	0.531	Ramkumar etc.
184	40	0.357	Rak Krupal, etc.
185	41/1, 41/2	0.139, 0.284	Pannalal, etc., Jayan Raman
186	42	0.645	Mahesh s/o Pyarelal, etc.
187	43/1, 43/2	0.279, 0.280	Saligram / Satyanarayan s/o Kallu
188	44	0.847	Ramnaresh Raju Bahadur, s/o Mathura
189	45/1, 45/2, 45/3	0.170, 0.177, 0.1	Shamlal s/o , Dheersingh, etc,
190	46	0.537	Sukhdev, etc.
191	47	0.531	Mewalal, etc.
192	48	0.563	Arjun Singh,e tc.
193	49	0.711	Prem etc.
194	50	0.632	Akbar, etc.
195	51	0.721	Pareedi, etc.
196	52	0.436	Arjun Singh etc., Charan Singh, Jai Singh
197	53	0.664	Arjun Singh etc., Charan Singh, Jai Singh
198	54	0.620	Sarju, etc.
199	55	1.265	Jagat Narayan, etc.
200	56	0.537	Keshav, etc
201	57	0.411	Panna Lal s/o Cheda, etc.
202	58	0.506	Ramsevak, etc.
203	59	0.771	Smt. Shastridevi, etc.
204	60	0.190	Mahesh, etc.
205	61	0.196	Ram Swaroop, etc.
206	62/1, 62/2	0.717, 0.200	Vikram etc, Ayodhya Prasad, Ganshyam Prasad.
207	131	0.506	Ramkumar etc.
208	132	0.392	Baba Jagmohandas, etc.
209	133	0.357	Baba Jagmohandas, etc.
210	134	0.132	Ramlal etc.
211	135	0.297	Santram, etc
212	136	0.202	Pyare, etc.
213	137	0.224	Rahie, etc.
214	138	0.019	Ram Kuvar Singh, etc.
215	139	0.034	Banjar
216	140	0.246	Ram Kuvar Singh, etc.
217	141	0.101	Ram Kuvar Singh, etc.
218	142	0.266	Santram, etc
219	143	0.047	Santram, etc
220	144	0.101	Sripal, etc.
221	145	0.275	Sripal, etc.
222	147	0.234	Sripal, etc.
223	148	0.461	Jungle
224	150	0.196	Balram, etc.
225	151	0.231	Jagat Narayan, etc.
226	152	0.063	Jungle
227	153	0.228	Jagat Narayan, etc.
228	154	0.405	Bhagwan, etc.
229	155	0.392	Bhagwan, etc.

Sr.	Gata No.	Area (ha)	Owner Name
230	156	0.016	Bhagwan, etc.
231	157	0.237	Rahie, etc.
232	158	0.341	Rahie, etc.
233	159	0.319	Prem etc.
234	160	0.063	Bhangar
235	161	0.300	Hulli
236	162	0.297	Balram, etc.
237	163	0.006	Balram, etc.
238	164	0.689	Banjarlal, etc.
239	165	0.224	Jagat Narayan, etc.
240	166	0.009	
241	167	0.711	Santram, etc
242	168	0.044	
243	169	0.461	Ramlal, etc.
244	170	0.376	Santram, etc
245	171	0.385	Santram, etc
246	172	0.034	Banjar
247	173	0.388	Punvapi, etc.
248	174	0.272	Balram, etc
249	175	0.044	Kuvarlal, Pulchand, Ramnaresh, Kishore, Keshav.
250	176	0.196	Balram, etc
251	177	0.047	Smt. Meena
252	178	0.367	Kanayalal, Ramkilavat
253	179	0.038	Smt. Meenana
254	180	0.155	Ramkumar
255	181	0.183	Matadin Ramadin
256	182	0.420	Ramsadan Molhe
257	183	0.436	Sarju
258	184	0.847	Ramnath Keshav
259	185	0.164	Sriram, etc
260	186	0.272	Sriram, etc
261	188	0.224	Rambalak
262	189	0.443	Smt. Meenana
263	190	0.028	Smt. Meenana
264	191	0.410	Abadi
265	192	0.051	Bhagwan, etc.
266	193	0.173	Bhagwan, etc.
267	194	0.082, 0.044	Jungle
268	195	0.031	Jungle
269	196	0.104	Bhagwan, etc.
270	197	0.253	Ramsharan, etc
271	198	0.142	Ramsharan, etc
272	199	0.170	Ramsharan, etc
273	200	0.443	Rambalak
274	201	0.089	Matadin Ramadin
275	202	0.101	Matadin Ramadin
276	203	0.120	Rampratap Ramdin
277	204	0.224	Prem etc.
278	205	0.132	Prem etc.
279	207	0.360	Ramvilas, etc.
280	208	0.237	Ramvilas, etc.
281	209	0.177	Santram, etc
282	210	0.132	Rahie, etc.
283	211	0.190	Ashakti and Ramrathi
284	212	0.085	Ashakti and Ramrathi
285	213	0.006	Ashakti and Ramrathi
286	214	0.316	Ramrathi Santoshkumar
287	215	0.135	Hariram Ramgulam

Sr.	Gata No.	Area (ha)	Owner Name
288	216	0.076	Ramnath
289	217	0.051	Ramnath
290	218	0.089	Paridhin
291	219	0.183	Ramnath
292	220	0.388	Banjar
293	221	0.313	Panalal, etc.
294	222	0.259	Munilal, etc.
295	223/1, 223/2	0.557, 0.531	Kurena, etc., Smt. Chandrakala
296	224	0.550	Smt. Neetaram
297	225	0.228	Kanayalal, etc.
298	226	0.388	Shreekeshan
299	227	0.370	Smt. Meethana
300	228	0.357	Jagdev, etc.
301	229	0.357	Phulchand
302	230	0.089	Phulchand
303	231	0.626	Prem etc.
304	232	0.135	Ramvilas, etc.
305	233/1, 233/2	0.117, 0.104	Matadin Ramprasad Shobha
306	234	0.095	Shobha
307	235	0.095	Premramchandra
308	236	0.082	Cheda, etc.
309	237	0.164	Lala, etc.
310	238	0.057	Lala, etc.
311	239	0.109	Lala, etc.
312	240/1, 240/2	0.199, 0.338	Deksha Aksh, Dubre Aksh
313	241	0.117	Shobha
314	242	0.120	Smt. Meenana
315	243	0.253	Smt. Meenana
316	244	0.082	Jagatnarayan, etc.
317	245	0.120	Smt. Meenana
318	246	0.142	Smt. Gauri, etc
319	247	0.269	Smt. Gauri, etc
320	248	0.484	Smt. Gauri, etc
321	249	0.107	Ramvilas, etc.
322	250	0.057	Duber Gangaram
323	251	0.069	Ramvilas, etc.
324	252	0.089	Duber etc.
325	253	0.196	Smt. Gauridevi, etc.
326	254	0.069	Smt. Gauridevi, etc.
327	255	0.120	Jagatnarayan, etc.
328	256	0.139	Jagatnarayan, etc.
329	257	0.329	Virendrakumar, etc.
330	258	0.228	Virendrakumar, etc.
331	259	0.019	Virendrakumar, etc.
332	260	0.019	Rakeshkumar
333	261	0.044	Rakeshkumar
334	262	0.107	Rakeshkumar
335	263	0.095	Virendrakumar, etc.
336	264	0.145	Ramsharan,. Etc.
337	265	0.190	Smt. Garui
338	266	0.205	Jagatnarayan, etc.
339	267/1, 267/2	0.490, 0.187	Brijkumar, Hariprasad
340	268	0.123	Shripal, etc
341	269	0.626	Hariprasad
342	270	0.066	Smt. Meethana
343	271	0.044	Smt. Meethana
344	272	0.025	Akbar, etc.
345	273	0.114	Jungle

Sr.	Gata No.	Area (ha)	Owner Name
346	274	0.063	Jagatnarayan, etc.
347	275	0.066	Akbar, etc.
348	276	0.076	Akbar, etc.
349	277	0.104	Prem, etc
350	278	0.013	Prem, etc
351	279	0.101	Prem, etc
352	280	0.069	Jagatnarayan, etc.
353	281	1.075	Ramkishore, Ramsuchin
354	282	0.060	Bhagrang, etc..
355	283	0.072	Bhagwant, etc.
356	284	0.101	Bhagwant, etc.
357	285	0.006	Bhagwant, etc.
358	286	0.006	Bhagwant, etc.
359	287	0.066	Bhagwant, etc.
360	288	0.038	Bhagwant, etc.
361	289	0.085	Bhagwant, etc.
362	290	0.095	Bhagwant, etc.
363	291	0.234	Jungle
364	292	0.164	Parideen etc.
365	293	0.126	Parideen etc.
366	294	0.044	Parideen etc.
367	295	0.038	Parideen etc.
368	296	0.060	Bajrang etc.
369	297	0.076	Bajrang etc.
370	298	0.110	Smt. Meenana
371	299	0.089	Chandra Pal, Rammilan, Kilash Bahadur
372	300	0.145	Jagdev, etc
373	301	0.069	Smt. Pithararamgopal
374	302	0.063	Hulli
375	303	0.076	Smt. Pithara, etc.
376	304	0.161	Hulli
377	305	0.152	Gram Panchayat
378	306	0.038	Gram Panchayat
379	322	0.107	Talaab
380	323	0.414	Mathuraprasad Gangadin Mahadev
381	324	0.734	Prem, etc
382	393	0.126	Ram Vilas etc.
383	394	0.070	Ram Vilas etc.
384	395	0.038	Bhangar
385	396	0.193	Chandra Pal
386	397	0.114	Jaidev Prasad
387	400	0.240	Ram Vilas etc.
388	401	0.321	Baba Jagmohandas, Etc.
389	402	0.331	Jaidev Prasad, etc.
390	403	0.474	Ramsharan, etc.
391	404	0.342	Punvasi, etc.
392	405	0.382	Pachprem, etc
393	406	0.218	Pachprem, etc
394	407	0.461	Balaram, etc
395	408	0.297	Santalal, etc.
396	409	0.398	Smt. Pithara, etc.
397	410	0.481	Duber, etc. Leela Bhanilal
398	411	0.162	Asharfi etc. Ramvati
399	412	0.079	Ramkumar Radhashayam
400	413	0.069	Baba Jagmohandas,
401	414	0.281	Ram Kumar etc.
402	415	0.016	Ram Kumar etc.
403	416	0.347	Ram Kumar etc.

Sr.	Gata No.	Area (ha)	Owner Name
404	417	0.202	Ramjiavan
405	418	0.145	Ramjiavan
406	419	0.417	Smt. Meenana, etc
407	420	0.316	Ramlalan, etc,
408	421	0.670	Mewalal, etc
409	422	0.426	Kallu, etc.
410	423	0.063	Naseer
411	424	0.249	Rakesh Kumar, etc
412	425	0.136	Banjar
413	426	0.253	Pannalal etc.
414	450	0.120	Gram Panchayat
415	459	0.287	Hariram etc.
416	460	0.246	Jaya Narayan
417	461	0.259	Umar Pal etc. s/o Babulal, Kumbarpal
418	462	0.259	Umar Pal etc. s/o Babulal, Kumbarpal
419	463	0.107	Virendra Kumar etc.
420	464	0.098	Santaram
421	465	0.098	Naseer
422	468	0.170	Prem etc.
423	469	0.196	Nusrat Ali etc.
424	476	0.322	Naseer s/o Basheer
425	477	0.120	Abaadi, Nazool
426	478	0.038	Abaadi, Nazool
427	479	0.069	Abaadi, Nazool
428	483	0.126	Dhirkhaya, etc
429	506	0.129	Vikram, Kisun s/o Nanha
430	508	0.294	Hariram etc.
431	509	0.072	Kumari Reena / Kurjan
432	510	0.177	Kumari Reena / Kurjan
433	511	0.190	Naushad
434	512	0.215	Naushad
435	513	0.025	Kumari Reena Kurjan
436	514	0.076	Pannalal s/o Chedda
437	518	0.379	Pannalal s/o Chedda
438	519/1, 519/2	0.379	Parideen s/o Maiku, Paridhi
439		0.658	