DELHI METRO RAIL CORPORATION

ENVIRONMENTAL IMPACT ASSESSMENT FOR PHASE-II CORRIDORS OF DELHI METRO

AUGUST 2005

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ABBREVIATIONS

BIS	:	**Bureau of Indian Standards**
CBD	:	Central Business District
CPCB	:	Central Pollution Control Board
MoEF	:	Ministry of Environment & Forests
DMRC	:	Delhi Metro Rail Corporation
CO	:	Carbon monoxide
CRRI	:	Central Road Research Institute
dB(A)	:	Decibel
DDA	:	Delhi Development Authority
DMA	:	Delhi Metropolitan Area
DPR	:	Detailed Project Report
DMP	:	Delhi Master Plan
DTC	:	Delhi Transport Corporation
DUA	:	Delhi Urban Area
DUT	:	Delhi Urban Territory
EIA	:	Environmental Impact Assessment
EMP	:	Environmental Management Plan
ha	:	Hectare
HCS	:	High Capacity System
IMD	:	India Meteorological Department
ISBT	:	Inter State Bus Terminus
ISI	:	Indian Standard Institution
IS	:	Indian Standards
Km/hr	:	Kilometre per Hour
m	:	Metre
MLD	:	Million litres per day
Mm^3	:	Million Cubic Metre
mm	:	Millimeter

MRTS	:	Mass Rapid Transport System
NCR	:	National Capital Region
NO_x	:	Nitrogen Oxides
%	:	Percentage
Pkm	:	Passenger Kilometer
PHPDT	:	Peak Hour Peak Direction Trips
PHRS	:	Passenger Hours
RITES	:	Rail India Technical and Economic Services
SPM	:	Suspended Particulate Matter
SO_2	:	Sulphur-di-oxide
PIU	:	Project Implementation Unit

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CHAPTER – 0
EXECUTIVE SUMMARY

0.1 INTRODUCTION

It is proposed to develop a Mass Rapid Transport System (MRTS) to meet the future transport demands of Delhi, using an optimal mix of over ground rail and underground metro systems. The mass transport needs of Delhi are currently met mainly by buses. The bus system is operated by Delhi Transport Corporation (DTC) assisted by private operators. It has, however, not been able to meet the expectations of Delhi commuters. The basic reason for this is the ever increasing average trip length (13 kms) with corresponding increase in journey time to about 60 minutes. In city buses, trip length beyond 5 to 7 kms or journey time more than 25 to 30 minutes becomes uncomfortable and tiring. The bus services are over crowded and unreliable, with long waiting periods at bus stops. This has resulted in growing use of personal vehicles leading to increase in road congestion, delays, fuel wastage and environmental pollution.

In addition the Phase-I of Delhi Metro Shahdara-Trinagar-Barwala is already in operation. The existing railway network within Delhi comprises two rings and four radials(144 Kms) also meet the transport requirements in Delhi. RITES has prepared project feasibility Report and also conducted Environmental Impact Assessment study for Phase I of the proposed MRTS Project.

0.1.1 Format of the Report

The report has been prepared in eight chapters and an Executive Summary. This is the **Chapter-0** titled Executive Summary and it presents key findings. **Chapter-1** gives a brief Introduction about Delhi on population, vehicles and scope of work. **Chapter-2** analyses the need for the project, construction schedules, cost estimates etc. **Chapter-3** summarises environmental baseline data, including physical, biological and socio-economic parameters and pre-project environmental constraints such as problems related to air pollution, water, noise, public health and traffic congestion. Potential negative and positive impacts are presented in **Chapters 4 and 5** respectively. An Environmental Management Plan has been outlined in **Chapter-6,** while **Chapter- 7** suggests post project Environmental Monitoring Programme. Finally a summary of the costs of the environmental management and monitoring programmes is presented in **Chapter-8.**

0.1.2 The Approach

Several important aspects of the existing environment in and around the project site were monitored and supplementary relevant data was obtained from various Government and Private organisations. The proposed transport network and its operating characteristics provided details of likely emissions and effluents, which would affect the environment. Taking these into account, an assessment has been made of the significant consequences for the existing environment in the area. Finally, recommendations for mitigating the impacts and monitoring the environment on a continuous basis have been formulated along with an environmental management plan as also disaster management and emergency information systems.

0.2. PROJECT DESCRIPTION

The present EIA report deals with the MRTS Phase-II which includes six corridors mainly (I) Viswa Vidyalaya- Jahangiri Puri (ii) Central Secretariat- Qutub Minar (iii) Shahdara- Dilshad Garden (iv) Indraprastha – New Ashok Nagar (v) Yamuna Bank – Anand Vihar (vi) Kirti Nagar - Mundka. The total length of this Phase – II is 53.02 Kms.

0.2.1 Future Needs of Transport

The Delhi population will increase from 12.79 million 2001 to 23 million in the project horizon year 2021, out of which, 9.66million people will be employed. The road network of Delhi (30m or wider right of way) which was 652 km in 1981, 994 km in 1993 and 1122 Km in 2001is planned to increase to 1340 km in 2021. It is predicted that by the year 2001, 450 km (40%of roads network will carry trips in excess of 10,000 Peak Hour Peak Direction Trips (PHPDT), out of which 150 km of roads will carry trips in excess of 20,000 PHPDT. Based on the carrying capacity of a bus system, atleast 40% of roads will not be able to cope with the transport demand in the year 2021.

To meet future transport demand by buses, it is estimated that future number of buses will increase two and half times and that of personal vehicles three times. It is also estimated that 148 km of additional roads with associated infrastructure such as flyovers, bus terminals, maintenance depots and car parks will be required by 2021. Assuming 45m wide right of way, approximately 981ha of land will be required for. this purpose. It is difficult to acquire so much land, particularly In core city area. Hence the road/ bus system alone cannot meet the future demands of transport.

0.2.2 Mass Rapid Transport System

RITES has studied different alternatives for Mass Rapid Transport System for Delhi. The project is planned in two phases. The first phase planned to be commissioned by 2005, will cover a distance of about 62.16 km while full development will cover a distance of over 294.86 km. In the second phase, about 8.93 km will be underground, 42.24km elevated and 1.85 km at grade and would carryout 28.7 million trips per day in the year 2021. In all, there will be 45 stations in this phase-II.

The salient features of the project for Metro (Underground) and Rail (above ground) corridors in respect of rolling stock, power supply, traction system and signalling are summarised in feasibility report. The coaches will be light weight of 3.66m width, with electro-pneumatic brakes for rail corridor and 3.2 m width for metro corridor with regenerative brakes. The power/traction system will be 750 V DC and 25 KV AC for Metro and Rail Corridors respectively, with necessary traction sub-stations. Automatic, solid state, interlocking type of signals have been planned. The temperature and humidity of underground metro stations are planned to be controlled at 30°C and 70% respectively, with chilled water type plant. Facilities such as escalators, lifts and pumps, illuminations, emergency light, telecommunication, fare control, fire detection and control are also planned.

The second phase will cost about Rs. 69840 million. This cost is excluding custom duty and work tax including general charges @ 3% on all items except land and

rolling stock and 3% contingencies on all items including general charges as per April 2004 prices.

0.3. ENVIRONMENTAL BASELINE DATA

The Environmental baseline data collected for EIA study includes Physiography, geology and soils, ground water hydrology, flora and fauna, meteorology, air pollution, noise, socio-economics and landuse pattern.

0.3.1 Physiography, Geology and Soils

Considerable variation in micro-relief is noticeable. However, the average gradient of the terrain at 1.0 m/km is gentle. Over burden is mostly clay of low plasticity, containing high percentage of silt. Sandy to silty clay has been observed in North-South corridor. Chemical composition of soils has indicated the properties as pH (7.1-8.8), organic content (7.4%), Nitrogen (347-3397 kg/ha) and Phosphate (8-347 kg/ha).

0.3.2 Ground Water Hydrology

Delhi receives two seasonal rainfalls. These are due to South-West and North-East monsoons. About 75% of rainfall occurs during July to September due to South-West monsoon. The annual average rainfall is 660mm. Ground Water occurs in silty to sandy layers of the alluvial sediments and also in the jointed quartzite having secondary permeability under unconfined conditions. Semi confined aquifer zones are present below 150m depth. The permeability varies from 0.5 to 8m per day and transmissivity from 10 to100 m^2/day. The depth of water table is observed between 3 to 7m below ground level. The slope of the water table is away from the ridge on either side. Hydraulic gradient is gentle and of the order of 1.8m to 2.0m per km. The ground water quality has not indicated any parameter likely to affect on under ground structures.

0.3.3 Flora and Fauna

As such, no forest area exists along the railway alignment or in its corridor. Most of the trees were planted along road side in the past. There are 5147 trees enroute. The main species are Pipal, Neem, Kikar, Eucalyptus, Ashok, Mango, Bhor etc. No rare or endangered species of trees has been observed during field studies. There is no wildlife park/reserve in or around the project area.

0.3.4 Air Quality

The main sources of air pollution in Delhi are vehicles, thermal power plants and industries. Vehicles contribute about 70% of total ambient air pollution. The main fuels used in vehicles are petrol, diesel and CNG. Guru Teg Bahadur Chowk, Azadpur Chowk, Sanjay Gandhi Transport Nagar, Green Park, New Ashok Nagar and Sarai Chowk areas are highly polluted. At present, the observed mean monthly concentrations of pollutants are SPM (295 to 1655 $\mu g/m^3$) and Nitrogen oxides (15 to 63 $\mu g/m^3$) during a year. The SPM maximum concentrations are three to four times more than the acceptable standards.

0.3.5 Noise

The noise levels in Delhi vary from 54 dB(A) to 84.6 dB(A). The highest level is near the main highway with horn blowing. In the heart of the city area, it varies from 60 dB(A) to 78 dB(A).

0.3.6 Socio-Economics

MRTS Phase-II project most of the routes are on Government lands. About 4.22 ha land will be acquired from private owners. The total land requirement will be about 160.12 ha. About 300 jhuggies in Yamuna River area have to be removed who have occupied the area illegally and will/or may create rehabilitation and resettlement problems. The socio-economic pattern was assessed for these areas. As many as 56.1% people are male as against 43.9% female. Male to Female ration is 1.28:1 maximum number of male in Kirti Nagar to Mundka corridor being 65%. Maximum number of people (40.1 %) falling in the age group of 15-35 years, 33.9% belong to the age of 36-60 years. Remaining 20.7% and 5.2 % people belong to the age of below 14 years and above 60 years respectively. The mean average age of the people is 30.34 years. Majorities of population are Hindu (92.5%). The proportion of the people belonging to Muslim (6.4%) and Jain (1.1%) religions. Majority of the people (42.6%) are belongs to General Castes. But the second largest group of the people belongs to Scheduled Castes (38.3%), followed by those coming from other Backward Castes (19.1%). About 25.5% of project affected people studied up to college, 21.2% up to middle, 19.8 % up to primary and 19.6% up to high school. It is important to note that remaining 13.9% are illiterate. The occupation of majority OF people (53.2%) are engaged in business activities and remaining 40.4% and 6.4% of them are engaged in daily wages activities and service respectively. About 38.3% of families have their income less than Rs. 25,000/-, 44.7% of them have an income of Rs.25001-100,000/- per annum. About 12.7 % of the families have an income range between Rs.100,000 to 200,000 per annum. Remaining 4.2% of the families have an income more than Rs. 200,000/- per annum. Most of the families are small 47.9%, 30.8 % are medium, 11.7% are large in size and remaining 9.6 % are individual. The mean average size of family is 4 members. Most of the project affected families (44.7%) are squatters have been staying on the government land whereas 30.8% and 24.5% of people having structure in leased and in their owned land.

0.4. NEGATIVE ENVIRONMENTAL IMPACTS

For the assessment of negative environmental impacts, the following issues have been discussed for various activities of project cycle namely;

- Impacts due to project location,
- Impacts due to project design,
- Impacts due to project construction, and
- Impacts due to project operation.

0.4.1 IMPACT DUE TO PROJECT LOCATION

During this phase, those impacts which are likely to take place due to the layout of the project, have been assessed. These impacts are as follows:

a) Rehabilitation and Resettlement

About 658 families are likely to be affected due to the project. The total population in these families is about 2632 people. People are likely to be affected because of acquisition of land for this project.

About 160.12 ha of land is likely to be utilised for the project, out of which 97% belongs to Government Departments, and 3% private, (residential, commercial and agriculture). There is no forest in the project area. However planted trees do exist throughout the project layout. In all, 5147number of trees are likely be lost during the project construction. There is no encroachment on nature reserves as the project area is in urban centre. No rare or endangered species have been observed in project area. There is no cultural monuments on the proposed alignment.

b) Drainage and Utilities Problems

The project may dislocate/disrupt under ground telephone & electric lines, water Supply, sewerage and drainage systems. It is estimated that 5.11 km of sewer/storm water, 5.59 km of water supply and 6.65 km of underground electric lines will be dislocated. Support to water supply pipes, telephone and electric lines need to be provided during construction. Sewerage and drainage systems underground need to be relocated/diverted before starting the construction phase.

0.4.2 IMPACTS DUE TO PROJECT DESIGN

Design of entry & exit to station, ventilation and lighting, and risk of earthquake need to be incorporated in the designs of the project. In normal operating conditions the platform and other areas are designed to accommodate 1.5 to 2.5 persons per sq.m, under emergency conditions, the platforms, inlets and outlets are designed to dis-embark a full train load. The platform, concourse halls, staircase and escalator areas will have adequate and uniform fluorescent light (i.e 250 lux) to provide pleasant and cheerful environment. Delhi lies in zone-IV of seismological zones. Earthquakes of 3 to 6.7magnitude on Richter scale have occurred in the past. The India Meteorological Department has considered seismic factor which need to be incorporated adequately for design purposes of Civil Engineering structures in this zone. The implementation of the project is not likely to increase seismic activity in the region.

0.4.3 IMPACTS DUE TO PROJECT CONSTRUCTION

The impacts due to construction works are mostly of temporary nature. The likely impacts due to construction works are:

a) Soil Erosion, Pollution and Health Risk at Construction Sites

The runoff from unprotected excavated areas, quarry sites and underground tunnel faces can result in excessive soil erosion. Mitigation measures include careful planning, timing of cut and fill operations and revegetation. The construction spoils (concrete, bricks), waste materials etc. may cause water pollution. The health risk and cultural hazards could be avoided by providing water supply and sanitation facilities in construction camps and by employing local labour.

b) Traffic Diversions and Risk To Existing Building

During construction phase, there will be a need for traffic diversions. These diversions need to be planned well in advance and communicated to the public through Mass Media. The rail corridor does not pose any risk to existing buildings. However, sufficient care has to be taken for metro corridor. In this case it will be appropriate to carry out stability analysis before taking up construction activities.

c) Problem of Excavated soil Disposal problem & seepage risk

Construction activities involve cut and cover, tunnelling, foundation laying, filling of .embankment. These activities will generate 2.5 $Mm^3$of soil (cutting 1.0 Mm^3 and filling 1.2 Mm^3). Out of this, 0.03 Mm^3 is likely to be reutilised in filling and about 1.2 Mm^3 in Yamuna depot and the balance 0.23Mm^3 will be will be needed for filling purpose.

d) Dust Generation

Estimates of quantities of construction material required for the project indicate that transportation of about 1.2 Mm^3 of earth and other materials will be necessary. It is assumed that the material will be hauled over a period of 280 days in year. The truck movement required to transport the soil/ earth will be about 140 truck trips per day for the entire length. Equal number of trips will be required to transport construction material at site.

e) Increased Water Demand

The water demand will increase during construction phase. Sufficient water for construction purpose is made available by digging borehole / bore-well within the vicinity of the project site during the construction phase. Hence proper care shall be taken while deciding the location of these activities or drawing water from public facilities.

f) Impact due to Construction of Bridges on Yamuna

no impact on ground water quality is anticipated from the project during the construction phase. Proposed project will not alter the existing water quality of River Yamuna. One major bridge is planned on the alignment on river Yamuna. It is proposed to Construct Bridge with well foundation, substructure with mass concrete and superstructure with PSC girder.

g) Impact due to Supply of Construction Material

About 10-15% of the construction material such as waste material from contractor camps is left behind by the contractor as construction waste/spoils. Dumping of construction waste/spoil in an haphazard manner may cause surface and ground water pollution near the construction sites.

h) Loss of Historical and Cultural Monuments

No historical/cultural monuments will be affected as a result of the proposed development.

i) Impact due to Construction near Qutab Minar

Due to construction of Metro alignment near Qutab Minar, it is expected that the construction activity may have little impact on tourist activities. However during operation the tourist activity may increase.

0.4.4 IMPACTS DUE TO PROJECT OPERATION

Along with many positive impacts, the project is likely to cause the following negative impacts during project operation.

a) Noise

The noise level has been computed and it is predicted that noise level in Metro corridor would be between 54dB(A) to 84.6dB(A). The ambient noise level in core city area will reduce by 6 dB(A). However near rail corridors the noise levels will increase significantly which could be reduced through mitigation measures.

b) Water Demands and Sanitation

The water will be required for personal use of staff, washing of platforms, fire demands, make up water for air conditioning and ventilation and wastage. The quantities have been estimated based on standard norms applicable to Railways.

c) Pedestrian Issues

The main aim of MRTS system is to decongest the road traffic in Central Business Districts. The connections will further reduce the pedestrian number, which are available now on the roads.

0.4.5 IMPACTS DUE TO DEPOT

The depots are planned at Yamuna bank Station and will be in an area of 45 ha. The deport area is about 3 m lower than the surrounding area and hence have to be filled up. About 1.2 Mm^3 of earth will be required. About 2000 trees are existing the proposed depot site.

a) Water Supply

About 1056 m^3 of water will be required at Depot for different uses. This will be collected from ground water. There will be a need of water treatment plant to meet water quality standards. The river and ground water quality in the depot area have TDS more than permissible limits. The water after conventional treatment can be processed through Reverse Osmosis (RO) technology for specific use such as drinking/ cooking and final washing of equipment/ trains.

b) Sewage and Effluent

About 25 M^3 of sewage and 12 m^3 of effluent are expected to be generated.

c) Oil Pollution

Oil spillage during change of lubricants, cleaning and repair processes, in the maintenance Depot cum workshop for maintenance of rolling stock, is very common. The spilled oil should be trapped in oil and grease trap. The collected oil should either be auctioned or incinerated, so as to avoid any underground/ surface water contamination.

d) Noise Pollution

The main sources of noise from depot are the operation of workshop. Only five trains will be coming to depot for washing and maintenance daily. The roughness of the contact surfaces of rail and wheel and train speed is the factors, which influence the magnitude of rail - wheel noise. The vibration of concrete structures also radiates noise. Due to less activity, no impact on the ambient noise is anticipated.

e) Loss of Livelihood

About 50 nurseries are in operation on the government land proposed for depot site. There are unauthorised. With the development of project site these 50 people will loose their economic base.

f) Impact due to filling of Area (Leachate)

About 1.2 Mm^3 of earth will be required to fill this area. Out of this about 1.0 Mm^3 will be collected from the excavation of metro corridor. About 0.2 Mm^3 of earth has to be identified for collection during detail engineering. The analysis of soil/ earth has indicated that soil/ ground geology have poor, nitrogen and phosphate. More over the soil will compacted at site before levelling which will further reduce doing the permissibly. Hence possibility of leachates and eutrophication in river is not anticipated.

g) Impact on River Regime

The depot site is a low-lying area on the bank of Yamuna River. The underground drainage is towards river Yamuna. There is a bund between Yamuna River and the proposed area. The construction will not impede the river regime.

h) Surface Drainage

Due to the filling of the low-lying area for the construction of depot. The surface drainage pattern may change specially during monsoon. Suitable drainage measures will be required.

0.5. POSITIVE ENVIRONMENTAL IMPACTS

Based on project particulars and the baseline environmental conditions, potential impacts have been identified. Positive impacts have been discussed, under the following headings:

0.5.1 Employment Opportunities

The project is likely to be constructed and commissioned progressively over 5 years. About 5303 persons are likely to work during the peak period of construction activity. In post-construction phase, about 2300 people will be employed for operation and maintenance of the system. In all about 26,500 man-year will be employed due to the project construction. In addition to these, more people would be indirectly employed in allied activities.

0.5.2 Enhancement to Rural Economy

The MRTS project corridors will facilitate the rural population to move from one end of the city to another end and, one State to another State to buy and sell off their produce. With the development of MRTS, it is likely that more people will be involved in trade, commerce and allied services. The project will make it convenient for people,. to move in rural areas. This will reduce population pressure in DUA and will be a boon to rural economy.

0.5.3 Quick Service and Safety

The optimized network is estimated to carry 22.5 and 28.70 million trip per day in year 2011 and 2021 respectively. The optimized network is estimated to save passenger time by about 50%. It is reported that on an average, six persons die in road accidents everyday in Delhi. This is likely to increase to 8 by year 2021. MRTS will provide, improved safety and will lower the accidental deaths.

0.5.4 Less Fuel Consumption

Upon the implementation of MRTS, both petrol and diesel consumption will be reduced significantly. The savings will be due to two factors namely:

- reduction in vehicles, and
- decongestion on roads.

It is estimated that about 7 million litres of Diesel, 31.5 million litres of petrol and 18.68 million kg of CNG will be saved due to the Metro project phase –II. This will benefit in foreign exchange savings to the tune of Rs. 1722.24 million.

0.5.5 Reduction in Air Pollution

It is estimated that yearly there will be a reduction of air pollutant upto 5884.35 tonnes due to implementation of phase –II. The total reduction of air pollution due to Phase I &II will be around 22755 MT/year.

0.5.6 Carbon dioxide Reduction

The CO_2 reduction due to MRTS is estimated as 39730 tonnes in year 2001. The cumulative reduction in the global warming/green house effect causing gas CO_2 will be about 0.7 million tonnes in the life time of MRTS (35 years). However with more share of MRTS trips and improvements in fuel efficiency and energy use efficiency in transport sector in Delhi, the cumulative CO_2 reduction may further increase.

Thus induction of proposed MRTS will not only reduce the need for personalised transport, leading to reduction in the growing road congestion, which causes slow movement of vehicular traffic with consequent fuel wastage and increased emissions, but it will also arrest the rapidly increasing surface. transport, pollution load and bring. about substantial saving in fuel consumptions which is responsible for rapidly growing oil import expenditure.

0.5.6 ENVIRONMENTAL ASSESSMENT

Environmental assessment can be effectively used for inter-comparison various alternative systems. Based on environmental impacts a checklist prepared as follows:

CHECKLIST OF IMPACTS

S. NO	PARAMETER	NO IMPACT	NEGATIVE IMPACT	POSITIVE IMPACT
A	***Impacts Due To Project Location***			
1	Rehabilitation and Resettlement		*	
2	Change of land use and Ecology		*	
3	Impact on Historical/Cultural Monuments	*		
4	Drainage and utilities problems		*	
B	***Impacts Due To Project Design Construction***			
1	Platforms Inlets and outlets	*		
2	Ventilation and lighting	*		
3	Railway Station Refuse		*	
4	Risk Due to Earth Quakes	*		
C	***Impact Due to Project Construction***			
1	Soil Erosion pollution and health risk at construction site		*	
2	Traffic diversions and risk to existing buildings		*	
3	Soil disposal problem and seepage risk		*	
D	***Impact Due to Project Operation***			
1	Oil Pollution		*	
2	Noise and vibration		*	
4	Water Demands		*	
E	***Positive Environmental Impacts***			
1	More Employment Opportunities			*
2	Enhancement of Economy			*
3	Quick service and safety			*
4	Traffic Congestion Reduction			*
5	Less Fuel Consumption			*

S. NO	PARAMETER	NO IMPACT	NEGATIVE IMPACT	POSITIVE IMPACT
6	Less Air Pollution			*
7	Carbon dioxide reduction			*
8	Reduction in Number of buses			*
9	Saving in Road infrastructure			*

0.6 ENVIRONMENTAL MANAGEMENT PLAN

Most of the environmental issues are likely to arise during construction and operation phases. These will be mitigated or reduced by incorporating environmental management plan into the project cycle as follows:

0.6.1 Rehabilitation and Resettlement

The project involves the displacement of 300 Jhuggis in unauthorized areas, and 358 families likely to be affected due to land acquisition. These will affect about 2632 people. About **Rs 330.2 million** will be paid as compensation for relocation of shops, commercial cum residential buildings and hutments likely to be affected due to the project along the alignment.

0.6.2 Compensatory Afforestation

According to the results of the present study, it is found that about 5147 trees are likely to be lost due to the project. Ten trees have to be planted for each tree cut. Hence 51470 trees to be planted. These trees would have occupied about 43 ha in the forest. No non-forest land is available, hence 43ha have to be re-afforested in degraded forests in Delhi. In addition to these efforts need to be made to plant trees at appropriate places on completion of the works along the road and rail alignment. Cost of afforestation is about Rs.35,880/-. Compensatory reafforestation cost will thus be about Rs.15.42 lakhs including road side plantation. The indigenous tree species such as Neem, Sisso, Eucalyptus, Acacia, Ashok and Jamun are recommended for plantation.

0.6.3 Draining of water from tunnel

The water table generally varies from 3 to 7m which rises to about 2m during monsoon season in low lying areas. Suitable piezometers will installed to monitor the water table constantly and to see how much it get lowered and recharged accordingly. About 3.6 m^3/hr per meter length seepage water is likely to come into the tunnel which will be pumped out and discharged into storm water drains. Suitable water collection drain, need to be constructed on the side retaining structure to collect seepage water during operation phase.

0.6.4 Soil Disposal

As noted earlier construction activities will generate 1.20 Mm^3 of soil causing excavated soil disposal problem. This can be mitigated by utilising around 0.3 Mm^3 in filling and the balance will be disposed of at suitable location.

0.6.5 Utility Restoration

There are mainly water supply and sewer pipe, storm water drains, telephone cables, over head transmission lines, electric poles, traffic signals etc. these utilities are essential and have to be maintained in working conditions during different stage of construction, by temporary/ permanent diversions or by supporting in position.

0.6.5 Noise & Vibration control

For elevated corridors, ballast less track structure is supported on two layer of rubber pads to reduce noise and vibrations. In addition, baffle wall as parapets will be constructed upto the rail level so as reduce sound levels. Noise at source be controlled or reduced by incorporating suitable feature in the design of structures and layout of machines and by use of resilient mounting and dampers etc.

To reduce the harmful effects of point sources of high levels of noise operators duty hours in the vicinity must be restricted and personal protect measures such as ear plugs could be issued to them for use during periodical automatic examination of such personnel for testing hearing ability would also become necessary.

0.6.6 Management plans for Depot

i) Water supply and sanitation: About 1056 m^3 of water per day will be required for operation and functioning of depot. This could be either collected from Municipal Corporation or through boring tube well into the ground.

ii) Oil Pollution Control: The oil tends to form scum in sedimentation chambers, clog fine screens, interfere with filtration and reduce the efficiency of treatment plants. Hence oil and grease removal tank has to be installed at initial stage of effluent treatments.

iii) Effluent Pollution Control: About 80% of domestic water supply will available as sewage, hence about 25 m^3 of sewage is likely to be generated. The sewage could be treated up to the level so that it could be used for horticulture purpose in the campus and can also be discharged into the stream

iv) Drainage control : The area should have proper drainage. The drainage costs have been included in project cost. However provisions of out fall have been made in environmental costs.

v) Provision for Green belt development: In addition to augmenting present vegetation, it will also check soil erosion, make the ecosystem more diversified and functionally more stable, make the climate more conducive and restore balance.

vi) **Provision of Rainwater harvesting:** it has been proposed to construct roof top rainwater harvesting structure of suitable capacity in the construction depot site.

0.6.7 Disaster Management

To ensure proper disaster management, an Emergency Action Committee will be constituted, consisting of officers from MRTS, Railway, Police, Health, Central and Delhi Governments.

0.6.8 Emergency Lighting

The emergency light operated on battery power is to be provided for each station.

0.6.9 Fire Protection

The building materials will be of appropriate fire resistance standard. The materials which have zero surface burning characteristics will be used to the extent possible. The design of stations will include provision for Fire prevention and control measures, Fire detection systems, Means of escape, Access for firemen and Means of fire fighting. All aspects of fire prevention and control will be dealt in close liaison with the city fire fighting authority.

0.7. ENVIRONMENTAL MONITORING PROGRAMME

Environmental monitoring programmes are vital to assess the effectiveness of environmental management plans. The monitoring will be required during construction and operational phases for the following:

- Rehabilitation and Resettlement programme,
- Afforestation,
- Water quality,
- Air and Noise quality,
- Soil disposal and conservation, and
- Sanitation and waste disposal.

An Environment Division is proposed in MRTS Authority to effectively carryout above activities.

0.8. *ENVIRONMENTAL COSTS*

All costs involved in environmental management and monitoring will be put on account of MRTS project are as summarised below:

S. NO.	*ITEM*	*COST RS. MILLIONS*
1.	*Rehabilitation And Resettlement Of*	*330.20*
2.	*Compensatory Afforestation*	*1.542*
3.	*Water Supply Treatment*	*10.0*
4.	*Establishment Of Environment Division*	*2.44*
5.	*Training And Extension*	*0.43*
6.	*Sewage Effluent Treatment*	*10.0*
7.	*Drainage*	*0.30*
8.	*Rain Water Harvesting In Depot Area*	*1.0*
9.	*Green Belt Development*	*2.0*
10.	*Water Quality/ Epimidiological*	*0.64*
11.	*Air & Noise Monitoring*	*0.58*
TOTAL		***359.132***

The Environmental management plan should be implemented in phases so that optimum benefit could be achieved and should be synchronized with the construction schedules. The cost of land compensation will be about Rs.3505.1million. While environmental management and monitoring costs are **Rs.359.132** million

0.9. EPILOGUE

Impacts as discussed above on natural resources, terrestrial and ecology of the area do not appear to be significant and could be mitigated with available know-how in technology. Based on environmental baseline data, prediction of positive and negative impacts and assessment, it could be concluded that the project will bring benefit at local and global levels. In nutshell it could be concluded that the project is environmentally sustainable and eco-friendly.

CHAPTER – 1
INTRODUCTION

1.1 POPULATION

The earliest Pandavas founded capital city of Indraparastha in 1450 BC. The Delhi has derived its name from Dillu's Dilli (100 BC), which was sited east of Lalkot, or from Dhilba founded by Tomar Kings in 736 AD. Some say it came from the mediueval town of Dhillika located near Mehrauli. The other cities recorded are Surajpal's Surajkund (1024 AD), Anangpal's Qila Lal Kot (1302 AD) Prithviraj Chauhan Qila Rai Pithora (1170AD), Ala-ud-din Khiljii Sri Fort (1302 AD), Ghiya-ud-din Tughlaq, Tughlakabad (1320 AD). Mughal Emperor Shahajahan founded the present Delhi in 17th Century with about one lakh population (1642 AD). This area now knows as old Delhi. Finally British built New Delhi south of Shahjahanabad and shifted their capital from Calcutta to Delhi in 1931. The growth of Delhi up to the end of 19th century was nominal and started gaining momentum during the 20th century. Subsequently, he size, structure and character of Delhi have been continuously changing with rapid urbanisation. The migration in 1947, industries, entrepreneurs and search for livelihood and success are the factor for continuous urbanisation. However, the traffic and transportation systems in Delhi have not developed to the desired level despite continuous effort towards it.

Delhi had a population of 9.40 million in 1991 and 12.79 million in 2001. It is expected that the population will grow to 19.0 million by 2011 and 23 million in 2021. The total area of Delhi is 1486 sq. km. with an urban are of about 500 sq. km. The population of Delhi Urban Area (DUA) between 1941 and 1991 is given in **Table 1.1.** It is clear from this table that Delhi's population has increased by eighteen times in a span of last six decades.

The average population growth rate is estimated as 4.80% per year during last six decades. This also includes the migration in Delhi which is about 0.16 million person per year. The Delhi Master Plan (DMP) has projected population between 12.5-13.0 million in 2001. Out of this population, 0.64 million will be outside the urban area. However, it was also recommended to restrict this population to 11.2 million in 2001 **(Ref. Annexure1).** The Projected population in DMP is summarised in **Table 1.2.**

TABLE-1.1
POPULATION OF DELHI URBAN AREA (1941-91)

YEAR	POPULATION (MILLION)	ANNUAL GROWTH RATE (%)
1941	0.70	-
1951	1.44	7.5
1961	2.36	5.1
1971	3.65	4.5
1981	5.71	4.6
1991	9.40	6.4
2001	12.79	3.6
2011	19.00	4.8
2021	23.00	2.1

Source: Household Surveys in Delhi, RITES (1994) Ref.2 Annexure1)

TABLE-1.2
POPULATION OF DELHI IN 2001 (MILLION)

AREA	URBAN	RURAL	TOTAL
NCR	23.4	9.1	32.5
DMA	14.7	0.3	15.0
DUA	11.0	0.2	11.2

Source: Delhi master Plan for 2001(Ref.1 Annexure1)

It is also reported that 35% of Urban Delhi and 33% in the area of Delhi outside the urbanisable limit of UTD will be employed. This would generate a work force of 4.91 million including floating workers population. The trade-wise distribution is as follows:

- Agriculture : 1.5%
- Establishment : 22.6%
- Construction : 4.7%
- Trade and Commerce : 19.9%
- Transport : 10.2%
- Other Services : 32.4%
- Floating Work Force : 8.7%

Further the work force in different sectors is envisaged as follows:

Central Government : 22.0%
Quasi – Government : 26.7%
Delhi Administration : 10.6%
Local Bodies : 16.8%
Private : 23.9%

Delhi Master Plan 2021 is over due for publication hopefully will be available for users soon.

1.2 VEHICLES

Vehicle population in Delhi is highest among all metropolitan cities (Bombay, Calcutta, Delhi and Madras). During 1985 to 2001 the total number has multiplied four times. It is observed that the rate of growth of personalised vehicles is more than other types. The average annual growth rate of vehicles is about 19.7. On an average about 500 new vehicles area added in Delhi every day.

The main sources of air pollution in Delhi are buses, cars, auto rickshaws, trucks and scooter/ motor cycles. In the year 1993 there were about 47,800 cars/ jeeps; 1,403,000 scooters/ motorcycles; 11,400 taxis; 70,500 three wheelers; 23,200 buses and 111, 300 trucks. These put together indicate that about 2.1 and 3.6 million vehicles were plying in Delhi during years 1993 and 2001. The details of these vehicles are given in **Table 1.3.** This data has been utilised to predict fuel consumption and ambient air quality as reported in **Chapter-4.**

TABLE-1.3
DETAILS OF VEHICLES IN DELHI

YEAR	CAR/ JEEPS	MOTORCYCLE/ SCOOTER	3-WHEELER	TAXI	BUSES	TRUCKS	TOTAL
1985	175	637	31	9	14	59	925
1986	203	746	41	9	15	62	1076
1987	242	868	45	9	15	71	1250
1988	280	979	52	9	16	80	1416
1989	333	1083	58	9	17	90	1590
1990	384	1191	62	10	19	99	1765
1991	413	1253	65	10	20	102	1863
1992	440	1317	67	11	20	107	1962
1993	478	1403	70	11	23	111	2096
2001	957	2378	95	19	41	169	3658

Source: Delhi Transport Authority

1.3 REVIEW OF PREVIOUS STUDIES

The first ever traffic study of Delhi was carried out by the Central Road Research Institute (CRRI) in 1957 titled 'Origin –Destination Survey of Traffic of Greater Delhi'. This study indicated average trip length for vehicles and suggested the ring railway system. The output of this study in 1962 were utilised in the preparation of "Master Plan for City of Delhi" having 1981 as the horizon year. In 1984, Delhi Development Authority (DDA) revised this document for the year 2001. In all about 35 studies have been carried out in Delhi.

The important studies are as follows:

- Transportation study (1969) by CRRRI, New Delhi,
- Town and Country Planning Organisation, (1973),
- Metropolitan Transportation Team, Ministry of Urban Development (1974),
- Metropolitan Transport Project, Ministry of Railway (1975),
- Planning Commission, Study group (1982),
- Indian Railway Study Group (1986),
- Task Force, Ministry of Urban Development (1987),
- Planning of Mass rapid Transports System for Delhi, CRRI (1989),
- Mass Rapid Transport System for Delhi (1990) by RITES, and
- Mass Rapid Transport System DPR Phase-II for Delhi by RITES (2004)

From the above studies, it is clear that the Mass Rapid Transport System (MRTS) for Delhi has been under active consideration for more than three decades. The Indian Railways Study Group in 1986 suggested a specific alignment for the East-West Corridor and Task Force of Ministry of Urban Development in 1987 recommended a system for the East-West Corridor. Based on RITES study the construction of Delhi Metro Phase-I is progress. This phase of the network comprises of about 65 km of route length with about 13 km underground called Metro Corridor and 52 km surface/ elevated rail corridor. The Rail corridor form Shahdara to Rohini/ Rithala and Metro corridor form Vishwa Vidyalayala to ISBT have been completed, commissioned and in operation. The Barakhamba-Dwarka corridor is under construction. The Government in principle has agreed for implementation of six more lines totalling to 53.02 km and construction of depot at Yamuna Bank in second phase of construction. These lines are:

- Vishwa Vidayalaya – Jahangiri Puri,
- Central Secretariat – Qutab Minar,
- Shahdara – Dilshad Garden,
- Indraprastha – Yamuna Bank, New Ashok Nagar,
- Yamuna Bank – Anand Vihar ISBT,
- Kirti Nagar – Mundka

The Mass Transport needs of Delhi are currently met mainly by buses which are over crowded and unreliable with long waiting periods at bus stops. Consequently the use of personalised vehicles is growing, leading to increased road congestion, fuel wastage and environmental pollution. **(Refer Chapter-3).** It is in this context that a detailed feasibility for MRTS Phase-II along with Environmental Impact Assessment (EIA) study has been assigned to RITES by Delhi Metro Rail Corporation (DMRC). This report is on EIA of Phase-II.

1.4 SCOPE OF WORK

The Terms of Reference (TOR) for the present study were drawn up in accordance with the guidelines for Environmental Impact Assessment (EIA) studies issued by Ministry of Environment and Forests (MoEF), Government of India (GOI) for Transport Projects. Schedules I list the projects need environmental clearance from MoEF. However Rail projects are exempted from this list and hence environmental clearance. The study has been conducted by RITES as per TOR and the requirements of the Environmental Appraisal Committee (EAC) constituted by MoEF for transport projects.

RITES were in-charge for the preparation of the feasibility study (FS) as well as the EIA study. RITES was, therefore, in a position to integrate environmental concepts in the project preparation process. Such integration was advantageous both for FS and EIA. To prepare this report, literature review, consultation with various departments, ground truth and sampling mission were undertaken and laboratory analysis was carried out.

The consultant has collected baseline information on land use and demography, flora and fauna, air pollution and noise, soils, ground water regime, historical monuments and property.

1.5 FORMAT OF THE PROJECT

The main elements of the study are as follows:

In **Chapter-2** a concise documentation is given of current and planned activities and the expected main beneficiaries. **Chapter-3** summarises environmental baseline conditions including physical, biological and socio-economic parameters and pre-project environmental constraint such as air pollution, problems related to public health and traffic congestion. Potential negative and positive impacts are presented in **Chapters-4 and 5** respectively. Expected negative impacts are listed under the following headings:

- Impact due to project location,
- Impact due to project design,
- Impact due to project construction, and
- Impact due to project operation.

These include issues such as loss of land, rehabilitation and resettlement, disposal of soil, loss of trees, noise and vibration, disruption of utilities/ facilities, socio-economic

and other problems due to the development of proposed Mass Rapid Transport System Phase-II in Delhi.

Based on the anticipated negative impacts, the project may bring about an environmental management strategy, which has been outlined in **Chapter-6.** This as indicated in **Chaptre-4. Chapter-7** includes post project environmental monitoring programmes. This programme aims at signalling any potential environmental problem during construction and operation of the project and it should allow for timely implementation of corrective measures. Finally, a summary of the costs of the environmental management and monitoring programmes falling under the responsibility of the project is presented in **Chapter-8.** This also includes the cost of disaster management plans and emergency information systems. The literature, books, reports referred, is detailed in References. Where applicable, more detailed information on methods used is included in concerning paragraphs.

CHAPTER-2
PROJECT DESCRIPTION

2.1 EXISTING SYSTEM

Mainly buses currently meet the mass transport needs of Delhi only. Delhi Transport Corporation (DTC) assisted by Private operators the bus system. DTC has achieved the highest productivity amongst city bus undertakings in the country and carries over 5 million trips a day. However, it has not been able to meet the expectations of Delhi commuters. The basic reason for this is the ever-increasing average trip length (14 kms) with corresponding increase in journey time of 55 to 60 minutes. In city buses, trip length beyond 5 to 7 kms or journey time more than 25 to 30 minutes becomes uncomfortable and tiring. The peak hour traffic on some roads such as Patel Road is as high as 400 buses (each-way) per hour. This is four times the number of buses, which can be run effectively. The bus services are over crowded and unreliable with long waiting periods at bus stops. This has resulted in growing use of personalised vehicles leading to increasing road congestion, delays, fuel wastage an environmental pollution.

The existing railway network within Delhi Union Territory comprises two rings and four radials (144 kms). The two rings are:

i) Main ring from Nizamuddin to Nizamuddin passing through Lajpat Nagar, Patel Nagar, Delhi Kishan Ganj, Subzi Mandi, New Delhi and Tilak Bridge Station (35 kms), and

ii) Other ring from Tilak Bridge to Tilak Bridge via Anand Vihar, Sahibabad, Delhi Shahdara, Delhi main and New Delhi Stations (32 kms).

About 4.5 kms rail section between Sadar Bazar and Tilak Bridge Stations is common to the two rings. The four radials are one each from Sonepat in the North, Rothak in the West, and Bijwasan in the Southwest and Tughlakabad in the south.

iii) The present modified of Phase-I of Delhi MRTS, which is under implementation at present, consists of following three corridors of 62.16 kms.

- Shahdara – Trinagar – Rithalka : 28.00 kms
- Vishwa Vidyalaya Central Secretariat : 11.00 kms
- Barakhmba Road – Kirti Nagar – Patel Nagar- Dwarka : 23.16 KMS

The existing bus, metro and rail network is shown in **Figure-2.1.**

2.2 FUTURE NEEDS OF TRANSPORT

The Delhi population would increase from 12.79 million (2001) to 23 million in the horizon year 2021. Out of these 9.66 million will be employed. These will need about 28.70 million total vehicular daily trips. Out of these 24.72 million trips will be intracity and balance 4.08 millions intercity (Rail Road). The transport scene in 2021 is presented in **Table-2.1.**

TABLE-2.1
TRANSPORT SCENE IN YEAR 2021 (WITHOUT MRTS)

S. NO.	ITEM	2003	2011	2021
1	Population (in million)	14.70	19.00	23.00
2	Employment (in million)	5.31	7.73	9.66
3	Per capita trip rate-vehicular (including home based & non home based (in million)	0.87	1.00	1.05
4	Total Daily Trips (in million)	15.30	22.50	28.70
5	Intra-city trips/ day (in million)	13.30	19.37	24.72
6	Inter-city trips/ day (in million)	2.25	3.13	4.08
7	Modal Split for intra city trips (in percentage)	65	75	80
8	Mass public transport trips/ day (intra+inter-city trips) (in million)	10.55	17.32	23.66
9	Peak Hour Factor (in percentage)	9.80	9.80	9.80
10	Peak Direction Factor (in percentage)	58	58	58

Source: DPR of Phase-II, RITES (2004)

The road network of Delhi (30m or wider right of way) is planned to increase from 652 km in 1981: 974 km in 1984 and 1122 km in 2001 to 1340 in 2021. It is also estimated and predicted that 536 km (40%) of roads network will carry trips in excess of 10,000 peak hour peak direction trips (PHPDT) out of which 150 kms of roads will carry trips in excess of 20,000 PHPDT. Based on the carrying capacity of a bus system will not be able to cope with the transport demand in the year 2021.

To meet the transport demand by buses, it is estimated that the future number of buses will have to be increased to at least two and half times. In addition to these, the number of personalized vehicles is estimated to grow at least threefold. It is also estimated that 148 kms of additional roads with associate infrastructure such as flyovers, bus terminals, maintenance depots and car parks will be required. Assuming a 45 m wide right of way approximately 981 ha of land will be required for this purpose. It is difficult to acquire so much land particularly in core city area. Two tier roads will be aesthetically unacceptable. Hence the road/ bus system cannot meet the future demands of transport. RITES have studies different alternatives of optimization.

The RITES feasibility study 1991 proposes road + rail + metro optimized network. In view of transport it is proposed to develop with following lines in Phase II:

- Vishwa Vidayalaya – Jahangiri Puri,
- Central Secretariat – Qutab Minar,
- Shahdara – Dilshad Garden,
- Indraprastha – Yamuna Bank – New Ashok Nagar,
- Yamuna Bank – Anand Vihar ISBT,
- Kirti Nagar – Mundka

The maximum PHPDT on any section in Phase- II will be about over 48,000. A summary of daily load and PHPDT in 2021 is presented in Table-2.2 for Phase- II.

TABLE-2.2
LOAD OF SECTIONS (2021)

S. NO.	SECTION	DAILY	PHPDT
1	Vishwa Vidayalaya – Jahangiri Puri	410,852	23,353
2	Central Secretariat – Qutab Minar	392,162	22,290
3	Shahdara – Dilshad Garden	262,943	14,946
4	Indraprastha – Yamuna Bank – New Ashok Nagar	810,604	46,075
5	Yamuna Bank – Anand Vihar ISBT	235,265	13,372
6	Kirti Nagar – Mundka	986,913	56,096

Source: DPR of Phase II, RITES (2004)

2.3 MASS RAPID TRANSPORT SYSTEM

Mass Rapid Transport System (MRTS) forms part of the overall transport development scheme of Delhi State. This project will provide services to a total area of 1486 sq. km with an urban area of about 500 sq. km. The proposed MRTS network has been divided into fifteen operational corridors as reported in **Table-2.3.** The project is planned in four phases. The first an second phase are designed to meet the demand in years 2005 and 2021 receptively. The project layouts for Phase-I and II are shown in **Figure-2.2** and **Figure-2.3** respectively. The first phase will cover a distance of about 62.16 kms while the full development will cover a distance of 294.86 kms.

TABLE-2.3
MRTS NETWORK CORRIDORS

S. NO.	FROM - TO	LENGTH (KM)
PHASE-1 (2005)		**62.16**
1	Shahdara-ISBT-Trinagar-Barwala	28.00
2	Vishwa Vidyalaya – Central Secretariat	11.00
3	Barakhamba Road - Patel Nagar – Dwarka	23.16
PHASE-II (2011)		**53.02**
4	Vishwa Vidyalaya – Jahangiri Puri	6.36
5	Central Secretariat – Qutab Minar	10.87
6	Shahdara – Dilshad Garden	3.09
7	Indraprastha – Yamuna Bank – New Ashok Nagar	8.07
8	Yamuna Bank – Anand Vihar ISBT	6.16
9	Kirti Nagar- Mundka	18.47
PHASE-III (2016)		**58.20**
10	Jahangiripuri- Raja Garden – Dhaula Kuan – AIIMS- Nehru Place – Okhla Industrial Area Phase- I	34.60
11	Barwala – Bawana	5.20
12	Rangpuri – IGI Airport-Shahbad Mohammadpur – Dwarka City	8.20
13	Shahbad Mohammadpur – Dwarka – Kakraula Village	10.20
PHASE – IV (2021)		**72.80**
14	Jahangiri Puri – Peeragarhi – Pankha Road – Sagarpur	24.20
15	Narela – Bawana –Gheora – Najafgarh	33.00
16	Mehrauli – Gurgaon	11.60
17	Dilshad Garden – Nand Nagri	4.00
	TOTAL	**244.86**

In order to keep the system in good running condition, a depot is planned at Yamuna Bank. This depot will be similar to one existing at Shastri Park and other two planned at Khebar Pass and Nazafgarh during first phase. In this Environmental Impact Assessment (EIA) study, only for the second phase components have been considered. The passenger time saved will be about 30%. The proposed network will thus fulfill various planning objectives namely:

- Meeting transported demands in 2021 and beyond,
- Reduction in travel time,
- least cost solution, and
- Relief to bus/ road system.

In order to complete the works the infrastructure required is reported in subsequent sections.

2.3.1 Infrastructure

As several roads or railway lines cross the alignment an elevated section has been proposed. Under ground option has been adopted only in the busy congested areas and the walled city. The recommended type of infrastructure is indicated in **Table-2.4.** The total length in Phase-II will be about 53.02 kms. The underground constructions will involve 4.55 km bored tunneling and 2.693 km cut and cover. The planned stations in Rail and Metro corridors are summarized in **Table 2.5.**

TABLE-2.4
TYPES OF INFRASTRUCTURE IN PHASE-II

S. NO	SECTION	UNDER GROUND	ELEVATED	AT GRADE	TOTAL
1	Viswa Vidyalaya- Jahangiri Puri	0.94	5.42	-	6.36
2	Central Secretariat- Qutub Minar	7.99	2.88	-	10.87
3	Shahdara- Dilshad Garden-NOIDA	-	3.09	-	3.09
4	Indraprastha - Yamuna Bank - New Ashok Nagar	-	6.22	1.85	8.07
5	Yamuna Bank – Anand Vihar ISBT	-	6.16	-	6.16
6	Kirti Nagar - Mundka/ Indra Lok	-	18.47	-	18.47
	TOTAL	**8.93**	**42.24**	**1.85**	**53.02**

TABLE-2.5
METRO AND RAIL CORRIDORS STATIONS

S. NO	SECTION	UNDER GROUND	ELEVATED	AT GRADE	TOTAL
1	Viswa Vidyalaya- Jahangiri Puri	1	6	-	7
2	Central Secretariat- Qutub Minar	7	2	-	9
3	Shahdara- Dilshad Garden-NOIDA	-	3	-	3
4	Indraprastha - Yamuna Bank - New Ashok Nagar	-	4	1	5
5	Yamuna Bank – Anand Vihar ISBT	-	5	-	5
6	Kirti Nagar - Mundka/ Indra Lok	-	16	-	16
	TOTAL	**8**	**36**	**1**	**45**

In all 38 stations are planned in this Phase-II. A list of these us presented in **Appendix-2.1.** Out of these 8 will be underground.

2.3.2 Rolling Stock, Traction and Signaling

The salient features of proposals for Metro (underground) and Rail (above ground) sections in respect of rolling stock, power supply and traction system and signaling are summarized in feasibility main report and reproduced below:

- The rolling stock/ coaches will be of the same design as being procured buy DMRC for corridors. 4 car trains in 2011 and 6/8 car trains in future with 3-minute peak frequency are planned. The maximum speed will be 80 km/hr. in all there will be 312 coaches in 2011.

- The power/ traction system will be 25 KV AC 50 Hz in Metro and Rail corridor with necessary traction sub-station. The underground portion will have rigid OHE while outside the tunnel overhead traction lines are planned with flexible copper OHE.

- Continuos Automatic Train Control (CATC) system with Automatic Train Protection (ATP), Automatic Train Operation (ATO), Fibre Optic Transmission system (FOTS), Automatic Fare Collection (AFC) System and Automatic Train Supervision System (ATSS) are planned.

- The temperature and humidity of underground metro tunnels and stations are planned to be controlled at 300C and 70% respectively, with chilled water type plant and air washeries. In addition, tunnel ventilation is also planned.

2.3.3 Facilities

For smooth operation of activities at metro and rail corridors, various facilities are planned such as telecommunications, fare control, fire detection and control etc. telecommunication facilities are planned on the basis of optical fibre cables. These will include radio communications, control telephones, PA systems, CCTV, department of telecommunication telephones, hotlines and centralized clock system. Fare control system is fully automatic with enclosed tickets, turnstile gates and computer accounting. The other facilities include escalators, lifts and pumps, illumination; emergency lights; ventilation and exit.

2.3.4 Property Development

Vehicle methods are being suggested for the financing of the project. One of these is property development. It is true worldwide that the maximum benefit of transport system goes to landowners alongside the system. The Metro corridors are fully underground, largely under the existing roads. The airspace above the stations therefore is not available for commercial development. It is excepted that 5% of the financing can be achieved through property development, through the potential is much higher.

2.3.5 Depot at Yamuna Bank

The depot is planned at Yamuna Khadir adjoining the proposed Yamuna Banks Station. The depot is connected to the junction stations at the station's West End through a cross over. With the proposed arrangements rakes could enter the depot from Anand Vihar (ISBT) end a well as New Ashok Nagar end. The depot will be spread on an area of 17 ha having an average level of RL 203.5m. With the formation level of RL 207 m. the average filling will be 3.5m. Earthwork required will be about 0.6 Mm^3.

2.4 COST ESTIMATES

The capital cost of the underground metro, surface rail and elevated components of MRTS system is in general based on conceptual design of various MRTS structures. These were suitably modified to suit the specific design features of Delhi MRTS and local conditions. Moreover n order to arrive at realistic cost of various items, costs have been assessed on the basis of accepted rates in various contracts recently awarded by DMRC for their on going works. A suitable factor has been applied to bring these costs to April 2004 price levels. For some of the items, tender have been finalized recently and most of these tenders are with fixed price rate with no escalation. The details on cost estimates are as given in **Table-2.6** on April 2004 price level.

The total cost of the Phase-II is estimated as Rs.69,840 million. The above estimates are excluding custom duty and Work Tax but including general charges @ 3% on all items except land rolling stock and 3% contingencies on all items including general charges.

TABLE-2.6
ABSTRACT OF COST

S. NO	DESCRIPTION	(1)	(2)	(3)	(4)	(5)	(6)
1.	Land	129.5	483.9	374.0	914.6	474.6	1,128.5
2.	Civil Engg. Works	4008.9	15,838.8	1,296.7	3,416.4	2,524.9	7,395.8
3.	Electrical Works	589.7	1,053.0	234.7	553.5	522.0	1,402.5
4.	S&T Works	913.9	1,577.6	430.8	1053.3	833.4	4,521.8
5.	Inspection, Maintenance & stabling Facilities	290.0	620.0	200.0	1000.0	440.0	500.0
6.	Rolling stock	1,020.0	2,720.0	1,870.0	3910.0	850.0	2,890.0
7.	General Charges @ 3%	204.7	652.8	121.0	298.0	155.1	441.3
8.	Contingencies (3% on item 1 to 7)	214.7	686.9	135.8	334.4	174.0	488.4
	TOTAL	**7,371.4**	**23,583.0**	**4,663.0**	**11,480.2**	**5,974.0**	**16,768.3**

(1) Vishwa Vidyalaya – Jahangiri Puri (2) Central Secretariat – Qutab Minar, (3) Shahdara – Dilshad garden, (4) Indraprastha – Yamuna Bank – New Ashok Nagar, (5) Yamuna Bank – Anand Vihar ISBT (6) Kirti Nagar- Mundka

2.5 CONSTRUCTION SCHEDULE

The phase-I of Delhi Metro Project is scheduled for completion by December 2005. As per master plan, Phase-II of the project is to be taken up for implementation in continuation of phase-I.

The proposed sequence of construction for the MRTS network is shown in **Table-2.7.** The second phase, which includes about 42 km, will be completed by 2009 while full system will be operational by the year 2021. This phase will connect North with South and eastern outskirts of the city and NOIDA with Delhi core area.

TABLE-2.7
CONSTRUCTION SCHEDULE PHASE-II

S. NO.	ACTIVITY	DURATION				
		JULY 2005	2006	2007	2008	2009
1.	Land Acquisition					
2.	Design Details					
3.	Tendering					
4.	Construction					
5.	Track, Power, S&T Works					
6.	Rolling Stock					
7.	Testing & Commissioning					

Tunnel boring is to be carried out from Udyog Bhawan Station to AIIMS Station. Four EPB type TBMs may be required to complete the tunneling in two year. Based on progress achieved in Phase-I, it is proposed that the viaducts and stations are completed in 18 to 24 months period with additional provision of 4 months for preparatory works. Under ground section can be completed in 30 months. Addition one year is required for installation of system, testing and commissioning of rolling stock. Thus total work can be completed in about 48 months from date of start. The suggested phases opening are report in **Table 2.8.**

TABLE 2.8
COMPLETION/ OPENING SCHEDULE

S. NO.	SECTION	OPENING DATE
1.	Viswa Vidyalaya- Jahangiri Puri	October, 2008
2.	Central Secretariat- Qutub Minar	December, 2009
3.	Shahdara- Dilshad Garden-NOIDA	December, 2007
4.	Indraprastha - Yamuna Bank - New Ashok Nagar	June, 2008
5.	Yamuna Bank – Anand Vihar ISBT	September, 2008
6.	Kirti Nagar - Mundka/ Indra Lok	June, 2009

APPENDIX-2.1
LIST OF RAILWAY STATIONS

A. VISHWA VIDYALAYA TO JAHANGIRI PURI		
1	Vishwa Vidyalaya	UG
2	GT Bahadur Nagar	UG
3	Derawal Nagar	EL
4	Azadput	EL
5	Azadpur Mandi	EL
6	Mool Chand/ Piplthala	EL
7	Jahangiri Puri	EL
B. CENTRAL SECRETARIAT TO QUTAB MINAR		
1	Central Secretariat	UG
2	Udyog Bhavan	UG
3	Race Course	UG
4	Jor bagh	UG
5	INA	UG
6	AIIMS	UG
7	Green park	UG
8	IIT	UG
9	PT School	EL
10	Qutab Minar	EL
C. SHAHDARA TO DILSHAD GARDEN		
1	GTB Enclave	EL
2	Jhilmil	EL
3	Dilshad Garden	EL
D. INDRAPRASTHA – NEW ASHOK NAGAR		
1	Indraprastha	EL
2	Yamuna Bank	AG
3	Games Village Complex	EL
4	Mayur Vihar, Phase-I	EL
5	Mayur Vihar, Phase-II	EL
6	New Ashok Nagar	EL
E. YAMUNA BANK TO ANAND VIHAR		
1	Yamuna Bank	EL
2	Lakshmi Nagar	EL
3	Preet Vihar	EL
4	Karkarduma	EL
5	Anand Vihar ISBT	EL
F. KIRTI NAGAR TO MUNDKA		
1	Kirti Nagar	EL
2	Punjabi Bagh	EL
3	Shivaji Park	EL
4	Madipur	EL
5	Paschim Viahr	EL
6	Sachdeva Park	EL
7	Peera Garhi	EL
8	Udyog Vihar	EL

9	Surajmal Stadium	EL
10	Nangloi	EL
11	Nangloi Railway Station	EL
12	Rajdhani Park	EL
13	Mundka	EL
14	Punjabi Bagh East	EL
15	Ashok Park New	EL
16	Inderlok	EL

CHAPTER –3
ENVIRONMENTAL BASELINE DATA

3.1 GENERAL

The information presented in the Chapter stems from various sources. Data on land use has been collected and compiled from various reports, field survey and monitoring. The majority of data on Physiography, infrastructure, soil and geological features have been taken from the feasibility report of MRTS prepared by RITES **(Annexure1 Ref.2)**, while data on population, water quality, ground water hydrology, vegetation and fauna, air and noise quality was collected during field studies. Climatological data was collected from meteorological office. The data has also been compared with data collected by RITES few years back. Efforts have been made to compile the data from other sources. Additional data was collected from various reports **(Annexure –1)** The project area is divided in two parts by river Yamuna. New Ashok Nagar and Anand Vi-har in East Delhi; Jahangirpuri in North Delhi to Qutub Minar in South Delhi; and Mundka in West Delhi. The construction of second phase will integrate east with west and south with north. About 6 places passengers will have inter changing facilities.

3.2 PHYSIOGRAPHY

The project area is situated in Delhi, the capital of India. The average elevation of Delhi plain is 198 m to 200 m above the mean sea level (amsl). The ridge, however has a higher elevation going upto 250 m above mean sea level (amsl) and is about 15 to 20 m above the surrounding plains. The Shahdara area drains from East to West into Yamuna River. Similarly Delhi and New Delhi areas also drain in Yamuna River through various drains such as Najafgarh drain. Many small watercourses intersect the terrain causing a variation in relief. However, the average gradient of terrain is gentle, in the order of 1 to 3 m per km. Delhi area is generally flat except for a gentle rise to form a central ridge from North-North-East to South-South-West. The ridge almost touches the East-West alignment near Jhandewalan Station.

3.3 GEOLOGY AND SOILS

The area under study is part of the Yamuna basin comprising the newer alluvium made-up of fine to medium, sands, silts, gravel, clay and canker. The surface beds are admixed with wind blown sediments of recent age. These alluvial sediments are known to be underlined by hard formations of Delhi system of rock. Following is the general sequence of formations met within the area:

- Recent to Sub-Recent : Alluvium
- Post Delhi Intrusive : Pegmatic and Basic Intrusive
- Algonkian (Delhi System) : Alwar Quartzites

RITES has carried out detailed investigations by drilling a series of boreholes throughout the alignment/project area during 2000-2001 and 2003-2004. The area has mature topography with scattered isolated hillocks where rocks are exposed. The bedrock comprises of Quartizites with intercalated beds of mica-Schists

belonging to Alwar formation of Delhi group of pre-Cambrian age. Quartz Veins and pegmatites boudins are seen along some of the major horizontal fractures. The regional strike of the Alwar quartzite's varies from North-North-East to North West and South-South-West to South-East and has 35 degrees to 80 degrees dip towards East to North-East directions.

The over burden is mostly clay of low plasticity containing high percentage of silt are available in all corridors. The STP values vary from 6 to 107. The soils strata soft to stilt to hard and loose to medium dense. The properties of soil strata are summarised in **Table 3.1.**

TABLE 3.1
PROPERTIES OF OVER BURDEN SOIL STRATA

S. NO	SECTION	TYPE OF SOIL	SALIENT PROPERTIES	
			SPT Value	Consistency/ Relative Density
1	Viswa Vidyalaya- Jahangiri Puri	Sandy Silt	6-57	Soft to stiff to hard loose to very dense
2	Central Secretariat- Qutub Minar	Sandy Silt (SM, ML-CL/CL)	77-107	Firm to stiff-hard loosed to dense
3.	Shahdara- Dilshad Garden-NOIDA	Sandy Silt (ML- CL)	15-30	Medium hard, loose to medium dense.
4.	Indraprastha – New Ashok Nagar	Sandy Silt (ML-CL)	15-20	Medium Hard, Loose to Medium Dense
5.	Yamuna Bank – Anand Vihar	Sandy Silt (SM)	6-30	Soft to Medium hard
6.	Kirti Nagar - Mundka	Sandy Silt (CL)	8-82	Soft to very stilt to hard loose

CL: Fine grained soils with more than 50% soil particles (by weight) passing through 75 micron IS Sieve when shaken. Low compressibility and liquid limit less than 35%. The soil contains in organic clay of low plasticity.

SM: Sandy soil with more than 50% particles (by weight) passing through 4.75 mm IS Sieve and retained by 75 microns IS Sieve. This soil contains more than 12% fines and is named as silty sand. This is relatively coarser.

SC: Clayey sand, relatively coarser with more than 50% soil particles (by weight) passing through 4.75 mm IS Sieve and retained by 75 microns sieve and having more than 12 % fines.

The soil samples have been analysed. The results so obtained are reported in **Table 3.2.** The soils are slightly alkaline in nature. The soils are mainly sandy to sandy clay in texture. Nitrogen content is more in open areas. Organic content in soils vary from 0.34 to 7.48%.

3.4 GROUND WATER HYDROLOGY

Delhi receives two seasonal rainfalls. These are due to South West and North-East monsoons. About 75% of rainfall occurs during July to September due to South-West monsoon. The North East monsoon is active during December-April. The annual rainfall is about 660 mm. The ground water occurs in silty to sandy layers of the alluvial sediments and also in the jointed quartzite having secondary permeability under unconfined conditions. Semi confined aquifer zones are present below 150 m depth. The permeability varies from 0.5 to 8 m per day and transmissivity from 10 to

100 m^2/day. The depth of water table is observed between 4.5 to 21.6 m below ground level as indicated in **Table 3.3.**. The slope of the water table is away from the ridge on either side and the ridge acts as ground water divider between the eastern and western parts of Delhi. The hydraulic gradient is gentle and of the order of 1.8 to 2.0 m per km. Based on the analysis of soil and water data it could be concluded that the sub soil and underground water are unlikely to have any deteriorating effect on under ground MRTS structures and foundation.

TABLE 3.2
PHYSIO-CHEMICAL CHARACTERISTICS OF SOILS

S. NO	SAMPLE / PARAMETER	SAMPLE LOCATIONS									
		1	2	3	4	5	6	7	8	9	10
1	pH	8.01	8.05	8.49	8.82	8.01	7.99	7.11	7.96	7.57	8.1
2	Texture										
	Sand (%)	59.03	81.23	68.26	76.30	78.24	60.00	59.03	65.98	66.25	70.5
	Silt (%)	11.10	3.03	15.44	9.15	10.24	19.14	10.83	12.71	14.24	10.7
	Clay (%)	29.87	15.74	16.30	14.55	11.52	20.86	30.14	21.31	19.51	18.8
3	Nitrogen (kg/hectare)	545.65 ppm	734.79ppm	1030	347.47	500.18	2054.0	3397.69	1098.82	844.54	955.12
4	Phosphorus(kg/hectar)	31.32ppm	123.16ppm	605	57.09	84.24	17.93	32.05	7.94	10.12	11.15
5	**K (meq/100gm)**	----	--------	0.74	1.75	2.5	1.51	1.86	1.28	1.87	2.15
6	Ca(meq/100gm)	5.12ppm	2.41ppm	25.12	148.00	152	9.99	9.73	10.8	11.15	13.24
7	Mg (meq/100gm)	1.21ppm	1.81ppm	15.49	15.83	21	1.82	2.41	3.24	2.74	3.15
8	Na (meq/100gm)	5.44ppm	4.43ppm	3.15	5.58	2	0.7	2.63	2.30	2.87	3.10
9	Organic matter (%)	0.65	7.48ppm	0.69	0.34	0.74	2.15	3.28	0.88	1.42	1.8

1. Panchwati Chowk, 2-Lal Bagh Azadpur, 3-AIIMS, 4-Qutub Minar, 5-Near Karkardum flyover, 6-Yuman River area, 7-Near Sanjay Park, 8-New Ashok Nagar Station, 9-Near Punjabi Bagh, 10-Near Mundaka

TABLE 3.3
DEPTH OF GROUND WATER

S. NO.	SECTION	DEPTH (M)
1	Viswa Vidyalaya-Jahangiri Puri	5.5 - 7.0
2	Central Secretariat-Qutub Minar	8 – 22.0
3.	Shahdara - Dilshad Garden -NOIDA	5.5 - 8.0
4.	Indraprastha - New Ashok Nagar	4.5 – 8.0
5.	Yamuna Bank - Anand Vihar ISBT	4.7 – 6.2
6.	Kirti Nagar - Mundka	5.5 - 9.0

3.5 WATER QUALITY

Water availability and its quality will play a significant role in this project. Water supply to Delhi is made from Yamuna River. Water quality of Yamuna water at Wazirabad is good while at Ring Road, down stream; it had deteriorated due to addition of various polluted drains/streams in the river. About 3000-million litres of water per day is supplied to Delhi from this river through water works. In addition to this, about 230-million litres per day of ground water is also exploited for use. It was expected that water demand in Delhi will be about 4300 mld by end of 9^{th} Plan (2002). It is reported that Delhi treats about 2000-million litres of sewage, which is treated at 17 different treatment plants of Delhi. In addition about 6500-tonnes of solid waste is also generated in Delhi. This is disposed at specified sites approved by regulatory agency. RITES has collected ground water and river samples. The results so obtained are reported in **Table 3.4.** The analyses have indicated that water is slightly alkaline in nature. In most of the samples, the total dissolved solids are also high. These high values may be due to excess withdrawal of ground water. Few samples has indicated more concentration of chlorides and sulphates specially in Mayur Vihar area. The project is planning to utilise the water during construction and operation from ground water source or river Yamuna through water works. The

construction and operation activity of this project will have a negligible impact on Yamuna water quality.

TABLE 3.4
CHEMICAL ANALYSIS OF WATER SAMPLES

S NO	PARAMETER	SAMPLE LOCATIONS										
		1	2	3	4	5	6	7	8	9	10	11
1	pH	7.51	7.64	8.09	7.67	7.85	8.14	8.07	8.23	8.2	8.46	8.02
2	TDS (mg/l)	709.20	1224.74	1125	646	124	785	315	734	734	772.83	800.2
3	TSS (mg/l)	1.20	8.50	1.8	0.6	4.90	15.2	1.6	8.6	8.6	2.2	5
4	Calcium as Ca (mg/l)	40.00	327.67	108.21	73.67	32.03	443	45	36	36	47.95	50.23
5	Chloride as Cl (mg/l)	60.00	311.69	283.72	139.86	8.00	108	28	119	119	123.88	100.24
6	Sulphates as SO_4 (mg/l)	141.58	383.33	249.99	16.35	23.31	74	9.68	99.72	99.7	121.81	151.2
7	Fluorides as F (mg/l)	2.47	0.85	0.94	0.27	0.05	0.15	0.62	0.02	0.02	0.8	1.5
8	Iron as Fe (mg/l)	0.16	0.30	0.11	0.02	0.48	0.52	0.94	0.15	0.15	0.08	0.1
9	Nitrates as NO_3 (mg/l)	22.75	0.12	24.1	31.09	2.77	2.52	ND	15.06	15	2.6	2.5
10	BOD (mg/l)	2.20	1.50	0.3	ND	ND	<2	ND	ND	ND	<2	ND
11	Phosphates as PO_4(mg/l)	0.17	N.D	ND	ND	ND	ND	ND	ND	ND	ND	ND

1-Ground Water Model Town Crossing, 2-Bypass chowk near Sanjay Gandhi Tower, 3-Lal Bagh near Azadpur, 4- Nagaland House, 5-AIIMS, 6-Adihini Village, 7-New Ashok Nagar station, 8-Near Sanjay Park, 9-Yamuna River, 10-Near Punjabi Bagh, Mundaka Area.

3.6 FORESTRY

Tree survey was carried out along the proposed alignment. As such, no forest area exists along the MRTS alignment or its corridor. Most of the trees were planted along the roads in the past. The main species are Pipal, Neem, Kikar, Eucalyptus, Ashok, Ficus and Bakaan, etc. No rare or endangered species of trees have been noticed during field studies. An inventory of trees, likely to be lost is presented in **Table 3.5.** About 3147 trees are existing on the proposed alignment with an average of 51 trees/ km. In addition about 2000 trees are existing on the land likely to be used for Depot near proposed Yamuna Bank Railway Station. The total numbers of trees are 5147. The length wise trees in the corridors are report in **Table 3.6.**

TABLE 3.5

TREES IN CORRIDORS

S. NO	SECTION	NO. OF TREES			TOTAL
		LEFT	MIDDLE	RIGHT	
1	Viswa Vidyalaya-Jahangiri Puri	124	---	240	364
2	Central Secretariat-Qutub Minar	479	387	418	1284
3.	Shahdara-Dilshad Garden	75	---	56	131
4.	Indraprastha-New Ashok Nagar	111	---	84	195
5.	Yamuna Bank-Anand Vihar ISBT	143	50	144	337
6.	Kirti Nagar-Mundka	281	244	253	778
7.	Inderlok – Shivaji Park	26	---	32	58
8.	Depot at Yamuna Bank	---	---	---	2000
	TOTAL	1239	681	1227	5147

TABLE 3.6
TREES IN CORRIDOR LENGTH WISE

S. NO.	CHAINAGE IN KM		NO. OF TREES		
	FROM	TO	Left	Middle	Right
Viswavidyalaya – Jahangirpuri (Total route length = 6.362km)					
1	10.015	9.527 (CL of GTB Nagar)	0	-	0
2	9.527	8.281 (CL of Derawal nagar Station)	8	-	10
3	8.281	7.451 (CL of Model Town Railway Station)	1	-	2
4	7.451	6.714 (CL of Azadpur Railway Station)	4	-	6

S. NO.	CHAINAGE IN KM		NO. OF TREES		
	FROM	TO	Left	Middle	Right
5	6.714	5.854(CL of Azadpur mandi Railway Station)	27	-	25
6	5.854	4.778(CL of Mool chand Nagar Railway Station)	22	-	85
7	8.281	4.778 (CL of Jahangirpuri Railway Station)	62	-	111
8	4.778	3.653 (End of the alignment)	0	-	1
			124		240
Average number of trees per km = 57No.					
Central Secretariat - Qutab Minar (Total route length = 10.87km)					
9	20.25	20.970 (CL of Udyog Bhawan Rly stn.)	12	15	25
10	20.970	22.300 (CL of Race Course Rly. Stn.)	60	16	87
11	22.300	23.500 (CL of Jor Bagh Rly. Stn.)	101	13	52
12	23.500	24.850 (CL of INA Rly. Stn.)	89	101	81
13	24.850	25.910 (CL of AIIMS Rly. St.)	24	42	19
14	25.910	26.850 (CL of Green Park Rly. Stn.)	41	25	14
15	26.850	28.15 (CL of IIT Rly.Stn.)	26	20	55
16	28.15	29.500 (CL of PT School Rly. Stn.)	73	49	27
17	29.5	30.95 (CL of Qutub Minar Rly. Stn.)	21	58	43
18	30.95	Final end (32.38)	32	48	15
			479	**387**	**418**
Average number of trees per km = 110 No.					
Shahdara - Dilshad Garden (Total route length = 3.094km)					
19	0.00	1.14 (C.L of GTB enclave station)	10	**--**	**--**
20	1.14	2.15 (C. L of Jhilmil station)	33	--	33
21	2.15	3.56 (Dend of the alignment of Dlshad Garden)	32	--	33
			75	**--**	**66**
Average number of trees per km = 40 No.					
Indraprastha - New Ashok Nagar (Total route length = 8.074km)					
22	3.52	(CL of Yamuna Depot Station Rly stn.) 5.158	82	-	56
23	5.158	(CL of Games village station) 6.784km	10	-	12
24	6.784	(CL of Mayur vihar phase – I) 8.59km	9	-	0
25	8.59	(CL of Mayur vihar phase – I ext.) 9.659	10	-	11
26	9.659	(New Ashok Nagar station) 11.594	0	-	5
			111	-	84
Average number of trees per km = 24 No.					
Yamuna Bank - Anand Vihar ISBT (total length 6.155km)					
27	5.158	(CL of Laxmi Nagar station) 6.547	5	-	7
28	6.547	(C. L .of Scope tower station) 7.688	5	-	10
29	7.688	(C. L. of Preet Vihar station) 8.612	36	-	40
30	8.612	(C. L . Karkarduma station) 9.889	47	-	37
31	9.889	(C. L. of Anand Vihar station dead end) 11.433	50	50	50
			143	50	144
Average number of trees per km = 55 No.					
Kirti Nagar – Mundka (Total route length = 14.284km)					
32	7.466	(C. L. of New Moti Nagar) 8.877	160	-	19
33	8.877	(C. L .of Pujabi Bagh station) 9.866	35	-	6
34	9.866	(C. L. of Shivaji park station) 11.209	6	9	6
35	11.209	(C. L. of Madipur station) 12.194	2	4	13
36	12.194	(C. L. of Paschim Vihar station) 12.915	7	10	4
37	12.915	C. L. of Sahdev park station) 13.915	2	5	67
38	13.915	(C. L. of Peera Garhi station) 14.837	11	59	11
39	14.837	(C. L. of Udyog vihar station) 16.019	2	6	53
40	16.019	(C. L. of Suraj mall stadium station) 16.721	4	52	13
41	16.721	(C. L. of Nangloi station) 17.55	8	29	19
42	17.55	(C. L. of Nangloi r.station) 18.424	27	12	10
43	18.424	(C. L. of Rajdhani park station) 19.637	13	51	22
44	19.637	(C. L. of Mundka station and to the dead end) 21.750	4	7	10
			281	244	253
Average number of trees per km = 55 No					
Inderlok –Shivaji park station (total route length = 4.168km)					
45	11.209* (0Km)	(C. L. of Punjabi Bagh east) 1.701	10	-	10
46	1.701	(C. L .of Ashok park station) 2.701	6	-	7
47	2.701	(C. L. of Inderlok –II station) 4.168	10	-	15
			26	**-**	**32**
Average number of trees per km = 14No					
Average number of trees per km considering all the corridors of total length of 53.778km			**= 51No**		

3.7 AIR QUALITY

Little work was done before 1984 for measurement of air pollution in Delhi. National Environmental Engineering Research Institute (NEERI), Nagpur and Central Pollution Control Board, New Delhi have monitored ambient air quality in Delhi from time to time. These studies have indicated worst affected areas as Delhi gate, Azadpur, ITO and Rajendra Place. However, load due to vehicular pollution would be very high in congested areas like Azad Market, Delhi Gate, Darya Ganj, Connaught Place etc due to entrapping of air between high rise buildings. The main fuel used in vehicles are petrol, diesel and CNG Gas. The main pollutants that come out from the exhaust tail of vehicular engines are:

- Carbon dioxide;
- Carbon monoxides;
- Oxides of Nitrogen,
- Oxides of Sulphur,
- Hydrocarbon, and
- Particulate Matter.

In addition to above pollutants, unburnt products like aldehydes, formaldehydes, acrolein, acetaldehyde and smoke would also be emitted from petrol and diesel operated vehicles. The concentration of these pollutants in the engine exhaust varies with the type of engine namely, spark ignition (petrol engine) or compression ignition (diesel engine) two stroke or four stroke engines; and also mode of engine operation. **Table 3.7** gives the emission factor of various major pollutants from petrol (SI), diesel (CI) and CNG engines.

Diesel exhaust concentration of hydrocarbons is more than that of SI engine exhaust. Carbon monoxide concentrations in diesel engine exhaust is negligible to that of S I engines. Concentrations of oxides of nitrogen is more in diesel exhaust. Thus diesel engine exhaust contains lower concentrations of harmful pollutants like hydrocarbons, carbon monoxide and therefore, it is less hazardous. **Table 3.8** summarises the comparative emissions from CNG and Diesel engines. From this table it could be concluded that CO, NO_x and PM are about 45 to 300% higher in diesel vehicles than CNG vehicles.

The atmospheric concentrations of air pollutants were monitored by setting up ambient air quality monitoring stations at locations as shown in **Figure 3.1** for parameters SPM, CO, SO_2 and NO_x under ambient air quality monitoring (AAQM). The monitoring was carried out during September 2003 to November 2004. The results so obtained in Delhi are reported in **Table 3.9** and in reported corridors in **Table 3.10**. The ambient air quality data indicates much higher values of suspended particulate matter, than the prescribed limits established by CPCB at all the monitoring stations. However the values of SO_2, NOx and CO are within the permissible limits. These values have been compared with the available previous years data. There is an improvement in the concentration of suspended particulate matter in and around Delhi. This improvement is due to change of fuel from Diesel and petrol to CNG. The Central Pollution Control Board (CPCB) ambient air quality standards are reported in **Table 3.11.**

TABLE 3.7
EMISSION FACTORS FOR DIFFERENT VEHICLES

TYPE	NORMS	CO	HC	NO_x	PM
PCG/MUVG Passenger Car gasoline (PGCL) Multilevel Utility Vehicle Gasoline (MUVG)	India Stage 2000 norms (Euro-I)	2.4	0.48	0.39	0.04
	Bharat Stage-II (Euro-II)	1.98	0.25	0.2	0.03
	Bharat Stage-III (Euro-III)	1.39	0.15	0.12	0.02
	Bharat Stage-IV (Euro-IV)	1.0	0.126	0.127	0.016
PCD/MUVD Passenger Car Diesel (PCD) Multi utility Vehicle Diesel (MUVD)	India Stage 2000 norms (Euro-I)	1.0	0.25	0.59	0.14
	Bharat Stage-II (Euro-II)	0.9	0.13	0.5	0.07
	Bharat Stage-III (Euro-III)	0.58	0.05	0.45	0.05
	Bharat Stage-IV (Euro-IV)	0.50	0.056	0.5	0.05
LCV	India Stage 2000 norms (Euro-I)	5.1	0.14	1.28	0.2
	Bharat Stage-II (Euro-II)	0.72	0.063	0.59	0.07
	Bharat Stage-III (Euro-III)	0.64	0.056	0.50	0.05
	Bharat Stage-IV (Euro-IV)	0.50	0.030	0.025	0.025
Trucks	India Stage 2000 norms (Euro-I)	3.6	0.87	6.3	0.28
	Bharat Stage-II (Euro-II)	3.2	0.97	5.5	0.12
	Bharat Stage-III (Euro-III)	2.8	0.77	5.0	0.10
	Bharat Stage-IV (Euro-IV)	1.4	0.39	2.45	0.06
Bus	India Stage 2000 norms (Euro-I)	3.6	0.87	12.6	0.56
	Bharat Stage-II (Euro-II)	3.2	0.87	11.0	0.24
	Bharat Stage-III (Euro-III)	2.8	0.77	10.0	0.24
	Bharat Stage-IV (Euro-IV)	1.4	0.39	4.9	0.22
2 Wheelers 2 stroke	2001-2005 norms (India Stage 2000 norms)	2.2	2.13	0.06	0.05
	2005-2010 norms (Bharat Stage –II norms)	1.4	1.32	0.07	0.05
2 Wheelers 4 stroke	2001-2005 norms (India Stage 2000 norms)	2.2	0.7	0.3	0.05
	2005-2010 norms (Bharat Stage –II norms)	2.4	0.7	0.3	0.05
3 Wheelers 2 stroke	2001-2005 norms (India Stage 2000 norms)	4.3	2.05	0.11	0.08
	2005-2010 norms (Bharat Stage –II norms)	2.45	0.75	0.12	0.08
CNG Bus	2001 Norms	0.66	2.75	9.87	0.05
3 Wheeler 2 Stroke	2001 Norms	0.29	1.45	0.02	---
3 Wheeler 4 stroke	2001 Norms	0.29	2.40	0.75	---

TABLE 3.8
EMISSION FACTORS COMPARISON

FUEL	EMISSION IN G/JN				RATIO OF PM
	CO	NMVOC	NO_x	PM	
Low sulphur Diesel (500 ppm)	1.32	0.50	14.72	0.22	440% Higher
ULSD (50 ppm)	1.41	0.52	14.32	0.16	320% Higher
CNG	0.66	2.75	9.87	0.05	----

TABLE 3.9
AIR QUALITY IN AND AROUND PROJECT SITE

S. NO.	LOCATION	SPM $\mu g/m^3$	SO_2 $\mu g/m^3$	NOx $\mu g/m^3$	CO mg/m^3
1	Guru Teg Bahadur Chowk	1016-1552	18-31	35-63	2.4-2.7
2	Bhamshah Chowk	710-1172	16-34	31-59	2.1-2.8
3	Azadpur Chowk	799-1655	15-37	41-53	2.4-3.6
4	Sarai Chowk	1107*-1443	23-35	35-44	2.7-3.9
5	Opp. GT Karnal Road DTC Depot	870-1233	22-38	41-56	2.6-3.2
6	Sanjay Gandhi TPT Nagar	642-1187	20-33	43-58	1.8-2.4
7	Central Secretariat	619	16	32	1.7
8	Akbar Road crossing	295	17	40	1.6
9	Akbar road –Prithviraj Road crossing	494	17	35	1.6
10	INA Market	1045	26	46	2.5
11	Gulmohar Park-Green Park crossing	1111.	27	50	3.3
12	Outer ring road	818	27	43	2.3
13	Navjeevan Vihar crossing	753	27	35	2.0
14	Andheria Mor	538-758	13-34	25-31	1.4-2.1
15	Vasant Kunj Sector A	720-1147	15-28	30-44	1.5-1.8
16	Rangpuri	406-752	23-27	34-40	1.3-1.8
17	Indraprastha station	549 – 818	3 -9	5.3 –7.3	3.2 -4.3
18	Near Railway crossing at Shakarpur	588 –716	2 - 9	8.4 –9.2	2.3 -2.5
19	Pandav Nagar petrol pump	431 – 588	3 -5	2.0 –9.2	2.4 - 3.0
20	Near New Ashok Nagar	2174 *-2654	<3	7.0 –9.4	5.0 -6.0
21	Near Dharmashila cancer hospital	592 – 1020	<3	6.7- 7.2	2.0 -2.2
22	Near Kotla proposed station	497 –881	<3	4.7 –5.4	1.8 -2.8
23	Near Atta market	752* -1001	<3 - 14	4.3 –8.4	1.1 -1.2
24	Near Noida City center	589 - 664	2 -6	5.3 –9.6	1.0 - 1.2

Note: * SPM values are high due to dusty atmosphere

TABLE 3.10
AIR QUALITY AT PROJECT SITE ($\mu g/ m^3$)

S. NO.	LOCATION	SPM $\mu G/M^3$	SO_2 $\mu G/M^3$	CO MG/M^3	NOX $\mu G/M^3$
	Viswavidyalaya - Jahangirpuri				
1	Guru Teg Bahadur Chowk	1016-1552*	18-31	2.4-2.7	35-63
2	Bhamshah Chowk	710-1172	16-34	2.1-2.8	31-59
3	Azadpur Chowk	799-1655*	15-37	2.4-3.6	41-53
	Central Secretariat - Qutab Minar				
4	Central Secretariat	619*	16	1.7	32
5	Akbar road crossing	295	17	1.6	40
6	Akbar Road – Prithviraj Road Crossing	494	17	1.6	35
7	INA Market	1045*	26	2.5	46
8	Gulmohar park green park crossing	1111*	27	2.3	50
9	Outer ring road	818*	27	2.3	43
10	Navajeevan Vihar crossing	753	27	2.0	35
	Shahdara - Dilshad Garden				
11	Near GTB enclave	497 -881	<3	1.8 -2.8	47 -54
	Indraprastha - New Ashok Nagar				
12	Indraprastha station	549 - 818	<3 -9	3.2 -4.3	53 -73
13	Near New Ashok Nagar	2174 - 2654	<3	5.0 -6.0	70 -94
14	Near Dharmashila cancer hospital	592 - 1020	<3	2.0 -2.2	67- 72
	Yamuna Bank - Anand Vihar ISBT				
15	Near Karkarduma flyover	588 -716	2 - 9	2.3 -2.5	84 -92
16	Depot Site (Proposed)	215-300	<4	<4	20-31
	Kirti Nagar – Mundka				
17	Near Surajmall stadium pump	431 - 588	<3 -5	2.4 -3.0	20 -92
18	Near Nangloi	500 - 642	<4	1.2 -5.0	15 –89

S. NO.	LOCATION	SPM µG/M^3	SO_2 µG/M^3	CO MG/M^3	NOX µG/M^3
	Inderlok –Shivaji Park				
19	Near Punjabi Bagh area	450 - 580	<4	1.3-1.8	25-85

Note: * SPM values are high due to dusty atmosphere

TABLE 3.11
AMBIENT AIR QUALITY STANDARDS

S. NO.	Category of Area	Concentration in µg/m^3			
		SPM	NO_x	SO_2	CO
1	Industrial and Mixed use	500	120	120	5000
2	Residential and Rural	200	80	80	2000
3	Sensitive	100	30	30	1000

3.8 SEISMICITY

The project area falls in Zone-IV of Seismic Zoning Map of India.. Delhi region shows active and prolonged seismic history. Earthquakes of 3 to 6.7 magnitude on Richter scale have occurred in past around Delhi. Most of the shocks are interpreted to have shallow focus and have locations to the West of Delhi. Maximum concentrations of the earthquakes epicentre have been around Sonepat, Rohtak and Gurgaon. The seismic factor needs to be appropriately incorporated while finalising civil designs

3.9 NOISE

RITES have measured noise levels at different places in Delhi at 2m away from source as per standard practice. The noise levels so obtained during monitoring in 2003-04 for metro corridors are summarised in **Table 3.12** and **Table 3.13.** It could be concluded that the noise levels recorded at various places are higher than prescribed permissible levels of 65-dBA (day) and 55-dBA (night). The noise level standards are documented in **Table 3.14.**

TABLE 3.12
NOISE LEVELS IN AND AROUND DELHI (Leq)

LOCATION (TYPE OF AREA)	TIME	L_{eq}	L_{max}	L_{10}	L_{50}	L_{90}	L_{min}	L_{day}	L_{night}
Andheria More (Residential)	09-10	73.60	97.50	75.20	68.10	59.00	48.10	75.1	65.95
	18-19	76.60	100.60	78.40	69.90	62.20	49.00		
	00-01	66.50	88.30	67.70	61.60	51.60	41.70		
	04-05	65.4	88.3	67.80	61.80	51.90	41.80		
	Average	70.53	93.68	72.28	65.35	56.18	45.15		
Vasant Sector A (Residential)	09-10	79.80	105.70	81.60	73.80	64.00	52.20	79.95	66.80
	18-19	80.10	105.20	82.00	73.10	65.00	51.30		
	00-01	69.40	90.00	69.00	62.90	52.60	42.50		
	04-05	6420	85.40	65.60	59.70	50.10	40.40		
	Average	73.38	96.58	74.55	67.38	57.93	46.60		
Rangpuri (Residential)	09-10	76.40	101.2	78.10	70.70	61.30	50.00		
	18-19	75.80	99.50	77.60	69.20	61.50	48.50		

LOCATION (TYPE OF AREA)	TIME	L_{eq}	L_{max}	L_{10}	L_{50}	L_{90}	L_{min}	L_{day}	L_{night}
	00-01	67.50	84.30	64.60	58.80	49.30	39.80	76.10	64.80
	04-05	62.10	83.40	64.00	58.30	49.00	39.40		
	Average	70.45	92.10	71.08	64.25	55.28	44.43		
Noida City Center Station (Commercial)	09: -10	68.8	91.2	70.3	63.6	55.2	45.0	70.7	54.1
	18-19	71.5	93.9	73.2	65.3	58.1	45.8		
	04-05	58.2	81.2	62.4	56.8	47.7	38.4		
	00-01	60.2	76.3	58.5	53.2	44.6	36.0		
	Average	64.7	85.7	66.1	59.7	51.4	41.3		
Atta Chowk (Commercial)	09: -10	69.5	92.1	71.0	64.3	55.7	45.5	73.2	57.3
	18-19	76.1	99.9	77.9	69.5	61.8	48.7		
	04-05	55.8	77.7	59.7	54.4	45.7	36.8		
	00-01	56.3	73.6	56.4	51.4	43.0	34.8		
	Average	64.4	85.8	66.3	59.9	51.6	41.5		
New Ashok Nagar (Residential)	09: -10	72.4	95.9	74.0	67.0	58.1	47.3	72.0	54.9
	18-19	82.1	107.8	84.1	75.0	66.7	52.5		
	04-05	49.2	70.5	54.2	49.3	41.4	33.4		
	00-01	60.5	70.5	54.1	49.2	41.2	33.3		
	Average	66.1	86.2	66.6	60.1	51.9	41.6		
Near Dharamsheela Hospital (Silence Zone)	09: -10	72.3	95.8	73.9	66.9	58.0	47.3	70.4	60.0
	18-19	74.4	97.7	76.2	67.9	60.4	47.6		
	04-05	55.2	75.7	58.2	53.0	44.5	35.8		
	00-01	66.5	84.8	65.0	59.2	49.6	40.1		
	Average	67.1	88.5	68.3	61.8	53.1	42.7		
Sanjay Lake Park (Residential)	09: -10	68.5	90.8	70.0	63.4	54.9	44.8	65.8	55.9
	18-19	66.3	87.1	67.9	60.5	53.8	42.4		
	04-05	55.1	76.7	58.9	53.6	45.0	36.3		
	00-01	58.2	69.4	53.2	48.5	40.6	32.8		
	Average	62.0	81.0	62.5	56.5	48.6	39.1		
Near Pandav Nagar Petrol Pump (Commercial)	09: -10	77.0	102.0	78.7	71.2	61.8	50.4	71.5	58.9
	18-19	75.0	98.5	76.8	68.5	60.9	48.0		
	04-05	54.3	82.8	63.6	57.9	48.7	39.2		
	00-01	60.2	76.3	58.3	53.2	44.6	36.0		
	Average	66.6	89.9	69.4	62.7	54.0	43.4		

Note: L_{10}, L_{50} and L_{90} are the sound level, which is exceeded 10%, 50% & 90% of the total time

TABLE 3.13

NOISE LEVELS IN DELHI (Leq)

LOCATION (TYPE OF AREA)	TIME	L_{eq}	L_{max}	L_{10}	L_{50}	L_{90}	L_{min}
Viswavidyalaya – Jahangirpuri							
Guru Teg Bahadur Chowk (Commercial)	09-10	83.6	110.8	85.4	77.3	67.0	54.7
	18-19	81.4	106.9	83.4	74.3	66.1	52.1
	00-01	84.6	113.2	86.8	79.0	66.2	53.5
	04-05	66.2	88.6	68.1	62.0	52.0	44.3
	Average	79.0	104.9	80.9	73.2	62.8	51.2
Bhamshah Chowk (Commercial/Industrial)	09-10	68.4	90.6	69.9	63.3	54.9	44.7
	18-19	76.3	100.2	78.1	69.7	62.0	48.8
	00-01	68.6	91.8	70.4	64.1	53.6	43.4
	04-05	70	93.7	72	65.5	55	44.3
	Average	70.8	94.1	72.6	65.7	56.4	45.3
Azadpur Chowk (Commercial)	09-10	77.2	102.3	78.9	71.4	61.9	50.5
	18-19	77.4	101.6	79.3	70.7	62.8	49.5
	00-01	70.0	93.7	71.8	65.4	54.7	44.2
	04-05	70	93.7	72	65.5	55	44.3
	Average	73.7	97.8	75.5	68.3	58.6	47.1
Central Secretariat - Qutab Minar							
Central Secretariat (Commercial)	09-10	74.3	98.4	75.9	68.7	59.6	48.6
	18-19	74.2	97.4	76.0	67.7	60.3	47.5
	00-01	65.8	87.4	67.0	61.0	51.1	41.3
	04-05	64.6	88.7	68.2	62.1	52.1	42.0
	Average	69.7	93.0	71.8	64.9	55.8	44.9
Akbar road crossing (Residential)	09-10	72.6	96.2	74.2	67.2	58.2	47.5
	18-19	74.5	97.8	76.3	68	60.5	47.7
	00-01	66.2	86	66	60.1	50.3	40.6
	04-05	62.2	84.8	65.2	59.3	49.8	40.1
	Average	68.9	91.2	70.4	63.7	54.7	44.0
Akbar Road – Prithviraj Road crossing (Residential)	09-10	78.3	103.7	80	72.4	62.8	51.2
	18-19	80.4	105.6	82.3	73.4	65.3	51.5
	00-01	62.1	84.8	65	59.2	49.6	40.1
	04-05	65.3	86.2	66.2	60.3	50.6	40.8
	Average	71.5	95.1	73.4	66.3	57.1	45.9
INA market (Commercial)	09-10	75	99.4	76.7	69.4	60.2	49.1
	18-19	84	110.3	86	76.7	68.2	53.8
	00-01	72.7	94.5	72.4	65.9	55.2	44.6
	04-05	69	92.3	70.3	64.6	54.2	43.5
	Average	75.2	99.1	76.4	69.2	59.5	47.8
Green park – Gulmohar park crossing (Commercial)	09-10	78.3	103.7	80	72.4	62.8	51.2
	18-19	76.2	100.1	78	69.6	61.9	48.8
	00-01	69.3	90.3	69.3	63	52.8	42.7
	04-05	65.2	88.7	68.2	62.1	52.1	42
	Average	7.23	95.7	73.9	66.8	57.4	46.2
Outer ring road crossing (Commercial)	09-10	78.4	103.9	80.1	72.5	62.9	51.3
	18-19	78	102.4	79.9	71.2	63.3	49.9
	00-01	68.7	88.8	68.1	62	51.9	42
	04-05	66.4	86	66.1	60.2	50.5	40.7
	Average	72.9	95.3	73.6	66.5	57.2	46.0
Navjeevan Vihar crossing (Residential)	09-10	74.5	98.7	76.1	68.9	59.7	48.7
	18-19	77.4	101.6	79.3	70.7	62.8	49.5
	00-01	70	93	71.3	64.9	54.3	43.9

LOCATION (TYPE OF AREA)	TIME	L_{eq}	L_{max}	L_{10}	L_{50}	L_{90}	L_{min}
	04-05	67.3	88.8	68.3	62.2	52.2	42
	Average	72.3	95.5	73.8	66.7	57.3	46.0
Shadra-Dilshad Garden							
Near GTB Enclave (Residential)	09-10	68.5	90.8	70.0	63.4	54.9	44.8
	18-19	66.3	87.1	67.9	60.5	53.8	42.4
	00-01	64.3	89.5	69.2	63.2	52.3	43.0
	04-05	55.1	76.7	58.9	53.6	45.0	36.3
	Average	63.6	86.0	66.5	60.2	51.5	41.6
Indraprastha - New Ashok Nagar							
New Ashok Nagar (Residential)	09-10	72.4	95.9	74.0	67.0	58.1	47.3
	18-19	82.1	107.8	84.1	75.0	66.7	52.5
	00-01	60.5	70.5	54.1	49.2	41.2	33.3
	04-05	49.2	70.5	54.2	49.3	41.4	33.4
	Average	66.1	86.2	66.6	60.1	51.9	41.6
Near Dharamsheela Hosp (Silence Zone)	09: -10	72.3	95.8	73.9	66.9	58.0	47.3
	18-19	74.4	97.7	76.2	67.9	60.4	47.6
	04-05	55.2	75.7	58.2	53.0	44.5	35.8
	00-01	66.5	84.8	65.0	59.2	49.6	40.1
	Average	67.1	88.5	68.3	61.8	53.1	42.7
Yamuna Bank - Anand Vihar ISBT							
Near Karkarduma flyover (Residential +commercial)	09-10	72.3	95.8	73.9	66.9	58.0	47.3
	18-19	74.4	97.7	76.2	67.9	60.4	47.6
	00-01	66.5	84.8	65.0	59.2	49.6	40.1
	04-05	55.2	75.7	58.2	53.0	44.5	35.8
	Average	67.1	88.5	68.3	61.8	53.1	42.7
Kirti Nagar – Mundka							
Near Suraj mall stadium (Residential)	09-10	72.00	108.0	76.2	70.8	62.4	51.8
	18-19	74.0	102	74.4	69.25	60.8	46.4
	00-01	60.3	71.2	53.2	48.5	42.2	34.3
	04-05	58.3	95	62.1	56.7	49.4	40.30
	Average	66.2	94.1	66.5	61.3	53.7	43.2
Near Nangloi area (Residential)	09-10	75.4	99.7	72.4	70.4	61.8	50.14
	18-19	72.1	80.5	5.4	70.1	59.4	45.2
	00-01	62.2	83.8	65.2	58.4	48.3	42.1
	04-05	60.2	80.7	66.1	56.8	50.1	40.1
	Average	67.5	86.2	52.3	63.9	54.9	44.4
Inderlok-Shivaji Park							
Near Punjabi bagh area (Commercial)	09-10	72.1	84.2	72.4	69.5	60.1	51.4
	18-19	65.2	75.4	5.4	69.5	58.5	46.2
	00-01	64.2	87.3	67.3	61.5	52.3	44.0
	04-05	58.5	70.4	66.1	55.4	49.5	41.5
	Average	65.0	79.3	52.8	64.0	55.1	45.8

Note: L_{10}, L_{50} and L_{90} are the sound level, which is exceeded 10%, 50% & 90% of the total time

TABLE 3.14
NOISE LEVELS STANDARDS dB (A)

S.No.	Standard For	DAY	NIGHT
1	Industrial Area	75	70
2	Commercial Area	65	55
3	Residential Area	55	45
4	Silence Zone	50	40

3.10 SOCIO-ECONOMICS

A detailed socio-economic study has been carried out for the project involving about 10% of the affected population (the population with in the right of way). The sample performa used for such study has been enclosed **as Annexure 3.1**. No public hearing has, however been conducted during the study. In order to keep acquisition of private land to the barest minimum, the alignment has been so chosen, that it remains mostly within the government land. However, at few locations private land is required for entry, exit and other facilities of station and running section. The private land requirements will be about 4.22 ha. The details of land permanently required for the project are given in **Table 3.15.**

TABLE 3.15
LAND REQUIREMENT

SL. NO.	CORRIDOR NAME	TYPE OF LAND TO BE ACQUIRED (HA)		TOTAL
		GOVERNMENT	PRIVATE	
1	Viswavidyalaya – Jahangiripuri	5.67	0.09	5.76
2	Central Secretariat – Qutab Minar	31.19	0.08	31.198
3	Shahdara – Dilshad Garden	5.67	2.12	7.79
4	Indraprastha – New Ashok Nagar	16.97	0	61.97
5	Depot	45.00	---	---
6	Yamuna Bank – Anand Vihar ISBT	29.47	0.32	29.79
7	Kirti Nagar – Mundka along with Shivaji Park - Inderlok	21.93	1.68	23.61
	TOTAL LAND	**155.90**	**4.22**	**160.12**

During social survey we made some observations on land details along the all corridors, which are as follows:

i) ***In Viswa Vidyalaya to Jahangirpuri*** *corridor*, it was only few small shops area to be acquired for the purpose of entry to Guru Tegh Bahadur Nagar Station. Other than these shops, no displacement is likely to take place. However, these shops were covered under social survey in order to know their socio-economic status.

ii) ***In Central Secretariat*** - *Qutab Minar corridor*, in private land there are a few shops on Plot No. FP-6 (96.87 sqm.) at Green park Station, which need relocation. Private plots of land area to be acquired at Hauz khas Station at GP-1 &2 (545.55 sqm.), Institutional land at IIT station HP-1 (402.63 sqm). The shops can be relocated in the plot areas, proposed for acquisition for Traffic integration at stations, as the areas required are small.

iii) ***In Shahdara*** - *Dilshad Garden alignment,* only at location *i.e*. near GTB enclave the proposed station starting from railway crossing near Vishwamedha setu to the end of the fly over, private land needs to be acquired. It was observed during the field study that people in Jhilimil industrial area would be affected due to development of metro project from Shahdara to Dilshad Garden. The primary data for the study was collected through interviews with the project-affected people using the help of pre-tested structured interview schedule. These have been covered for the purpose of this study.

At these locations there are about 75 small-scale industries manufacturing mostly the copper wire, paper products etc., the average number of persons employed in each industry is about 10 –15. It is also observed that most of the industries are handling the hazardous waste and have obtained the valid clearance from state pollution control committee. The average area of each industry is about 1000m^2. During the survey, negative response from the owners has been received.

iv) **In *Indraprastha*** - *New Ashok Nagar* corridor, the alignment passes through the cultivated land for the total area of 60.55ha starting from Yamuna Bank to Mayur Vihar phase –I area. No private buildings are getting affected due to the alignment. About 312 Jhuggis in the running section of yamuna khadir area on DDA land also requires relocation along the Indraprashtha to new Ashok Nagar corridor alignment. Other than these, no displacement is likely to take place.

v) ***Along the Yamuna Bank -*** *Anand Vihar ISBT corridor* no loss of private land is getting affected due to the proposed corridors. Hence, no social survey is anticipated due to the project.

vi) ***Along the Kirti Nagar Mundka*** *corridor* there are few shops and houses in private land is getting affected due to the proposed station near by Mundka Bus Stop. These shops and houses were covered under social survey.

vii) ***Along the Inderlok to Shivaji park*** *station corridor,* the alignment passes there are about 100 Jhuggis in the running section of near Amar park area on Railway land which are getting affected and requires relocation. As such near 650-700 semi pucca hoses are existing near Amar Park area. However, for the metro alignment, it is estimated that about 100families will be affected. Sample surveys have been carried out accordingly. It is observed that most of the project-affected people in the area are working in telephone exchange and as daily wages. Near by no primary school exists for children and have to cross the railway line.

3.10.1 Survey Design

The present study is based on descriptive survey design. This descriptive design was picked up for portraying accurately the socio-economic characteristics of project-

affected families. It was observed during the field study that people in Central Secretariat – Qutab Minar, Indraprastha- New Ashok Nagar, Shahdara- Dilshad Garden and Indralok –Shivaji park areas would be affected due to development of metro project. It is therefore decided to conduct a social survey in these affected areas along the alignment by using random sampling method. The sample size in each area is presented in **Table 3.16**. About 94 project affected families were randomly selected. The primary data for the study was collected through interviews with the project-affected people using the help of pre-tested structured interview schedule. Almost all the residential dwellings are pucca houses and have been constructed with brick-mortar except along Inderlok to Shivaji park line near Amar Park where most of the houses are built in Railway land in semi pucca houses.

TABLE 3.16
SAMPLE SPECTRUM OF PAFS

NAME OF CORRIDORS	TOTAL PAFS	SAMPLE SIZE	PERCENTAGE
Vishwa Vidyalaya-Jahangirpuri	20	5	25.0
Central Secretariat –Qutab Minar	63	24	39.0
Shahdara –Dilshad Garden	75	10	13.0
Indraprastha to New Ashok Nagar	312	32	10.0
Inderlok –Shivaji park	102	13	13.0
Kirti Nagar-Mundka	86	10	12.0
TOTAL	**658**	**94**	

3.10.2 Socio-Economic Profile of the PAFs

Table 3.17 shows sex wise distribution of project-affected people. As many as 56.1% people are male as against 43.9% female. Male to Female ration is 1.28:1 maximum number of male in Kirti Nagar to Mundka corridor being 65%. It is also observed that male people preponderate in all corridors.

TABLE 3.17
SEX WISE DISTRIBUTION OF FAMILY MEMBERS

Sl. No	Sex	Central Secretariat – Qutab Minar (N=115)		Indraprastha to New Ashok Nagar (N=142)		Shahdara – Dilshad Garden (N=40)		Inderlok – Shivaji park (N=58)		Kirti Nagar-Mundka (N=46)		Vishwa Vidyalaya-Jahangirpuri (N=38)		Total (N=439)	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	Male	65	56.5	78	54.9	21	52.5	35	60.0	30	65.2	17	44.7	246	56.1
2	Female	50	43.5	64	45.1	19	47.5	23	40.0	16	34.8	21	55.3	193	43.9

Maximum number of people (40.1 %) falling in the age group of 15-35 years, 33.9% belong to the age of 36-60 years. Remaining 20.7% and 5.2 % people belong to the age of below 14 years and above 60 years respectively. The mean average age of the people is 30.34 years. Age wise distribution in corridors is presented in **Table 3.18.**

TABLE 3.18
AGE-WISE DISTRIBUTION OF PAPs

Sl No	Age Group (years)	Central Secretariat – Qutab Minar		Indraprastha to New Ashok Nagar		Shahdara – Dilshad Garden		Inderlok – Shivaji park		Kirti Nagar - Mundka		Vishwa Vidyalaya-Jahangirpuri		Total	
		(N=115)		(N=142)		(N=40)		(N=58)		(N=46)		(N=38)		(N=439)	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	0 - 14	13	11.3	34	23.9	11	27.5	23	39.6	7	15.2	3	7.9	91	20.7
2	15 - 35	69	60.0	42	29.6	15	37.5	10	17.2	26	66.5	14	36.8	176	40.1
3	36 - 60	29	25.2	52	36.6	14	35	23	39.6	12	26.1	19	50.0	149	33.9
4	60 & Above	4	3.48	14	9.8	0	0	2	3.5	1	2.2	2	5.3	23	5.2
Mean		29.98		32.56		28.10		23.36		29.02		36.92		30.91	
S.D		3.94		3.55		6.75		5.86		6.36		6.76		1.97	

Table 3.19 shows that majorities of population are Hindu (92.5%). The proportion of the people belonging to Muslim (6.4%) and Jain (1.1%) religions. Hindu family dominates in all surveyed corridors.

TABLE 3.19
RELIGIOUS GROUP

SL. No.	Religious group	Central Secretariat – Qutab Minar		Indraprastha to New Ashok Nagar		Shahdara – Dilshad Garden		Inderlok – Shivaji park		Kirti Nagar-Mundka		Vishwa Vidyalaya-Jahangirpuri		Total	
		(N=24)		(N=32)		(N=10)		(N=13)		(N=10)		(N=5)		(N=94)	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	Hindu	24	100	29	90.6	8	80	11	85	10	100.0	5	100.0	87	92.5
2	Muslim	0	0	3	9.4	1	10	2	15	0	0	0	0.0	6	6.4
3	Jain	0	0	0	0	1	10.0	0	0	0	0	0	0.0	1	1.1

The analysis of data reveals that the majority of the people (42.6%) are belongs to General Castes. But the second largest group of the people belongs to Scheduled Castes (38.3%), followed by those coming from other Backward Castes (19.1%). Mixed scenario is observed from this analysis. The caste distribution of PAFs is presented in **Table 3.20**. There was no schedule Tribe among the surveyed families.

TABLE 3.20
CASTE WISE DISTRIBUTION OF PAFS

Sl No	Caste	Central Secretariat – Qutab Minar		Indraprastha to New Ashok Nagar		Shahdara – Dilshad Garden		Inderlok – Shivaji park		Kirti Nagar-Mundka		Vishwa Vidyalaya-Jahangirpuri		Total	
		(N=24)		(N=32)		(N=10)		(N=13)		(N=10)		(N=5)		(N=94)	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	SC	1	4.17	25	78.2	1	10	6	46.2	3	30.0	0	0.0	36	38.3
2	OBC	1	4.17	5	15.6	1	10	7	53.8	4	40.0	0	0.0	18	19.1
3	General	22	91.6	2	6.2	8	80	0	0	3	30.0	5	100.	40	42.6

Table 3.21 shows that 25.5% of project affected people studied up to college, 21.2% up to middle, 19.8 % up to primary and 19.6% up to high school. It is important to note that remaining 13.9% are illiterate. Thus it is evident from the analysis that in most of the areas people have completed middle school.

TABLE 3.21
LEVEL OF EDUCATION AMONG THE PAPs

Sl No	Education level	Central Secretariat – Qutab Minar		Indraprastha to New Ashok Nagar		Shahdara – Dilshad Garden		Inderlok – Shivaji park		Kirti Nagar-Mundka		Vishwa Vidyalaya-Jahangirpu		Total	
		(N=115)		(N=142)		(N=40)		(N=58)		(N=46)		(N=38)		(N=439)	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	Illiterate	11	11	25	17.6	3	7.5	17	29	5	10.9	0	0.0	61	13.9
2	Primary	12	11	39	27.4	1	2.5	24	41	9	19.5	2	5.3	87	19.8
3	Middle	31	31	40	28.1	14	35.0	0	0	6	13.0	2	5.3	93	21.2
4	High	26	12	15	10.5	2	5.0	16	28	13	28.3	14	36.8	86	19.6
5	College	35	35	23	13.3	20	42.5	1	2	13	28.3	20	52.6	112	25.5

So far as marital status of family members are concerned it is observed from **Table 3.22** that out of 439 project affected people, majority of them (59.7%) are unmarried and 40.3 % are married.

TABLE 3.22
MARITAL STATUS OF PROJECT AFFECTED PEOPLE

Sl No	Marital Status	Central Secretariat – Qutab Minar		Indraprastha to New Ashok Nagar		Shahdara – Dilshad Garden		Inderlok – Shivaji park		Kirti Nagar-Mundka		Vishwa Vidyalaya-Jahangirpuri		Total	
		(N=115)		(N=142)		(N=40)		(N=58)		(N=46)		(N=38)		(N=439)	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	Married	45	39.1	48	33.8	19	47.5	27	46.6	21	45.6	17	44.7	177	40.3
2	Unmarried	70	60.9	94	66.2	21	52.5	31	53.4	25	54.4	21	55.3	262	59.7

Table 3.23 indicates that the occupation of majority OF people (53.2%) are engaged in business activities and remaining 40.4% and 6.4% of them are engaged in daily wages activities and service respectively.

TABLE 3.23
OCCUPATION WISE DISTRIBUTION OF PROJECT AFFECTED FAMILIES

Sl No	Occupation	Central Secretariat – Qutab Minar		Indraprastha to New Ashok Nagar		Shahdara – Dilshad Garden		Inderlok – Shivaji park		Kirti Nagar-Mundka		Vishwa Vidyalaya-Jahangirpuri		Total	
		(N=24)		(N=32)		(N=10)		(N=13)		(N=10)		(N=5)		(N=94))	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	Labour	0	0	30	93.7	0	0.0	6	46.2	2	20.0	0	0.0	38	40.4
2	Business	24	100	2	6.3	10	100	2	15.4	7	70.0	5	100	50	53.2
3	Service	0	0	0	0	0	0.0	5	38.5	1	10.0	0	0.0	6	6.4

About 38.3% of families have their income less than Rs. 25,000/-, 44.7% of them have an income of Rs.25001-100,000/- per annum. About 12.7 % of the families have an income range between Rs.100,000 to 200,000 per annum. Remaining 4.2% of the families have an income more than Rs. 200,000/- per annum **(Table 3.24)**.

TABLE 3.24
FAMILY INCOME OF PROJECT AFFECTED FAMILIES (PER annum)

Sl No	Income	Central Secretariat – Qutab Minar		Indraprastha to New Ashok Nagar		Shahdara – Dilshad Garden		Inderlok – Shivaji park		Kirti Nagar-Mundka		Vishwa Vidyalaya-Jahangirpuri		Total	
		(N=24)		(N=32)		(N=10)		(N=13)		(N=10)		(N=5)		(N=94)	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	0-25000	4	16.6	25	78.1	1	10.0	5	38.5	1	10.0	0	0.0	36	38.3
2	25001-50000	14	58.3	5	15.6	0	0.0	5	38.5	6	60.0	0	0.0	30	31.9
3	50001-100000	2	8.34	0	0.0	5	50.0	3	23.0	1	10.0	1	20.0	12	12.8
4	100001-150000	1	4.16	2	6.2	0	0.0	0	0.0	1	10.0	4	80.0	8	8.5
5	150001-200000	0	0.0	0	0.0	4	40.0	0	0.0	0	0.0	0	0.0	4	4.2
6	>200000	3	12.5	0	0.0	0	0.0	0	0.0	1	10.0	0	0.0	4	4.2
Mean		**60417.02**		**23437.61**		**108750.45**		**36538.77**		**63750.4**		**115000.5**		**52925.82**	
S.D		**41607.74**		**35839.10**		**66514.57**		**68175.51**		**65093.38**		**85201.99**		**17670.1**	

Table 3.25 indicates that 56.4% families are nuclear consisting of husband, wife and children, while 42.5% are joint families. The percentage of joint families is more in Central Secretariat- Qutab Minar (87.5%). Only 1.1% of them are individual.

TABLE 3.25
FAMILY PATTERN OF PAFs

Sl No	Family Pattern	Central Secretariat – Qutab Minar		Indraprastha to New Ashok Nagar		Shahdara – Dilshad Garden		Inderlok – Shivaji park		Kirti Ngar-Mundka		Vishwa Vidyalaya-Jahangirpuri		Total	
		(N=24)		(N=32)		(N=10)		(N=13)		(N=10)		(N=5)		(N=94)	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	Joint	21	87.5	7	21.8	1	10	5	38	3	30	3	60	40	42.5
2	Nuclear	3	12.5	25	78.2	9	90	7	54	7	70	2	40	53	56.4
3	Individual	0	0	0	0	0	0	1	8	0	0	0	0	1	1.1

Family size has been classified into four categories i.e., individual, small (2-4), medium (5-7) and large (7& above). Most of the families are small 47.9%, 30.8 % are medium, 11.7% are large in size and remaining 9.6 % are individual. The mean average size of family is 4 members **(Table 3.26)**.

TABLE 3.26
FAMILY SIZE OF PAFs

Sl No	Size of Family	Central Secretariat – Qutab Minar		Indraprastha to New Ashok Nagar		Shahdara – Dilshad Garden		Inderlok – Shivaji park		Kirti Nagar-Mundka		Vishwa Vidyalaya-Jahangirpuri		Total	
		(N=24)		(N=32)		(N=10)		(N=13)		(N=10)		(N=5)		(N=94)	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	Individual	2	8.33	5	15.6	1	10	1	7.7	0	0	0	0	9	9.6
2	Small (2to 4)	11	45.83	20	62.5	4	40	5	38.4	3	30	2	40	45	47.9
3	Medium (5 to7)	6	25.00	5	15.6	5	50	6	46.1	5	50	2	40	29	30.8
4	Large (7&above)	5	20.84	2	6.25	0	0	1	7.7	2	20	1	20	11	11.7
Mean		**4.42**		**3.41**		**4.30**		**4.5**		**5.30**		**5**		**4.2**	
S.D		**1.00**		**0.86**		**1.59**		**1.39**		**1.74**		**2.5**		**.52**	

Type of Structure to be acquired from project-affected families is given in **Table3.27.** On private land about 46.8% are houses, 41.5% are shops and 9.6% are house and shop. Whereas 2.1 % are revenue land including house.

TABLE 3.27
TYPE OF STRUCTURE

Sl No	Type of Structure	Central Secretariat – Qutab Minar		Indraprastha to New Ashok Nagar		Shahdara – Dilshad Garden		Inderlok – Shivaji park		Kirti Nagar-Mundka		Vishwa Vidyalaya-Jahangirpuri		Total	
		(N=24)		(N=32)		(N=10)		(N=13)		(N=10)		(N=5)		(N=94)	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	House	0	0	30	93.7	1	10.0	10	77	2	20.0	1	20.0	44	46.8
2	Shop	24	100	0	0	7	70.0	3	23	1	10.0	4	80.0	39	41.5
3	House & Shop	0	0	0	0	2	20.0	0	0	7	70.0	0	0.0	9	9.6
4	Others	0	0	2*	6.3	0	0	0	0	0	0.0	0	0.0	2	2.1

*Revenue land including house

Most of the structures of the project-affected families are semi-pucca (48.9%), pucca (46.8%) and remaining 4.2% are kutchha in nature. However, along the Indraprastha to New Ashok Nagar corridor, mostly cultivated lands are getting affected through which the project alignments have been proposed **(Table3.28).**

TABLE 3.28
CONSTRUCTION OF STRUCTURE

Sl No	Construction Structure	Central Secretariat – Qutab Minar		Indraprastha to New Ashok Nagar		Shahdara – Dilshad Garden		Inderlok – Shivaji park		Kirti Nagar-Mundka		Vishwa Vidyalaya-Jahangirpuri		Total	
		(N=24)		(N=32)		(N=10)		(N=13)		(N=10)		(N=5)		(N=94))	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	Kuchha	0	0	0	0	1	00.0	3	23	0	0.0	0	0.0	4	4.2
2	Semi-pucca	3	12.5	30	93.7	2	30.0	10	77	1	10.0	0	0.0	46	48.9
3	Pucca	21	87.5	2	6.3	7	70.0	0	0	9	90.0	5	100.0	44	46.8

It is also to be noted from **Table 3.29** that most of the project affected families (44.7%) are squatters have been staying on the government land whereas 30.8% and 24.5% of people having structure in leased and in their owned land respectively. Squatters have been observed along the corridors of Indraprashtah to New Ashok Nagar & Inderlok to Shivaji park corridor.

TABLE 3.29
OWNERSHIP OF STRUCTURE

Sl No	Ownership Of Structure	Central Secretariat – Qutab Minar		Indraprastha to New Ashok Nagar		Shahdara – Dilshad Garden		Inderlok – Shivaji park		Kirti Ngar-Mundka		Vishwa Vidyalaya-Jahangirpuri		Total	
		(N=24)		(N=32)		(N=10)		(N=13)		(N=10)		(N=5)		(N=94)	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	Owned	4	16.6	2	6.3	7	70.0	1	7.7	5	50.0	4	80.0	23	24.5
2	Leased	20	83.3	0	0	3	30.0	0	0	5	50.0	1	20.0	29	30.8
3	Squatters	0	0	30	93.7	0	0.0	12	92.3	0	0.0	0	0.0	42	44.7

3.11 EPILOGUE

Based on environmental baseline data documented in this chapter and project features reported in **Chapter 2**, the environmental impacts are described in **chapter 4.**

CHAPTER –4
NEGATIVE ENVIRONMENTAL IMPACTS

4.1 ENVIRONMENTAL LEGISLATIONS

In pursuance of the global goals of nature conservation and protection of environment to which India is committed since our participation in Stockholm conference, State Governments have initiated plans, schemes and action to implement the various legislations, the latest being the Environmental (Protection) Act 1986 of Ministry of Environment and Forests (MoEF). On May 1994, and 7TH July 2004, MoEF had issued notifications of Environmental Impact Assessment of Development Projects. The schedule-I lists 32 types of projects, need environmental clearance from MoEF. The Railways development projects are excluded from above environmental clearance from MoEF. The client and consultant, both are environment conscious and have carefully and critically assessed all negative impacts also. During this study following Acts, Rules and Standards issued there under were also consulted:

- Water (Prevention and Control of Pollution) Act 1974, amended in 1978 and 1988.
- Forest (Conservation) Act 1980 Amended in 1988,
- Air (Prevention and Control of Pollution) Act 1981 amended 1988,
- Environmental Impact Assessment Guidelines, MoEF, GOI Notification 1994,
- Notification of 10th April 1997, MoEF.
- Environmental (Protection) Act 1986.
- Guidelines for Rail/Road/Highways projects, Ministry of Environment & Forests, Government of India (1981).
- National Policy on Resettlement and Rehabilitation of Project Affected Families (2003).

With rapid strides in economic development, particularly in urban development, the need for rationalizing and upgrading the transport system is imperative. In the process of development, there has been intensive use of natural resources. Very often the process of development has adversely affected the environment, leading to ecological imbalances. The importance of conserving and enhancing the environmental assets have assumed urgency. Apart from landuse, conservation of flora and fauna, planning urban transportation is an important aspect of eco-development.

MoEF vide letter No.J-20012/47/92-1A-1 dated 27th January 1993 has welcomed the proposed idea of MRTS as the project is providing an alternative which is less energy intensive and relatively environmental friendly. Based on Project particulars (**Chapter 2**) and existing environmental conditions (**Chapter –3**) potential negative impacts, have been identified and wherever possible these have been quantified.

Negative impacts likely to result from the proposed development have been listed under the following headings:

- Impacts due to Project Location;

- Impacts due to Project Design;
- Impacts due to Construction; and
- Impacts due to Project Operation.

For each of these headings potential impacts have been considered, while recommendations for mitigating measures have been stated in **Chapter –6.**

4.2 IMPACTS DUE TO PROJECT LOCATION

During this phase, those impacts, which are likely to take place due to the layout of the project, have been assessed. These impacts are:

- Project Affected People (PAPs)
- Change of Land use;
- Loss of trees/forest;
- Utility/Drainage Problems, and
- Loss of Historical and Cultural Monuments

4.2.1 Project Affected People (PAPs)

Rehabilitation and Resettlement (R&R) of displaced families is an important issue addressed in this section. The intention of the project is to construct Mass Rapid Transport System Phase-II in Delhi, which can connect East-West, and North-South. The number of families and people affected by proposed activities are given in **Table 4.1.** Affected people from the project activities will be paid compensation. Rough estimates have indicated that about 658 families with 2632 people are going to be affected due to land acquisition. Out of above, 300 families/ huggies living on Government land in Yamuna Bank Area will also be affected/removed.

TABLE 4.1
AFFECTED PEOPLE

S.NO.	DESCRIPTION	NUMBER
1	Families	658
2	People	2632

4.2.2 Change of Land Use

Under the present study, project layout maps were superimposed on land use maps to find out the change in land use. It is estimated that about 4.22 ha of private land and 155.90 ha of Government land (total 160.12 ha) have to be acquired for the project. The change of land use is presented in **Table 4.2.** More details are available in Chapter-4 of DPR for MRTS Phase-II report. The Change of landuse is presented in **Table 4.3.** From the data it could be concluded that about 2.6% land to be acquired is from private sector. In addition 12.14 ha will be acquired temporary for storing of material during construction and 42.59 ha for property development. The corridor wise land requirements are given in **Table 4.4**. Temporary land acquisition will be only from Government Department and will be transferred back on completion

of construction works. This temporary requirements will be for traction receiving station, segment casting and for construction depot.

TABLE 4.2
LOCATION AND AREA TO BE UTILISED/ACQUIRED (M^2)

S. NO.	SECTION/ LOCATION/ STATION	PRIVATE	GOVERNMENT	TOTAL
1.	***VISWA VIDYALAYA TO JAHANGIRI PURI***			***57,253.67***
i)	Guru Teg Bahadur Nagar	475.19	5,745.47	6,220.66
ii)	Derawal Nagar		1624.45	1624.45
iii)	Model Town		13,376.08	13,376.08
iv)	Azadpur	422.07	15,044.12	15,466.19
v)	Azadpur Mandi		4,473.55	4,473.55
vi)	Moolchand		12,907.35	12,907.35
vii)	Jahangiri Puri		3,185.39	3,185.39
2.	***CENTRAL SECRETARIAT TO QUTAB MINAR***			***312,097.91***
i)	Udyog Bhawan		15,27.09	15,27.09
ii)	Race course		1,319.77	1,319.77
iii)	Jor Bagh		47,201.64	47,201.64
iv)	AIIMS		1,366.30	1,366.30
v)	Green Park	80.13	7757.89	7,838.02
vi)	IIT		5,787.69	5,787.69
vii)	PT School		28,287.25	28,287.25
viii)	Qutab Minar		218,770.15	218,770.15
3.	***SHAHDARA TO DILSHAD GARDEN***			***77,900***
i)	Stations	21,200	56,700	77,900
4.	***INDRAPRASTHA TO NEW ASHOK NAGAR***			***619,655***
i)	Yamuna Bank		522,720	522,720
ii)	Games Villages		30,000	30,000
iii)	Mayur Vihar		23,310	23,310
iv)	Mayur Vihar phase-I Extension		36,112	36,112
v)	New Ashok Nagar		7,513	7513
5.	***YAMUNA BANK TO ANAND VIHAR***			***297,905.55***
i)	Laxmi Nagar	3,200	3,366	6,566
ii)	Scope Tower		12,493	12,493
iii)	Preet Vihar		186	186
iv)	Karkarduma		276,442.8	276,442.8
v)	Anand Vihar ISBT		1,808.33	1,808.33
vi)	Anand Vihar ISBT		2,409.42	2,409.42
6.	***KIRTI NAGAR TO MUNDKA WITH INDERLOK***			***236,198***
i)	New Moti Nagar		2,365	2,365
ii)	Punjabi Bagh	4,000	59,500	63,500
iii)	Shivaji Park		24,920	24,920
iv)	Madipur		7,040	7,040
v)	Paschim Vihar		310	310
vi)	Shachdev Park		22,665	22,665
vii)	Peeragarhi		13,265	13,265
viii)	Udyog Vihar		6,090	6,090
ix)	Suraj Mal Station		13,010	13,010
x)	Nangloi		11,805	11,805
xi)	Rajdhani Park		2,665	2,665
xii)	Mundka	9,148		9,148
xiii)	Punjabi Bagh East		2,430	2,430
xiv)	Ashok Park Main	2,570	8,825	11,395
xv)	Inder Lok		3,020	3,020

TABLE 4.3
CHANGE IN LAND USE

S.NO.	DESCRIPTION	AREA (HA)
1	Government Land	155.90
2	Private land	4.22
	TOTAL	**160.12**

TABLE 4.4
TEMPORARY AND PROPERTY DEVELOPMENT LAND REQUIREMENT (HA)

S. NO.	CORRIDOR/ LOCATION	PROPERTY DEVELOPMENT	CONSTRUCTION
1.	Viswa Vidyalaya to Jahangiri Puri	2.53	4.98
2.	Central Secretariat to Qutub Minar	7.84	4.04
3.	Shahdara to Dilshad Garden	0.76	1.20
4.	Indraprastha to New Ashok Nagar	Nil	Nil
5.	Yamuna Bank to Anand Vihar	24.04	Nil
6.	Kirti Nagar to Mundka with Inder Lok	7.42	1.92
	TOTAL	**42.59**	**12.14**

Like most rail based mass urban transport system, this phase also need property development to make it financially viable and economically attractive.

4.2.3 Loss of Forests/Trees

The proposed metro lines are in urban/ city area and will not pass through any forests. Hence no loss to forest is anticipated due to the project. There are 5,147 trees along the alignment (**Refer Table 3.5)**. These trees are likely to be cut during construction. Out of these, it is estimated that 3,914 trees will be cut due to development of project. These trees may be equivalent to 1300 mature trees. Trees are major assets in purifications of urban air, by utilizing CO_2 from atmosphere and releasing oxygen into the air. With removal of these trees the process for CO2 conversion will get effected and the losses are reported below:

i) Total number of Mature Trees : 1300

ii) Decrease in CO_2 absorption @ 21.8 Kg/ year tree for 8 years : 226,720 kg

iii) Oxygen production @ 49 kg/ year tree For 8 years : 509,600 kg

The average consumption of oxygen for a person is about 182 kg/ year. It means these trees will meet the requirement of about 350 people round the year. The total value of these trees lost is Rs.1.17 million as reported in **Table 4.5.**

TABLE 4.5
LOSS OF FOREST PRODUCTS

Total loss of trees (Nos.)	1300
Average cost of one tree	900
Total loss (Rs. Lakhs)	1.17 Million

The main species to be cut are Pipal, Neem, Kikar, Ashok etc. trees act as carbon sequestration. It is a carbon sink by removing the carbon and storing it as cellulose while releasing oxygen back into the air.

4.2.4 Utility/Drainage Problems

Metro lines are mostly planned to run through the urban area at grade, underground and above ground (**Refer Table 2.4)**. The alignment will cross river systems, drains/nalas large number of sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, traffic signals etc. These utilities/ services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. In addition, cross drainage works such as bridges, culverts etc. will be required. Since these affect construction and project implementation time schedule/ costs for which necessary planning/ action needs to be initiated in advance. The details on affected utilities are available in **Chapter-8 of** DPR for Phase II of Delhi MRTS. In all about 5.11 Km of sewer/storm water, 5.59 Km of water supply and 6.65 Km of underground electric lines, will be dislocated.

4.3 IMPACTS DUE TO PROJECT DESIGN

There are impacts, which are due to project designs. These impacts are:

- Platform inlets and outlets,
- Ventilation and lighting,
- Railway station refuse, and
- Seismological factors.

4.3.1 Platforms Inlets and Outlets

Stations have been planned following the norms and criteria being adopted by DMRC for Phase-I. The platform level is about 12 m above for elevated and 12 m down for underground stations from Ground level. 4 to 6 coach trains of length 176 meters are envisaged. To accommodate the trains, 180 meters long platform is proposed. About 1600 m^2 floor area is estimated for operational and service requirements. A uniform platform width of 8 m wide including staircase and escalators in central section and 4 m wide in the end section for elevated have been provided. In the underground station, the side platforms are proposed to be 6 m wide. In normal operating conditions the platform and other areas are designed to accommodate 1.5 to 2.5 persons per sq.m. Under emergency conditions, it is assumed that a full trainload is required to disembark. All the stations have necessary provisions for space at inlet, outlet, elevators and platform to accommodate people in normal and emergency conditions. The planning standards are summarised in **Table 4.6.** Hence no hazards is anticipated due to the proposed sizes of inlets and outlets.

TABLE 4.6
STATION PLANNING STANDARDS

a.	Design passenger flow/2 min	5% of peak hour flow
b.	Escalators carrying capacity 2/min (1.11m width 30° slope) up & down	267 passengers
c.	Unidirectional staircase/m/s min. Up & Down	126, 140 passengers.
d.	Unidirectional staircase/m/s min. Up & Down	177 Passengers
e.	Ticket issuing machines/2 min	20 passengers
f.	Turnstile gates /2 min.	60 passengers
g.	Side platform	2.5 persons/sq.m
h.	Island platform	1.5 persons/sq.m
i.	Concourse	2.5 persons/sq.m
j.	Platform during emergency	5 persons/sq.m (including safety zone)
k.	Safety zone	0.65 m train side 0.25 m wall side
l.	Min. Platform widths	Island 8m : Side 6 m
m.	Emergency evacuation time	5.5 min
n.	Maximum travel distance in emergency	60 m
o.	Walking speed for passengers	1 m/sec.
p.	Escalator carrying capacity in emergency/2 min	240 passengers
q.	Stair case carrying capacity in emergency/2 min	114 passengers
r.	Time taken for reversing escalators	1 min.
s.	No. of passengers in 6 coach train with dense crush loading	2000 Nos.

4.3.2 Ventilation and Lighting

The halls, concourse and other space are ventilated as per required norms. The areas for underground and elevated stations will have adequate and uniform fluorescent lighting to provide pleasant and cheerful environment. It is proposed to adopt the norms prevailing in the world for similar projects for illumination reported in **Table 4.7**.

TABLE 4.7
ILLUMINATION AT DIFFERENT LOCATIONS

LOCATION/PREMISES	ILLUMINATION (LUX)
Entrance to stations from the road	250
Booking/Concourse	200
Platforms	150
Passenger staircase and escalator areas	250
Toilets	100
Offices	200
Tunnels	100
Sub-ways	250
Emergency lighting of stations, platforms, passages, escalators & public utilities.	50

4.3.3 Railway Station Refuse

The collection and removal of refuse from railway stations in a sanitary manner are of importance for effective vector control, nuisance abatement, aesthetic improvement and fire protection. The refuse from railway station includes;

- Garbage,
- Rubbish, and

- Floor Sweepings.

In phase-I of the project, there is hardly any solid waste generation at railway stations. Based on data generated for India, it is estimated that about 64 gm of refuse will be generated per person per day at Indian railway stations. There is no shop/ facilities for cooking at these station hence there is no generation of garbage. RITES has assumed about 3 gm/ person/ day of refuse generation at Metro Stations. The total refuse generated at all Delhi MRTS Phase-II stations will thus be about 2.4 tonnes/day. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the MRTS project authorities. The storage containers for this purpose need to be designed. However it is suggested that the capacity of these containers should not exceed 50 litres and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals.

4.3.4 Risk Due to Earthquake

The project area lies in Zone IV of Bureau of Indian Standards (BIS) Seismic Zoning Map. Earthquakes of 3 to 6.7 magnitude on Richter Scale have occurred in the past. Seismic factor proposed by India Meteorological Department (IMD) for the purpose of design of Civil Engineering structures shall be incorporated suitably while designing the structures.

4.4 IMPACT DUE TO PROJECT CONSTRUCTION

Although environmental hazards related to construction works are mostly of temporary nature, it does not mean that these should not be considered. Appropriate measures should be included in the work plan and budgeted for. The most likely negative impacts related to the construction works are: -

- Soil erosion, pollution and health risk at construction site,
- Traffic diversion and risk of existing building,
- Excavated soil disposal problems,
- Seepage risk and,
- Loss of historical/ cultural monument.

4.4.1 Soil Erosion, Pollution and Health Risk at Construction Site

Run off from unprotected excavated areas, and underground tunnel faces can result in excessive soil erosion, especially when the erodability of soil is high. Mitigation measures include careful planning, timing of cut and fill operations and revegetation. In general, construction works are stopped during monsoon season.

Problems could arise from dumping of construction spoils (Concrete, bricks) waste materials (from contractor camps) etc. causing surface and ground water pollution. However, it is proposed to have mix concret directly from batching plant for use at site. Batching plants will be located away from the site preferably, outside DUA. The other construction material such as steel, bricks, etc. will be housed in a fenced stored yard. The balance material from these yards will be removed for use/disposal. Mitigation measures include careful planning, cleaning, redressing, land scapping and revegetation.

Health risks include disease hazards due to lack of sanitation facilities (water supply and human waste disposal) and insect vector disease hazards of local workers and disease hazards to the local population. Mitigation measures should include proper water supply, sanitation, drainage, health care and human waste disposal facilities. In addition to these efforts need to be made to avoid water spills, adopt disease control measures and employment of local labour. Problems could arise due to difference in customs of imported workers and local residents. These risks could be reduced by providing adequate facilities in worker's camps and by employment of preferably local labour.

4.4.2 Traffic Diversions and Risk to Existing Buildings

During construction in corridors complete / partial traffic diversions on road will be required, as most of the activities are on the road and most of the roads are double lane hence it will be appropriate to make these roads as one way for smooth operation of construction activities and traffic. Moreover on both sides of road a clear passage of 8 m will be maintained for smooth operation of traffic, emergency and local movements. Advance information on communication systems will be an advantage to users of particular road. The rail corridor does not post any serious risk to existing buildings. However, the situation in the Metro corridor is not the same as it passes under the road/ buildings of some congested areas. Sufficient care has been taken while designing the system underground. Still it will be appropriate to carry out stability and ground settlement analysis for proceeding further during construction.

4.4.3 Problems of Excavated Soil Disposal

The excavation of soil is mainly involved in cut & cover, tunnelling & foundations. All these activities will generate about 2.5 Million cum of soil. This excavated soil is likely to be utilized in filling of at grade corridor, in Yamuna Depot and for backfilling purpose..

4.4.4 Dust Generation

Transportation of earth and establishment of the material will involve use of heavy machinery like compactors, rollers, water tankers, and dumpers. This activity is machinery intensive resulting in dust generation. However, this activity will be a short-term effect. Protective measures shall be undertaken during construction phase. Estimates of quantities of construction material required for the project indicate that transportation of about 1.2 Mm^3 of earth and other materials will be necessary. It is assumed that the material will be hauled over a period of 280 days in year. The truck movement required to transport the soil/ earth will be about 140 truck trips per day for the entire length. Equal number of trips will be required to transport construction material at site.

4.4.5 Increased Water Demand

The water demand will increase during construction phase. Sufficient water for construction purpose is made available by digging borehole / borewell within the vicinity of the project site during the construction phase. Hence proper care shall be taken while deciding the location of these activities or drawing water from public facilities.

4.4.6 Impact due to Construction of Bridges on Yamuna

Ground water contamination can take place only if chemical substances get leached by precipitation of water and percolate to the ground water table. This is not the case with the present project, as the activity does not use any harmful ingredients, which could leach down to water table. Therefore, no impact on ground water quality is anticipated from the project during the construction phase. Proposed project will not alter the existing water quality of River Yamuna. One major bridge is planned on the alignment on river Yamuna. It is proposed to Construct Bridge with well foundation, substructure with mass concrete and superstructure with PSC girder. On construction of these, no major impact on flow of water, surface and ground water quality is anticipated due to this project. Foundation of piers shall be on wells. Activities of well foundation and sinking shall be taken at intervals, so that there obstruction to the flow of water is limited. Care shall be taken that construction activities are not carried out during the monsoon period. Contamination of surface water bodies may result due to spilling of construction materials, however, the quantity of such spills will be negligible.

Central Water and Power Station (CWPRS) Pune has carried out hydraulic testing. HFL recommended by CWPRS for the bridge site is higher by 0.21m than that was in initial designs i.e. 8500 cumecs discharge. The afflux due to the proposed bridge will be around 9 cm at the proposed site. CWPRS report considers it negligible and hence inconsequential. The velocity of flow for maximum discharge 12,743 cumecs will be 3.90m/sec. The clearance for 100 year flood discharge has been kept as 2.01 m which is more than standard set in Indian Railway Bridge Manual of 1.8 m.

4.4.7 Impact due to Supply of Construction Material

Quarry operations are independently regulated activities and outside the purview of the project proponent, It is nonetheless, appropriate to give consideration to the environmental implications in selection of quarry sources since poorly run operations create dust problems, contribute noise pollution, ignore safety of their employees, or cause the loss of natural resources.

About 10-15% of the construction material such as waste material from contractor camps is left behind by the contractor as construction waste/spoils. Dumping of construction waste/spoil in an haphazard manner may cause surface and ground water pollution near the construction sites.

4.4.8 Loss of Historical and Cultural Monuments

No historical/cultural monuments will be affected as a result of the proposed development.

4.4.9 Impact due to Construction near Qutab Minar

Qutab Minar is one of the tourist place in Delhi, which attracts the tourists due to historical background. Due to construction of Metro alignment near Qutab Minar, it is expected that the construction activity may have little impact on tourist activities. However during operation the tourist activity may increase.

4.5 IMPACTS DUE TO PROJECT OPERATION

Along with many positive impacts, (Refer **Chapter 5**) the project may cause the following negative impacts during operation of the project due to the increase in the number of passengers and trains at the stations:

- Noise pollution,
- Water supply and sanitation at Stations,
- Refuse disposal and sanitation, and
- Pedestrainisation and visual issues

4.5.1 Noise Pollution

The main sources of noise are traction motors, cooling fans, wheel-rail interaction, electric generator and miscellaneous noise from rolling stock. An attempt is made to predict the rise in ambient noise at different distances. In the present study, following assumptions are adopted:

- Track is standard, and
- Maximum speed 80 km per hour.

The noise produced by the train has been split into:

- Noise due to rolling stock, and
- Traction motor noise at full powers: 90-dB (A)

The continuous point source model, has been used. The ambient noise in railways increases with train speed. The roughness of the contact surfaces of rail, wheel and train speeds are the factors which influences the magnitude of rail wheel noise. The contact surface of rail-wheel noise proposition two ways side is approximately by the continuous point should model, using the following relations.

$$LAWr = 30 \log_{10} (V/V_0) + 60 \text{ dB} \quad (1)$$

Where; LAWr - sound pressure level,
V - rail car speed, km/hr
V_o - reference sound, 24 km/hr.

The vibration, of concrete structures also radiates noise. This noise has lower frequencies than rail wheel noise. Contribution of this noise at wayside is generally insignificant in tracks. When a train is running, definite gear noise is generated at a frequency equal to the number of gear in unit time. The dependence of gear noise level on train velocity is rather intense, so it overcomes the rail wheel noise at the speed higher than 270 km/hr. However in the case of MRTS train velocity will be far below this speed.

Traction motor (LAtm) and gear noise (Lag) have been estimated using the following relationship:

$$LAtm = 60 \log_{10} (V) + C_1 \quad (2)$$
$$Laq = 10 \log_{10}(v) + C_2 \quad (3)$$

Where C_1 and C_2 are the constants and have values of -4.6 and 66.7 respectively.

Using the above relationships the noise at a distance of 2.0 m from the main three sources of noise i.e. motor, gear and wheel rail interaction has been computed as follows:

Average rail car Speed(V) =32 km/hr
Reference sound (Vo) =24 km/hr
C_1= -4.6
C_2= 66.7

a) The Motor Noise :

$Latm=60\log_{10}(V)+C1$
$Latm=60\log_{10}(32)+-4.6$
Latm =85.7dB(A)

b) Gear Noise:

$Laq=10\log_{10}(V)+C_2$
$Laq=10\log_{10}(32)+66.7$
Laq=81.7 dB(A)

c) Wheel – Rail Contact Noise:

$LAWr = 30\log_{10}(V/V_0)+60$
$LAWr = 30\log_{10}(32/24)+60$
LAWr = 63.74 dB(A)

Each aerodynamic noise mentioned above is generated from the local structure of the car surface. Magnitudes, numbers and distribution of noise sources are different from each other. These noise sources can be approximated as point sources, when we estimate the influence of these on wayside. Each aerodynamic noise from the solid surface is radiated strongly in the direction normal to the surface.

Presently, a hemispherical sound wave propagation model through a homogeneous loss free medium is used. the mathematical representation of the model is given below:

$$L(P) = Lps - 20 \log (d) - 8$$

Where, LP - sound pressure level, at a distance d,
D - distance in meters of the receptors,
LPS - point noise source

The cumulative impact of all these different sources in a particular place is calculated by the logarithmic addition model as:

$$LP\ (Total) = 10 \log (10^{LPQ1/10} + 10^{LPQ2/10} + 10^{LPQ3/10})$$

Using the above formula maximum noise level is calculated as follows at a distance of 5.5m form source.

At a distance of 5.5m sound pressure due to motor noise is given by
L(P) =Lps –20log(d)-8
L(P) =85.7 –20log(5.5)-8
L(P) =62.9 dB(A)

At a distance of 5.5m sound pressure due to gear noise is given by
L(P) =Lps –20log(d)-8
L(P) =81.7 –20log(5.5)-8
L(P) =58.9 dB(A)

At a distance of 5.5m sound pressure due to wheel – rail contact noise is given by
L(P) =Lps –20log(d)-8
L(P) =63.7 –20log(5.5)-8
L(P) =40.9 dB(A)
The cumulative impact of all these source is given by logarithmic addition model

$$LP\ (Total) = 10 \log (10^{LPQ1/10} + 10^{LPQ2/10} + 10^{LPQ3/10})$$
$$LP\ (Total) = 10 \log (10^{62.9} + 10^{58.9} + 10^{40.9})$$
LP (Total) = 64.3 dB(A)

The maximum noise level is thus estimated as 64 dB(A) including background noise level as 20 dB(A) inside the Metro corridor (Metro corridor is defined as the viaduct structure of 10m plus 5 meter on either side of viaduct. Thus the width of the corridor is normally taken as 20m.)

Noise level at a distance of 12.5m, 25m, and 50m from the alignment have been calculated similarly and these comes out to be 57.2, 54.2 and 45.2 dB(A) respectively. Similar sort of levels have been observed in Delhi Metro as summarised in **Table 4.8.**

TABLE 4.8
NOISE LEVELS AT THE PLATFORM IN CALCUTTA/DELHI METRO

S. NO.	POSITION	LEVEL dB(A)
i)	On the floor of the passenger coach	
	a) Train moving	79-92
	b) Train stationary	70-80
ii)	On Side wall of passenger coach	
	a) Train moving	70-72
	b) Train stationary	65-70
iii)	On the platform floor	
	a) Ambient	55-58
	b) Train leaving	68-70

For these sections of the rail which are underground, there will be no impact on the ambient noise. However, due to reduction of vehicular traffic, the road traffic noise will come down. It can be seen that the observed sound levels are near the industrial safe limit of occupational hazards (Refer **Table 3.12).** The levels are not comfortable for communication and other functional activities of commuters.

As a result of the reduction of vehicular traffic, the road traffic noise will come down. Noise levels as observed in the field before and after the construction of the metro shows a reduction of about 6 dB(A) after the construction of the metro .

4.5.2 Water Supply and Sanitation

Public Health facilities such as water supply, sanitation and toilets are very much needed at the stations, CPHEEO has recommended 45 litres per day, water supply to persons working at stations. The people working on stations will be about 30. The water demands on stations will be for following components: -

- Personal use of Railway staff,
- Fire demands, and
- Wastage.

The water demand on each stations will be about 11,000 litres/day. No water provision has been made for passengers. The platform-washing requirement has been worked out at the rate of 2 litres/sq.m.

The fire fighting water requirements have been taken as per Calcutta/Delhi Metro. It is proposed to have hydrants at an interval of 50 m. The desired static head available at nozzle point should be 2 m of water. Each pipe should supply 35,000 lit/m. The make up water has been taken as 10% of five hourly demand. The summary of total water supply at stations is reported in **Table 4.9.** The maximum water demand on a station will be about 10.3 m^3/day. This could be developed from existing ground water source or municipal water supply. The construction and operation of the proposed project will not have any major impact on the surface/ ground water quality in the area. But the quantities of such spills are very negligible.

TABLE 4.9
DAILY WATER REQUIREMENT AT EACH STATION

S.NO.	ITEM	WATER REQUIREMENT (M^3)
1.	Personal Use	1.35
2.	Makeup Water for Fire Fighting	3.50
3.	Wastage	1.00
4.	Washing of platform	2.88
5.	For AC/Ventilation	1.50
	TOTAL	**10.23**

Water should be treated before use upto WHO drinking water standards. Ground water shall be used for this purpose. In addition, water will be required for contractor's camps during construction.

4.5.3 Refuse Disposal and Sanitation

The collection and removal of refuse in a sanitary manner from the Station is of importance for effective vector control, aesthetic improvement, and nuisance and pollution abatement. The refuse from stations includes: garbage, rubbish from wrappers, discarded boxes, rags etc, and floor sweepings. Due to non-availability of solid waste data, it is assumed that about 2.4 tonnes per day of solid waste will be generated at all the stations.

4.5.4 Pedestrian Issues

There is a feeling that MRTS will increase the pedestrian in CBD. As has been demonstrated in several countries, notably in Western Europe and North America, Pedestrian station of certain localities is a desirable change in CBDs of the city. While initial reactions of the residents or commercial establishments are sometimes unfavourable to the concept, in no case has dissatisfaction been expressed, or a reversal of Pedestrainisation instituted, once an area has been so developed. The benefits are seen to out weigh any disadvantages of increased movements for access etc. There is a strong case for pedestrianising and banning two/three wheelers in several parts of the city. Pedestrian issues are well taken at ISBT in the existing system and similar will be the case for Metro Phase-II.

The main aim of MRTS system is to decongest the road traffic in Central Business Districts. The connections will further reduce the pedestrian number, which are available now on the roads.

4.5.5 Visual Impacts

The introduction of MRTS implies a change in streets through which it will operate. An architecturally well designed elevated section can be pleasing to the eyes of beholders. Recently MRTS projects have attempted to incorporate this objectives in their designs, as in the case of Singapore. Same has been incorporated in Delhi MRTS. Since a low profile would cause the least intrusion, the basic elevated section has been optimised at this stage itself.

4.6 IMPACTS DUE TO DEPOT

The depots are planned at Yamuna bank Station and will be in an area of 45 ha. This area is presently used for growing vegetables. It is about 3 m low than surrounding roads/ area. In order to develop this area as depot, it will need filling by earth from outside. The depot will have following facilities:

- Washing Lines,
- Operation and Maintenance Lines,
- Workshop, and
- Offices.

These facilities will generate water and noise pollution problems. The deport area is about 3 m lower than the surrounding area and hence have to be filled up. About 1.2 Mm^3 of earth will be required. The earth from metro corridor cutting will be utilised to fill the deport site the problems anticipated at depot site are:

- Water supply,
- Oil Pollution,
- Cutting of trees
- Sanitation,
- Effluent Pollution,
- Noise Pollution,
- Loss of livelihood,
- Impact due to filling of area, and
- Surface drainage.

About 2000 trees are existing the proposed depot site. Most of these trees will be cut and have been included along with corridor impacts as discussed in section 4.2.3.

4.6.1 Water Supply

The water supply will be required for the following purpose in the depot. The demands are summarised in **Table 4.10.**

TABLE 4.10
WATER DEMANDS

S. NO.	PURPOSE	DEMAND	NOS.	TOTAL (M^3)
1	Drinking Water	70 lit/c/day	350	24.5
2	Washing Train	1000 lit/ train	12	12.0
3	Fire Fighting & Replacement	---	10%	20.0
4	Horticulture	20,000 l/ha/day	---	900.00
5	Wastage / Losses	10%		94.7
6	Canteen	70 l/c/day	70	4.90
	TOTAL			**1055.60**

About 1056 m^3 of water will be required at Depot for different uses. This will be collected from ground water.

There will be a need of water treatment plant to meet water quality standards. The river and ground water quality in the depot area have TDS more than permissible limits. The water after conventional treatment can be processed through Reverse Osmosis (RO) technology for specific use such as drinking/ cooking and final washing of equipment/ trains. RO plant of about 8 litres/ minute capacity plant may be sufficient and sewage treatment at depot site to avoid/ prevent any water/ Yamuna pollution.

The treatment process flow chart is available in **Chapter-6.** The main pollutant will be detergent, oil and grease. Need to be treated before reuse/ disposal in water bodies

4.6.2 Sewage and Effluent

About 25 M^3 of sewage and 12 m^3 of effluent are accepted to be generated. Based on past experience in similar projects the wastewater characteristics could be as reported in **Table 4.11**.

TABLE 4.11
SEWAGE & EFFLUENT CHARACTERISTICS

S. NO.	PARAMETER	UNIT	SEWAGE	EFFLUENT
1.	pH	---	6-8	6-8.5
2.	BOD	Mg/l	250-350	150
3.	Suspended Solids	Mg/l	200-450	500
4.	COD	Mg/l	600-800	300
5.	Oil and Grease	Mg/l	Upto 50	500
6.	Detergents	Mg/l	---	100

4.6.3 Oil Pollution

Oil spillage during change of lubricants, cleaning and repair processes, in the maintenance Depot cum workshop for maintenance of rolling stock, is very common. The spilled oil should be trapped in oil and grease trap. The collected oil should either be auctioned or incinerated, so as to avoid any underground/ surface water contamination.

4.6.4 Noise Pollution

The main sources of noise from depot are the operation of workshop. Only five trains will be coming to depot for washing and maintenance daily. The roughness of the contact surfaces of rail and wheel and train speed is the factors, which influence the magnitude of rail - wheel noise. The vibration of concrete structures also radiates noise. Due to less activity, no impact on the ambient noise is anticipated.

4.6.5 Loss of Livelihood

About 50 nurseries are in operation on the government land proposed for depot site. There are unauthorised. With the development of project site these 50 people will loose their economic base.

4.6.6 Impact due to filling of Area (Leachate)

About 1.2 Mm^3 of earth will be required to fill this area. Out of this about 1.0 Mm^3 will be collected from the excavation of metro corridor. About 0.2 Mm^3 of earth has to be identified for collection during detail engineering. The analysis of soil/ earth has indicated that soil/ ground geology have poor, nitrogen and phosphate. More over the soil will compacted at site before levelling which will further reduce doing the permissibly. Hence possibility of leachates and eutrophication in river is not anticipated.

4.6.7 Impact on River Regime

The depot site is a low-lying area on the bank of Yamuna River. The underground drainage is towards river Yamuna. There is a bund between Yamuna River and the proposed area. The construction will not impede the river regime.

4.6.8 Surface Drainage

Due to the filling of the low-lying area for the construction of depot. The surface drainage pattern may change specially during monsoon. Suitable drainage measures will be required.

4.7 EPILOGUE

Based on above negative impacts, a checklist of impacts have been prepared along with positive impacts in **Chapter-5.** The net resultant impacts without management plans are also summarised. The management plans to mitigate the negative impacts are reported in **Chapter-6.**

CHAPTER-5
POSITIVE ENVIRONMENTAL IMPACTS

5.1 POSITIVE IMPACTS

Based on project particulars **(Chapter-2)** and the existing environmental conditions **(Chapter-3)**, potential positive impacts have been identified that are likely to result from the proposed project, viz., construction and operation of Metro Phase-II. These impacts have been quantified, wherever possible. This section deals with positive impacts of the project. The introduction of Metro Phase-II project will yield benefits from non-tangible parameters such as saving due to vehicle operating costs and socio - economic benefits of bulk transport of goods, less travel time, better accessibility, integration of different modes of transport and low operational cost. However, all benefits cannot be evaluated in financial terms due to non-availability of the accepted norms. Positive impacts have been listed under the following headings:

- Employment Opportunities,
- Benefits to Economy,
- Quick Service and Safety,
- Less Fuel Consumption,
- Less Air Pollution, and
- Carbon Dioxide Reduction

5.1.1 Employment Opportunities

The project is likely to be completed in a period of 5 years. During this period manpower will be needed for various project activities. About 5303 persons are likely to work during the peak period of construction activity. In post-construction phase, about 2300 people will be employed for operation and maintenance of the system. In all about 26,500 man-year will be employed due to the project construction. Thus, the project would provide substantial direct employment equal to the above number. In addition to these, more people would be indirectly employed for allied activities.

5.1.2 Benefits to Economy

In the present context, the project will streamline and facilitate movement of public from North to South and East to West in Delhi. The MRTS Phase-II will connect Shahdara in east to Mundka in west, Vishwa Vidayalaya in North to Jahangiri Puri, Central Secretariat to Qutab Minar in south and Dwarka in Southwest to New Ashok Nagar in East. This will facilitate the rural population to move from one end. MRTS will facilitate people to move quickly towards urban centres and return therefrom. MRTS integration/connection to NOIDA and Gurgaon in future will further enhance interstate movement. On completion of this phase the Delhi MRTS will have interchange facilities at 6 places. With the development of MRTS, it is likely that more people will be involved in trade commerce and allied services.

5.1.3 Quick Service and Safety

The optimised network is estimated to carry 17.32 and 23.66 million trip per day in year 2011 and 2021 respectively. The maximum PHPDT on any section will be 68,036. The passenger time saved will be about 50%. The proposed development will reduce journey time as reported in **Table 5.1**

TABLE 5.1
JOURNEY TIME

S. No	SECTION	LENGTH (KM)	JOURNEY TIME (MIN)	TYPE OF CORRIDOR
1.	Viswa Vidyalaya to Jahangiri Puri	6.36	13	Mixed (UG, E)
2.	Central Secretariat to Qutab Minar	10.87	22	Mixed (UG, E)
3.	Shahdara to Dilshad Garden	3.09	7	E
4.	Indraprastha to NOIDA City Centre Corridor	8.07	17	E (AG)
5.	Yamuna bank – Anand Vihar ISBT	6.16	13	E
6.	Kirti Nagar-Mundka/Inderlok	18.47	37	E

UG; Underground, E: Elevated , AG: At grade

It is reported that on an average 6-7 people die in road accident every day in Delhi. MRTS will provide improved safety and lower the number of accidental deaths. The accidental death risk involved may still be about 172 persons per year per million in Delhi.

5.1.4 Less Fuel Consumption

On implementation of the project, it is estimated that both petrol and diesel consumption will get reduced. The estimated number of vehicles in 2011 without metro will be about 4.37 million in Delhi based on 3% annual growth. The details of these vehicles are presented in **Table 5.2.**

TABLE 5.2
VEHICLES IN DELHI

(1000)

YEAR	CAR/ JEEPS	MOTOR CYCLE/ SCOOTER	3 WHEELER	TAXI	BUSES	TRUCKS	TOTAL
1985	175	637	31	9	14	59	925
1990	384	1191	62	10	19	99	1765
1993	478	1403	70	11	23	111	2096
2001	784	1920	148	24	31	150	3057
2011 (Projected)	1160	2627	219	35	45	222	4365

There will be reduction in number of vehicles on road due to implementation of project. Based on passenger trips the number of vehicles likely to reduce are reported in **Table 5.3**

TABLE 5.3
REDUCTION IN VEHICLES (2011)

METRO NETWORK	BUSES	2 WHEELER	CARS	3 WHEELERS
Phase -I	1400	220,000	50,000	17,000
Phase –I+II	1800	320,000	90,000	19,000

It is reported that daily movement of vehicle is as follows.

Bus : 210 km/day
2 wheelers : 25 km/day

Cars : 35 km/day
3 wheelers : 80 km/day

Based on above the reduction in fuel (diesel, petrol and CNG) consumption will be as reported in **Table 5.4.**

TABLE 5.4
REDUCTION IN FUEL CONSUMPTION DUE TO PHASE –II (2011)

MODE	Diesel (Million Litres)	PETROL (Million litres)	CNG (Million KG)
Buses (3.5 Km/l)	--	---	8.76
2 Wheeler (40 km/l)	--	17.50	---
3 Wheelers (20 km/l)	---	---	2.92
Cars (14 km/l)	7.00	14.00	7.00
TOTAL	**7.00**	**31.50**	**18.68**

It is estimated that about 7.00 million litres of diesel, 31.50 million litres of petrol or 18.68 million kg of CNG gas will be saved depending upon the fuel used. This will directly benefit in foreign exchange to the tune of Rs.1,722.54 million. The net saving in rupee is summarised in **Table 5.5**.

TABLE 5.5
NET SAVING ON FUEL EXPENDITURE (2011)

S. NO.	FUEL	RS. MILLION
1	Diesel	189.00
2	Petrol	1,197.00
3	CNG	336.24
TOTAL		**1,722.24**

While, the reduction in pollution due to Phase I &II and the estimated savings will be as reported in **Table 5.6** and **Table 5.7** respectively.

Table 5.6
REDUCTION IN FUEL CONSUMPTION DUE TO PHASE –I & II

Tonnes/year

Mode	Diesel (Million liters)	Petrol (Million liters)	CNG (Million Kg)
Bussess			39.42
2 wheelers		56.00	
Cars	15.75	31.50	15.75
3 wheelers			27.74
Total	**15.75**	**87.50**	**82.91**

TABLE 5.7
NET SAVING ON FUEL EXPENDITURE DUE TO PHASE –I & II

S. NO.	FUEL	RS. MILLION
1	Diesel	425.25
2	Petrol	3325.00
3	CNG	1492.38
TOTAL		**5,242.63**

5.1.5 Less Air Pollution

The major pollutants that define the ambient air quality are: Suspended Particulate matter, Sulphur dioxide, and Nitrogen oxides. The sources of these pollutants vary from domestic fuel burning to industrial and vehicular emissions. In addition to the above pollution, un-burnt products like aldehydes, formaldehydes, acrolein, acetaldehyde and smoke are byproducts of vehicular emissions. With the existing system on No metro scenario, the total estimated pollution load as per the project traffic on 2011 as per **Table 5.8** is as follows.

TABLE 5.8
ESTIMATED POLLUTION LAD BASED ON PROJECTED TRAFFIC 2011

Tonnes/year

TYPE OF FUEL	POLLUTION PARAMETER			
	CO	HC	Nox	Particulates
CNG	10775.46	44897.74	161142.06	816.32
Petrol	44671.76	39537.47	4558.09	1329.34
Diesel	0.54	0.08	0.30	0.04
Total	**55,447.75**	**84,435.28**	**165,700.45**	**2,145.70**
TOTAL LOAD	**307,729.18**			

RITES has made an attempt to estimate the pollution load scenario based on traffic data as given in **Table 5.2** as above and a compilation has been accordingly and placed in **Table 5.9.**

TABLE 5.9
POLLUTION LOAD SCENARIO BASED ON THE TRAFFIC DATA

FUELS	CO			HC			Nox			Particulates		
	1990	**2001**	**2011**	**1990**	**2001**	**2011**	**1990**	**2001**	**2011**	**1990**	**2001**	**2011**
CNG	4064.0	7311.3	10775.5	16933.3	30463.8	44897.7	60775.	109337.4	161142.1	307.9	553.9	816.3
Petrol	19731.4	32418.6	44671.8	17879.4	28876.6	39537.5	1639.3	3142.3	4558.1	552.0	949.1	1329.3
Diesel	0.2	0.4	0.5	0.0	0.1	0.1	0.1	0.2	0.3	0.0	0.0	0.0
	23795.6	**39730.3**	**55447.8**	**34812.7**	**59340.5**	**84435.3**	**62414.4**	**112479.9**	**165700.4**	**859.9**	**1503.1**	**2145.7**

The reduction of air pollutants with MRTS are presented in **Table 5.10** in year 2011. It is estimated that yearly there will be a reduction of our pollutant upto 5884.35 tonnes due

to implementation of phase –II. The total reduction of air pollution due to Phase I &II will be around 22755 MT/year . the derails are as summarized in **Table 5.11**.

TABLE 5.10
REDUCTION IN AIR POLLUTION LEVELS IN 2011 (FOR MRTS PHASE II ONLY)

Tonnes/year

POLLUTANTS	DIESEL	PETROL	CNG	TOTAL
Carbon Monoxide	0.01	1,681.12	123.46	1,804.59
Hydro-Carbons	0.00	1,503.35	514.42	2,017.76
Nitrogen Oxide	0.01	157.64	1,846.28	2,003.93
Particulate Matter	0.00	48.72	9.35	58.07
TOTAL	**0.02**	**3,390.83**	**2,493.51**	**5,884.35**

TABLE 5.11
REDUCTION IN AIR POLLUTION LEVELS IN 2011 (FOR MRTS PHASE I + II ONLY)

Tonnes/year

POLLUTANTS	DIESEL	PETROL	CNG	TOTAL
Carbon Monoxide	0.02	5,245.52	602.76	5,848.30
Hydro-Carbons	0.00	4,798.98	2,511.49	7,310.48
Nitrogen Oxide	0.01	394.59	9,013.97	9,408.58
Particulate Matter	0.00	142.87	45.66	188.54
TOTAL	**0.04**	**10,581.96**	**12,173.89**	**22,755.89**

5.1.6 Carbon Dioxide Reduction

In the business as usual scenario 23795 tonnes per year of carbon monoxide would have been emitted in 1991 and 39730 tonnes in the year 2001 respectively. Based on the existing scenario, there is an increase of about 3.0% per year in CO_2. As mentioned in **Table 5.9**, the corresponding carbon dioxide emissions in 2011 is 95,037tonnes/year. With the addition of MRTS Phase-I &II. the CO_2 reduction due to MRTS is estimated as 10023.98 tonnes in 2011 (*i.e*. 5848.3 x1.714). The cumulative reduction in CO_2 will be about 0.7 million tonnes in the lifetime of MRTS (35 years). However with more share of MRTS trips and improvements in fuel efficiency and energy use efficiency in transport sectors in Delhi the cumulative CO_2 reduction could be about two times amounting to 1.4 million tonnes. The cost and benefits of the project are summarised in **Table 5.12.**

TABLE 5.12
COST AND BENEFIT OF BASELINE PROJECT AND MRTS

PARAMETER	TOTAL COST MILLION RS.	DOMESTIC BENEFITS FUEL CONSUMPTION MILLION TONNES	GLOBAL BENEFITS MILLION TNNES CO_2 EQUIVALENT MILLION TONNES
Baseline	148442	**81.91**	6.34
MRTS	150000	76.70	4.94
Incremental	1558	5.21	1.4

The incremental cost per tonne of CO_2 saved is above Rs.1113 per tonnes of CO_2 saved.

5.1.7 Reduction in Number of Buses

It is estimated that in the year 2005, about 14,000 number of buses will be required. The buses requirement is estimated to reduce to 10,000. This means about 4,000 buses are likely to decrease with the introduction of MRTS. This will save capital and operating cost of existing bus system.

5.1.8 Saving in Road Infrastructure

In order to accommodate the vehicles on road additional land and infrastructure will be required which will be saved on implementation of the project. The saving due to infrastructure will be about Rs.1600 million. In addition cost of 666 ha of land will also be saved.

5.2 CHECKLIST OF IMPACTS

The impact evaluation determines whether a project development alternative is in compliance with existing standards and regulations. It uses acceptable procedures and attempts to develop a numeric value for total environmental impact. A transformation of the review of multiple environmental objectives into a single value or a ranking of projects is the final step in impact assessment. There are about a hundred methods for carrying out impact assessment, which can be grouped into the following categories:

- Ad-hoc method,
- Checklist,
- Matrix,
- Network,
- Overlays,
- Environmental Index, and
- Cost benefit analysis.

Each of the method is subjective in nature and none of these is applicable in every case. Of the 7 methods listed above, checklist has been used and presented. Checklist is the list of environmental parameters or impact indicators, which the environmentalist is encouraged to consider when identifying the potential impacts. A typical checklist identifying the anticipated environmental impacts is shown in **Table 5.13**.

The indirect benefit on health due to less air pollution, improvement in productivity due to time saved and less global warming are other positive impacts due to the development of project. RITES has prepared Environmental management to reduce or eliminate the negative impacts. Efforts are being made to enhance the environmental quality of the area by additional measures as reported in **Chapter 6.**

TABLE 5.13
CHECKLIST OF IMPACTS

S. NO	PARAMETER	NO IMPACT	NEGATIVE IMPACT	POSITIVE IMPACT
A	***Impacts Due To Project Location***			
1	Rehabilitation and Resettlement		*	
2	Change of land use and Ecology		*	
3	Impact on Historical/Cultural Monuments	*		
4	Drainage and utilities problems		*	
B	***Impacts Due To Project Design Construction***			
1	Platforms Inlets and outlets	*		
2	Ventilation and lighting	*		
3	Railway Station Refuse		*	
4	Risk Due to Earth Quakes	*		
C	***Impact Due to Project Construction***			
1	Soil Erosion pollution and health risk at construction site		*	
2	Traffic diversions and risk to existing buildings		*	
3	Soil disposal problem and seepage risk		*	
D	***Impact Due to Project Operation***			
1	Oil Pollution		*	
2	Noise and vibration		*	
4	Water Demands		*	
E	***Positive Environmental Impacts***			
1	More Employment Opportunities			*
2	Enhancement of Economy			*
3	Quick service and safety			*
4	Traffic Congestion Reduction			*
5	Less Fuel Consumption			*
6	Less Air Pollution			*
7	Carbon dioxide reduction			*
8	Reduction in Number of buses			*
9	Saving in Road infrastructure			*

CHAPTER – 6
ENVIRONMENTAL MANAGEMENT PLAN

6.1 MANAGEMENT PLANS

The Mass Rapid Transport System (MRTS) Phase II will provide employment opportunity, quick service and safety, traffic congestion reduction, less fuel consumption and air pollution on one hand and problems of Rehabilitation and Resettlement (R&R), soil disposal, traffic diversion, utility dislocation etc. on other hand. The environmental issues likely to develop during project construction and operation phases, could be minimized by making necessary provision in the project design and adopting Environmental Management Plan (EMP).

Based on Environmental conditions (**Chapter –3)**, planned project activities (**Chapter - 2)** and impact assessed in earlier chapters (**Chapter 4** and **5),** this chapter enumerates the set of measures to be taken during implementation and operation to eliminate or avoid offset adverse environmental impacts or to reduce them to acceptable levels, together with the action which need to be taken to implement them.

The most reliable way to ensure that the plan will be integrated into the overall project planning and implementation, is to establish the plan as a component of the project. This will ensure that it receives funding and supervision along with the other investment components. For optimal integration of EMP into the project, there should be investment links for:

- Funding,
- Management and training, and
- Monitoring.

The purpose of the first link is to ensure that proposed actions are adequately financed. The second link helps in embedding training, technical assistance, staffing and other institutional strengthening items in the mitigation measures to implement the overall management plan. The third link provides a critical path for implementation and enables sponsors and the funding agency to evaluate the success of mitigation measures as part of project supervision, and as a means to improve future projects. This chapter has been divided into three sections:

- Mitigation measures;
- Disaster management, and
- Emergency measures.

For every issue discussed for above measures, the implementing agency as well as staffing, equipment, phasing and budgeting have been presented as far as possible. All required funds will be channeled through the project authority. The Environmental Management Plans have been prepared and discussed in subsequent sections.

6.2 MITIGATION MEASURES

This section includes measures for:

- Rehabilitation and Resettlement,
- Compensation for Loss of Land,

- Compensatory Afforestation,
- Utility/ Drainage Plans,
- Water Supply and Sanitation,
- Air quality during construction,
- Draining of Water from Tunnel,
- Soil Disposal,
- Oil Pollution Control,
- Noise and control,
- Measures for loss of agricultural land, and
- Depot Pollution Control.

6.2.1 Rehabilitation and Resettlement

For several years the R&R package was confined to the provision of land acquisition statute enacted in 1894 and amended by Land Acquisition (Amendment) Act of 1984. Accordingly except for payment of compensation to the Project Affected People (PAPs) for their properties acquired, there was no legal obligation on the part of project authorities in regard to rehabilitation and resettlement. However, in recent years a number of State Governments/Ministries/Departments have issued instructions containing incentives and facilities to be given to PAPs.

The project involves the displacement of 300 Jhuggis in unauthorized areas, and 358 families likely to be affected due to land acquisition. These will affect about 2632 people. It is proposed to accommodate the permanent shops in the nearest area proposed for development. Similarly, PAPs could be paid compensation for land infrastructure as part of the project.

The Jhuggi dwellers may be resettled by making arrangements of acquisition of barren Government land available near by. Other suitable and convenient locations may also be identified with the help of DDA and Delhi Administration during actual implementation. These people should be provided with suitable transport to carry their houses hold goods to resettlement site. In addition to this, a financial assistance @ Rs. 10000 per family for reconstruction of their new Jhuggi/ working shed/shop may be provided.

Construction of New Jhuggi 300 Nos. about Rs.10,000 per Jhuggi Rs.3.0 million Jhuggis resettlement site will be provided with reasonable and adequate community facilities as under:

- Drinking water supply,
- Sanitation facilities,
- Schools,
- Electricity connection to each house,
- School, health centre, place of worship, place of cremation or burial, and place of recreation and entertainment, as may be appropriate and
- Other amenities existing earlier in the affected area.

About **Rs 330.2** million will be paid as compensation for relocation of shops, commercial cum residential buildings and hutments likely to be affected due to the project along the alignment. The details of resettlement cost are presented in **Table 6.1.**

TABLE 6.1
RESETTLEMENT COST

S. NO	PLOT NO.	LOCATION OF PLOT	PLOT AREA IN SQ M	CONSTRUCTION COST (RS. MILLION)
A.	**VISWAVIDYALYAYA - JAHANGIRI PURI**			**4.487**
1	AP1	Temporary Shops at corner of Guru Teg Bahadur Crossing	326.48	1.632
2	AP2	Shops	148.71	0.744
3	DP4	Plot No. D-1,east of Mall Road	243.72	1.219
4	DP5	Built up Open Park	178.35	0.892
B.	**CENTRAL SECRETARIAT – QUTAB MINAR**			**0.401**
5	FP4	Partly inside boundary wall and service road	39.61	0.198
6	FP6	Inside boundary wall in open ground	40.52	0.203
C.	**SHAHDARA – DILSHAD GARDEN**			**205.50**
7	AP1	Jhilmil Inds. Area	9175	91.750
8	AP2	Jhilmil Inds. Area	11110	111.100
9	AP3	Jhilmil Inds. Area	10	0.1
10	AP4	Jhilmil Inds. Area	180	1.8
Shifting allowance of the about 75 industries in Jhilmil Industrial area @ Rs. 10000/- per industry				0.75
D.	**INDRAPRASTHA – NEW ASHOK NAGAR**			**10.430**
11	Hutments in DDA land near Noida flyover, Govt. @ Rs. 29,000 per No.		300 Nos.	8.7
12	AP1	Station Area Yamuna Bank	28400	0.082+
13	AP2	Running Section Yamuna Bank	44320	0.128+
14	AP3	Maintenance Depot in Yamuna Bank	450000	1.301+
15	BP1	Games Village	16346.91	0.047+
16	CP1	Mayur Vihar Phase - 1	1077	0.003+
17	CP2	Mayur Vihar Phase- 1	722	0.002+
18	CP3	Mayur Vihar Phase- 1	1511	0.004+
19	CP4	Mayur Vihar Phase- 1	20000	0.058+
20	DP1	Mayur Vihar Phase- 1 Ext.	6112	0.018+
21	DP2	Mayur Vihar Phase- 1 Ext.	30000	0.087+
E.	**YAMUNA BANK – ANAND VIHAR**			**16.0**
22	AP2	Built up Laxmi Nagar	3200.0	160.00
F.	**KIRTI NAGAR – MUNDKA WITH INDERLOK LINK**			**93.38**
23	PNB, PD-4	BPS Power Oil	4000	200.00
24	KP-1	Open Land Rajdhani Park	60	3.00
25	LP-3	Private shops in Mundka	112	5.60
26	LP-4	Factory area Mundka	112	5.60
27	LP5	Residential area in Mundka	4072	203.60
28	LP-6	Residential area in Mundka	4740	237.00
29	MP-1	Open land in Punjabi bagh East	2430	121.50
30	NP-2	JVG Off. Ashok park main	650	32.50
31	NP-3	Shops Ashok park main	605	30.25
32	NP-4	Shops/PP	1315	65.75
Juggies near Amarpark area (Govt.) @ Rs. 29,000 per No.			100	29.00
GRAND TOTAL (A) + (B) + (C) + (D) + (E) + (F) =				**330.2**

+ - The project construction would cause loss of cultivated land. Paddy is the major crop, although other crops like vegetables are also grown. It is estimated that the average yield of the crop per acre as 1300kg and the resale price = Rs. 900per quintal, that maximum loss of crop yield per hectare would be due to loss of paddy crop amounting to Rupees 11700 per acre *i.e.* Rs. 28900per ha.

6.2.2 Compensation for the Land

The land likely to come under MRTS Project is summarised in **Section 4.2.1 (**Refer **Table 4.2** through **Table 4.3)**. About 160.12 ha of land is likely to come under the project. Out of this 155.90 ha is Government Land and 4.22 ha is Private Land. The Ministry of Urban Development, Government of India, New Delhi vide letter No. J-2901/4105-LD dated 16.4.1999 has fixed the price of Government land for other organizations. Government Land will be transferred from one department to another through book adjustment. The cost of Private Land has been taken into project report and estimated as Rs. 3,505.10 million. The corridor details are as follows:

- Vishwa Vidyalaya to Jahangiri Puri : Rs. 129.50 million
- Central Secretariat to Qutab Minar : Rs. 483.90 million
- Shahdara to Dilshad Garden : Rs. 374.00 million
- Indraprastha to New Ashok Nagar : Rs. 914.60 million
- Yamuna Bank to Anand Vihar : Rs. 474.60 million
- Kirti Nagar to Mundka : Rs. 1,128.50 million

The private plots are constructed up to single storey and hence will be paid at the prevailing rate of Rs. 5,000 per sqm. For construction in urban area. Rs. 10,000 per sqm is taken as construction cost in industrial area keep in view the dislocation of instrument and equipment.

6.2.3 Compensatory Afforestation

The Department of Forests, Delhi Administration is responsible for the conservation and management of trees/forests in the project area. The forest conservation act of 1983 stipulates strict forest protection measures and outlines procedures (guidelines1/08-I (ii) for compensatory reafforestation if the department accepts conversion of forest land for other purposes:

- If non-forest land is not available, compensatory forest plantation is to be established on degraded forest land to the extent of twice the affected or lost-forest areas;

- If non-forest land is available, compensatory forest plantation is to be raised over an area equivalent to the affected or lost area of the forest.

According to the results of the present study, it is found that about 5147 trees are likely to be lost due to the project. Ten trees have to be planted for each tree cut. Hence 51470 trees to be planted. These trees would have occupied about 43 ha in the forest. No non-forest land is available, hence 43ha have to be re-afforested in degraded forests in Delhi. In addition to these efforts need to be made to plant trees at appropriate places on completion of the works along the road and rail alignment. Cost of afforestation is about Rs.35,880/- Refer **Table 6.2** per ha**.** Compensatory reafforestation cost will thus be about Rs.15.42 lakhs including road side plantation. The objective of the afforestation programme should be to develop natural areas in which ecological functions could be maintained on sustainable basis. Therefore the planting of miscellaneous indigenous tree species should be applied. The recommended tree species are given in **Table 6.3**. Dense spacing should be applied (2x2 m or 500 plants/ha) or single tree plantation as per available space.

TABLE – 6.2
COST OF AFFORESTATION

S. NO.	ITEM	MANDAYS	RATE	COST (RS/DAY)
1	**First Year** (Pre-planting Operation)			
	i) Survey and demarcation	2	120	240
	ii) Cleaning	12	120	1440
	iii) Burning	10	120	1200
	iv) Alignment and stacking	2	100	200
	v) Pitting (40 pits/manday)	62	100	6200
2	**Nursery Cost**			
	a) Filling of Polythene bags	12	100	1200
	b) Treatment and sowing of seeds	2	100	200
	c) Watering and other	18	100	1800
3	**Planting**			
	a) Transport of seedlings including Loading and	25	100	2500
	b) Planting including 5% casualty replacement	30	100	3000
4	**Post Planting**			
	a) Ist weeding	11	100	1100
	b) Iind weeding	9	100	900
	c) Soil Working	11	100	1100
	d) Applying Insecticides	3	100	300
5	**Cost of Materials**			
	a) Polythene bags 1 kg of 400 No needing 10 Kg @ Rs 100/Kg			2000
	b) Cost of Insecticides 50 kg @ Rs 30 per Kg			1500
	c) Cowdung manure and earth			1000
	d) Cost of seeds			1000
	e) Fencing and Nursery Shed etc.			1000
6	**Miscellaneous**			
	Watcher, Inspection per 200 ha one watcher			1000
7	**Second Year**			
	a) Replacement	10	100	1000
	b) Weeding and soil working	30	100	3000
	c) Pruning	5	100	500
	d) Watch and Ward one watcher per 20 hec			1000
8	**Third Year**			
	a) Weeding and Pruning	5	100	500
	b) Watch Ward one watcher per 20ha			1000
	TOTAL			**35,880**

TABLE –6.3
RECOMMENDED TREE SPECIES FOR REAFFORESTATION

S. NO.	LOCAL NAME	BOTANICAL NAME
1.	Neem	*Azadirachta indica*
2.	Sisso	*Dalbergia sisso*
3.	Eucalyptus	*Eucalyptus*
4.	Kikar	*Acacia nilotica*
5.	Ashok	*Sarasca indica*
6.	Jamun	*Syzygium cumini*

6.2.4 Draining of Water from Tunnel

The water table generally varies from 3 to 7 m, which rises after the rains to about 2 m in low-lying areas. Problems of water flow associated with tunneling are bound to take

place. In cut and cover type construction continuous pumping is an economical alternative.

The well point system is recommended for dewatering as the volume of water to be pumped out is not large. The deep well system is adopted where the water table has to be lowered over a large depth in a small area. The deep wells can be installed either inside or outside the diphragm walls or inside the cut.

A suitable piezometer is installed to monitor the water table constantly and to see how much lowering has been effectively done. The dewatering should not be stopped unless it is ensured from design calculations that the load of the constructed box component has reached a stage where it will be able to counter act the hydrostatic pressure from below.

About 3.6m^3/hour per meter length of trench seepage water is likely to come into the tunnel during construction *(Refer 4.4).* This will necessitate dewatering, which can be achieved by:

(i) Leading the ground water to a sump by drains and them pump out the water from the sump. To prevent loss of fines, inverted filter may have to be used.

(ii) Dewatering as suggested above may not be effective in preventing sand flows. Lowering of the ground water by properly designed single or double stage well points will be effective in such cases.

(iii) The construction of diaphragm walls of concrete along the side of channels, before the commencement of excavation will be required. The concrete walls are taken down to rest on bed rock or impervious strata or, in their absence, deep enough below the bottom of excavation, to serve as an effective cut off for the inflow of ground water into the proposed excavation. The trenches are made in lengths of 2.5 to 5m and kept continuously filled with a thiotropic material like Bentonite slurry, which has the effect of stabilising the trench and preventing any subsidence. As the excavation proceeds, concrete wall ca be strutted mutually or anchored with surrounding rocks or soil with long tie rods.

(iv) During operation phase, seepage water have to be drained along the side of walls (retaining). Proper drainage system need to be incorporated in design and implemented during construction phase.

The pumped water from sump wells will be put into storm water drain to avoid any load to waste water treatment plants. These storm water drains finally join natural existing streams/nallah.

6.2.5 Soil Disposal

Construction of underground metro projects is a specialised and complex task. Owing to paucity of space in the busy cities and for safety reasons, elaborate measures need to be adopted for collection, transfer and disposal of excavated soil. Soil collection, transportation, disposal and its treatment need to be carried out in a systematic manner. Soil collection should be in containers from the dredging sites / places. These containers should be such that soil should not spill during movement to disposal site. The excavated soil will be first collected at dumping ground and then transferred to disposal sites. Dumping areas are essential to store the excavated earth temporarily for back

filling at later date and final disposal. The excavated earth/ soil can be used to fill the depot site at Yamuna Bank.

In the second phase 1.0 million cum. of soil is likely to be excavated. This will be ritualized in filling, at Yamuna bank station, depot and to stabilize river fronts. More area for disposal of earth need to be identified.

Generally 8-10 tonnes capacity trucks are utilized for this purpose. As the density of soil is about 2.5 tonnes/ m^3. About 120,000tonnes earth will need to be disposed each truck will be able to carry 4 tonnes. About 84000 truck trips will be required in a span of 4 years for this purpose i.e. 107 trips every day. As most of the disposal areas are low lying area, the available soil quantity will be sufficient for ground leveled at the site.

It is desirable to first clean the disposal area site for vegetation biomass exists over it. The surface of these sites need to be treated so that leached water does not contaminate soil and ground water. The faces and top should be treated/vegetated to avoid erosion.

6.2.6 Utility Restoration

During the project the utilities likely to be affected are sub-surface, surface and overhead. These are mainly water supply and sewer pipe, storm water drains, telephone cables, over head transmission lines, electric poles, traffic signals etc. these utilities are essential and have to be maintained in working conditions during different stage of construction, by temporary/ permanent diversions or by supporting in position. Since these may affect project schedules and costs hence advance actions will be required. The departments responsible for these utilities are reported in **Table 6.4.**

TABLE 6.4
DEPARTMENT RESPONSIBLE FOR UTILITIES

S. NO.	ORGANIZATION/ DEPARTMENT	UTILITY SERVICES
1.	Municipal Cooperation of Delhi (MCD	Roads, surface water drains, nallahs etc.
2.	Delhi Jal Board	Sewerage and drainage conduits, sewerage treatment plant, pumping stations etc. Water mains and their service lines, including hydrant, water treatment plants, pumping stations etc.
3.	Public Works Department (PWD Delhi)	Roads, surface water drains, nallahs etc.
4.	Irrigation and Flood Department, Delhi	Nallahs/ flood water drains, Najafgarh Drain & bunds etc.
5.	New Delhi Power Supply Company Ltd. (NDPL)	Power cables and their appurtenances H.T. and L.T. lines, their pylons, electric light posts, pole mounted transformers etc.
6.	Mahanagar Telephone Nigam ltd. (MTNL)	Telecommunication cables, junction boxes, telephone posts, O.H. lines etc.
7.	Delhi Traffic Police	Traffic signal posts, junction boxes and cable connection, etc.
8.	Indraparastha Gas Ltd.	CNG lines & gas filling stations
9.	DDA	Land development, stores, depots etc.
10.	Northern Railway	Railway crossings, signals, railways bridges etc.
11.	Private Telephone Companies e.g. Reliance, Tata, Touchtel etc.	OFC, cables etc.

6.2.7 Traffic Diversion/ Management

During construction traffic are affected. There is a need to keep the flow of traffic through appropriate diversions, such as road widening, traffic segregation, one way movement, traffic diversion on influence are road, and utilization of service roads for traffic. The enroachment need to be removed on the roadside. The traffic diversion plans are recommended in **Table 6.5.**

TABLE 6.5
TRAFFIC MANAGEMENT PLANS

S. NO.	SECTION NAME	PROJECTED PEAK HOUR VOLUME	ROAD CAPACITY DURING CONSTRUCTION	V/C DURING CONSTRUCTION
OPTION-I ADDITION OF 2 LANES TO C/W WITH MIXED TRAFFIC				
1	Vishwavidyalaya to Azadpur T-point	4981	7200	0.69
2	Azadpur T-point to Azadpur Intersection	5480	7200	0.76
OPTION-II ADDITION OF 2 NMV LANES WITH SEGREGATED TRAFFIC				
1	Vishwavidyalaya to Azadpur T-point	3910	6000	0.65
2	Azadpur T-point to Azadpur Intersection	4250	6000	0.71

TRAFFIC DIVERSION OPTIONS FOR VISHWAVIDYALAYA TO JAHANGIRIPURI CORRIDOR (AZADPUR INTERSECTION TO OUTER RING ROAD)

S. NO.	TSM MEASURES	IMPLICATIONS	IMPLEMENTATION LEVEL	DIVERTED TRAFFIC
I	No movement from Vishwavidyalaya to Azadpur while reverse movements are allowed	V/C Ratio on the section estimated at 0.74 affected traffic consisting all the vehicles moving from Azadpur T-intersection to Azadpur Ring Road Intersection Addition of 2 lanes to carriage way	Easy	3300 PCUs
II	2 way movement for public transport & non-motorized vehicles (NMV's) between Azadpur to Ring Road Junction	V/C Ration in the year 2008 is estimated at 0.76 affected traffic will be only of light fast vehicles moving in both directions Proposal strongly favours unrestricted & smooth movements of buses and NMV's Addition of 2 lanes is not required	Most difficult	5000 PCUs
III	For stretch between Azadpur to Ring Road Junction, all movement from Vishwavidyalaya is allowed while only public transport & NMV's movement is allowed in the reverse direction	V/C ratio in the year 2008 is e3stimated at 0.95 Diversion of only Light Fast Vehicles moving from Vishwavidyalaya to Jahangiripuri Proposal favours public transport and NMV's movement Addition of 2 lanes to carriage way between Azadpur to Ring Road Junction	Less difficult	1800 PCUs
IV	For stretch between Azadpur to Ring Road Junction, Movement form Vishwavidyalaya to Jahangiripuri is allowed while public transport & NMV's movement is allowed in the reserve direction	V/C Ration in the year 2008 us estimated at 0.76 Diversion of Light Fast Vehicles moving form Jahangiripuri to Vishwavidyalaya on stretch between Azadpur to Ring Road Junction proposal favours public transport and NMV's movement. Addition of 2 lanes to carriage way on stretch between Azadpur to Ring Road Junction	Difficult	3000 PCUs

6.2.8 Noise Control

There will be an increase in noise level in the tunnels (metro Corridor) and nearby ambient air (rail corridor). However, noise levels in the core city will go down. The increase in levels are marginal, hence local population will not be adversely affected. However the exposure of workers to high noise levels especially, near the engine, vent-shaft etc. need to be minimised. This could be achieved by:

- job rotation,
- automation,
- protective devices,
- noise barriers, and
- Soundproof compartments control rooms etc.

The workers employed in the high noise level area could be employed in low noise level areas and vice versa on rotation basis. At work places where automation of machinery is not possible or feasible, the workers exposed to noise should be provided with protective devices.

Special acoustic enclosures should be provided for individual noise generating equipments, wherever possible. Workers in those sections where periodic adjustment of equipment/machinery is necessary, should be provided with sound proof control rooms so that exposure to higher noise level is reduced. During construction, there may be high noise levels due to pile driving, use of compressors and drilling machinery. Effective measures should be taken during the construction phase to reduce the noise from various sources. The noise from air compressor can be reduced by fitting exhaust and intake mufflers.

The pile driving operation can produce noise levels upto 100 dB(A) at a distance of 25m from the site. Using a sound absorbent could reduce the noise levels. This can reduce the noise levels to 70dB(A) at a distance of 15m from the piles. The safety and precautions as stipulated in IS:5121 (1969) "Safety Code for Piling and other Deep Foundation" need to be adopted. The noise level from loading and unloading can be reduced by usage of various types of cranes and placing these on sand or sunny bag beds.

The side barriers are usually effective along a route having fast traffic. The reduction in noise level increases with height of barrier as reported in **Table 6.6.**

TABLE 6.6
REDUCTION IN NOISE LEVEL WITH BARRIERS

HEIGHT OF BARRIER (M)	REDUCTION OF NOISE LEVEL DB(A)
0.3	-
0.4	0.5
0.5	1.0
0.6	0.2
0.7	4.0
0.8	5.0
0.9	6.0

6.2.9 Vibration Control

Noise emanates from the rail wheel interaction and the same can be reduced by:

- minimizing the surface irregularities of the wheel and rail;
- improving track geometry,
- providing elastic fastenings, and
- Separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad.

While designing the track structure for Mass Rapid Transit System all the above points have been taken into consideration in the following ways:

- To prevent development of surface irregularities on the rail, a fairly heavy rail section of 52 kg/m, 90 UTS rail, supported at every 60 cms has been proposed further rail grinding at regular intervals by rail grinding machine and also lubrication of rail by vehicle mounted lubricator have been contemplated.

- Rails will be continuously welded and also will be laid to fine tolerances so that any noise/vibration on account of track geometry could be reduced.

- The vibration generated from rail interaction will be greatly Basorbed by the elastic fastening system.

- Proposed operation at two levels i.e one between the rail foot and the bearing plate with grooved rubber sole plate and shelter between the base plate and the concrete plinth with 20 mm thick grooved rubber sole plate will dampen and reduce the vibration.

In addition, we have proposed to provide skirting of coach shell covering the wheel which will screen any noise coming from the rail wheel interaction as of propagating beyond the viaduct. In the sensitive areas, track on flating slab can be provided so as to avoid propagation of noise to adjacent structures. Additional screening of noise can be arranged by providing parabolic noise reflecting walls on each side of the track.

6.2.10 Water Supply and Sanitation

Daily requirements of water supply at each station will be about $10m^3$ per day. This shall be provided from municipal source. Similarly about 8 m^3/ day of sewage will be generated which should also be connected to municipal facilities.

About 2.4 tonnes of solid waste will be generated at all metro stations. This should be collected and transported to local municipal bins for onward disposal to disposal site by municipality.

6.2.11 Management Plans for Depot

The management plans for depot site includes:

i) Water Supply and Sanitation,
ii) Oil Pollution Control,
iii) Effluent Pollution Control, and
iv) Surface Drainage.
v) Rain water harvesting
vi) Green belt development
vii) Provision of Rain water harvesting:

i) Water supply and sanitation: About 1056 m^3 of water per day will be required for operation and functioning of depot. This could be either collected from Municipal Corporation or through boring tube well into the ground. The ground water will need treatment depending upon its use. Domestic and some of the industrial application, a reverse Osmosis (RO) plant of 8 liter/ minute capacity will be appropriate. The water treatment plant flow chart is given in **Figure 6.1**.

ii) Oil Pollution Control: The oil tends to form scum in sedimentation chambers, clog fine screens, interfere with filtration and reduce the efficiency of treatment plants. Hence oil and grease removal tank has to be installed at initial stage of effluent treatments. Such tanks usually employ compressed air to coagulate the oil and grease and cause it to rise promptly to the surface. Compressed air may be applied through porous plates located in bottom of the tank. The tank may be designed for a detention period of 5 to 15 minutes. Adding Chlorine in an amount of 2.0 mg/l will increase the efficiency of removal.

iii) Effluent Pollution Control: About 80% of domestic water supply will available as sewage, hence about 25 m^3 of sewage is likely to be generated. The sewage could be treated up to the level so that it could be used for horticulture purpose in the campus and can also be discharged into the stream a process flow chart is presented in **Figure 6.2.** About 500 mg/l of oil and grease is anticipated in the effluent and about 50 mg/l in sewage.

About 17 m^3 of effluent is likely to be generated. This will have oil, grease and, detergent as main pollutants. This have to be treated as per requirement of regulatory pollution control agency of the state (DPCC). Process flow chart of effluent treatment plant is shown in **Figure 6.3.**

iv) Drainage control : The area should have proper drainage. The drainage costs have been included in project cost. However provisions of out fall have been made in environmental costs.

v) Provision for Green belt development: The greenbelt development / plantation in the depot area not only functions as landscape features resulting in harmonizing and amalgamating the physical structures of proposed buildings with surrounding environment but also acts as pollution sink / noise barrier. In addition to augmenting present vegetation, it will also check soil erosion, make the ecosystem more diversified and functionally more stable, make the climate more conducive and restore balance. It is recommended to have a provision of **Rs. 20 lakhs** in the cost estimate for the green belt development.

vi) **Provision of Rain water harvesting:** To conserve and augment the storage of groundwater and arrest seawater intrusion in groundwater, if any, it has been proposed to construct roof top rainwater harvesting structure of suitable capacity in the construction depot site. A provision of **Rs 10.00 Lakhs** (excluding the cost of storage tank) has been kept in the cost estimate.

The cost of water and wastewater treatment facilities will be as given below based as thumb rule.

- Water Supply : 10.0 million
- Sewage Treatment : 5.0 million

- Effluent Treatment : 5.0 million
- Drainage Facilities : 1.0 million

6.2.12 Training and Extension

The training and extension programmes need to be conducted by the Railway Staff College, for MRTS officers. These programmes could be extended for the local population for their active participation in the project implementation. Apart from training, such programme should include guidelines for safety, methods of disaster prevention, action required in case of emergency, fire protection, environmental risk analysis etc. Railways extension staff are currently trained in railway operation and maintenance techniques. Additional training in above areas is required. The cost involved for such programme is presented in **Table 6.7.**

TABLE 6.7
COST FOR TRAINING PROGRAMME

S. NO	ITEM	COST (Rs.)
1.	Curriculum Development and course preparation 2 months Rs.15000/month	30,000
2.	Extension Officer (1year) Rs.20,000/month	2,40,000
3.	Instructor 20 sessions of 10 days each	1,00,000
4.	Demonstration/Presentation Aids	20,000
5.	Material etc.	40,000

6.3 DISASTER MANAGEMENT

Disaster is an unexpected event due to sudden failure of the system, external threats, internal disturbances, earthquakes, fire and accidents. The first step is to identify the causes which develop/ pose unexpected danger to the structural integrity of Metro tunnel or overhead rail. The potential causes are excessive load, cracks, failure and malfunctioning of sensing instruments, accident, etc. These need to be looked into with care.

a. Preventive Action

Once the likelihood of a disaster is suspected, action has to be initiated to prevent a failure. Engineers responsible for preventive action should identify sources of repair equipments, materials, labour and expertise for use during emergency.

b. Reporting Procedures

The level at which a situation will be termed a disaster shall be specified. This shall include the stage at which the surveillance requirements should be increased both in frequency and details.

The Engineer-in-Chief should notify the officer for the following information:

- Exit points for the public,
- Safety areas in the tunnel/overhead rail, and
- Nearest medical facilities.

c. Communication System

An efficient communication system is absolutely essential for the success of any disaster management plan. This has to be worked out in consultation with local authorities. More often, the entire communication system gets disrupted when a disaster occurs. The damage areas need to be clearly identified and provided with temporary and full proof communication system.

d. Emergency Action Committee

To ensure coordinates action, an Emergency Action Committee should be constituted. The civic administrator may be the Chairman of this Committee. The committee may comprise of:

- Station Master concerned,
- Police Officer of the area,
- Delhi Transport Corporation Representative,
- Home Guard representative,
- Fire Brigade representative,
- Health Department representative,
- Department of Information and Publicity, and
- Non-Governmental Organization of the area.

Emergency Action Committee will prepare the evacuation plan and procedures for implementation based on local needs and facilities available. The plan should include:

- demarcation of the areas to be evacuated with priorities,
- safe route to be used, adequacy of transport for evacuation, and traffic control,
- safe area and shelters,
- Security of property left behind in the evacuated areas,
- Functions and responsibilities of various members of evacuation teams, and
- Setting up of joint control room.

All personnel involved in the Emergency Action Plan should be thoroughly familiar with all the elements of the plan and their responsibilities. They should be trained through drills for the Emergency Action Plan. The staff at the site should be trained for problem detection, evaluation and emergency remedial measures. Individual responsibility to handle the segments in emergency plan must be allotted.

Success of an emergency plan depends on public participation, their response to warning notifications and timely action. Public has to be educated on the hazards and key role in disaster mitigation by helping in the planned evacuation and rescue operations. It is essential to communicate by whom and how a declared emergency will be terminated. There should be proper notification to the public on de-alert signals regarding termination of the emergency. The notification should be clear so that the evacuees know precisely what to do when re-entering or approaching the affected areas.

6.4 EMERGENCY MEASURES

The emergency measures are adopted to avoid any failure in the system such as lights, fire, means of escape, ventilation shafts etc. The aim of Emergency Action Plan is to identify areas, population and structures likely to be affected due to a catastrophic event of accident. The action plan should also include preventive action, notification, warning

procedures and co-ordination among various relief authorities. These are discussed in following sections.

6.4.1 Emergency Lighting

The emergency lights operated on battery power should be provided at each station. The battery system should supply power to atleast 25% of the lights at the station, platforms, tunnels/viaducts for a period of 2 hours. The underground station should have transformer at each end of the platform. Both the transformers need to be kept energized and should feed independently alternate rows of lights so that in case of failure of one transformer, there will not be complete darkness. The tunnels need to be provided with fluorescent incandescent lamps at a spacing of 20 m.

6.4.2 Fire Protection

The building materials should be of appropriate fire resistance standard. For underground structures the fire resistance period should be atleast 4 hours, and two hours for surface or over head structures. Wood shall not be used for any purpose, excluding artificial wood products, which are flame resistant. The materials which have zero surface burning characteristics need to be used. The electrical systems shall be provided with automatic circuit breakers activated by the rise of current as well as activated by over current. The design of a station will include provision for the following:

- Fire prevention measures,
- Fire control measures,
- Fire detection systems,
- Means of escape,
- Access for fireman, and
- Means of fire fighting.

Accumulations of refuse of any inflammable material like paper, plastic cartons constitute a major fire hazards and should not be permitted. Smoking should be strictly prohibited at all locations of MRTS.

All aspects of fire prevention and control will be dealt in close collaboration with the city fire fighting authority. Smoke control will be achieved by the following means:

- Downstand bulkheads of a minimum depth of 600 mm to provide smoke containment. These will be provided around openings for escalators, lifts and stairs in underground stations,

- In underground stations the ventilation system will be designed to extract smoke in the event of fire, and

- In enclosed public areas of above ground stations (e.g. a concourse located below a platform) arrangement for smoke extraction will be provided.

A minimum of 30 minutes supply of water is to be assured in the case of fire. The pumps/overhead tanks shall have the capacity to discharge the water at the rate of 1100 litres per minute at a head of 21 m at nozzle mouth.

The storage capacity in an underground or overhead tank, may be divided into two parts i.e. dead storage and running storage. Fire fighting pumps shall be provided with a diesel pump as a standby arrangement, in case of power failure.

Fire of electrical origin, water cannot be used until the electric system has been made dead and earthened. For electrical fires, non-aqueous agents like ABC Power Chloro Bromo Methane or CO_2 gas are utilized for fire fighting. Fire extinguishers with these agents shall be liberally provided at static installations and on the rolling stock.

Generally there are often more casualties from smoke inhalation than from burning. Smoke need to be transported away from the site of the fire. In order to achieve this, both fresh air has to be introduced into the underground section and exhaust gases should be sucked out from other section.

Openings, including ducts and passages, between MRTS property and any adjoining structures which allow free access into the MRTS property will be protected by fire doors, fire shutters, fire dampers etc. as appropriate. Fire detection and alarm systems will be provided as per the prevailing state of are technology.

a. Prevention and Safety Measures

Fire prevention measures will be designed and implemented to minimize the risk of outbreak of fire by appropriate choice, location and installation of various materials and equipment. In stations planning, potential sources of fire can be reduced by:

i. Fire Prevention

- Use of non-combustible or smoke retardant materials where possible,
- Provision of layout which permits ease of maintenance for equipment and cleaning of the station premises,
- Provision of special storage spaces for combustible materials such as paint and oil,
- Prohibition of smoking in fire prone areas,
- Provision of cigarette and litter bins, and
- Good housekeeping.

ii. Safety

Following provisions will be required from fire safety point of view:

- Automatic sprinkler/detection system to be provided if floor area exceeds 750 sq.m
- One wet riser-cum-down comer per 1000 sqm floor area with static underground storage tank, overhead tanks and pumps of suitable capacity with hydrants, first-aid reel, etc.
- Portable fire non-aqueous extinguishers of Carbon di Oxide, chemical dry powder etc. at suitable places.
- Automatic smokes venting facilities.
- Two separate means of exit shall be provided, if more than 10 persons are working and the area exceeds 1400 sq.m
- Fire resisting doors shall be provided at appropriate places along the escape routes to prevent spread of fire and smoke.
- The travel distance for fire escape shall not exceed 20 m where escape is available in more than one direction, the distance could be upto 40 m.

b. Fire Alarm and Detection System

A complete fire detection system with equipment complying with the requirements of Delhi Fire Services shall be provided through out each station and ancillary buildings including entrance passageways, subways and adits etc. to give visual and audible

indication of alarm conditions actuated by the operation of break glass contact or fire sensors e.g. detector heads, linear heat detecting cables etc. The system shall be operated from 24 V DC Power sources.

Manually operated call points shall be provided at every hydrant and nose reel points, station head wall, tail wall and other locations. Alarm bells shall be installed in each plant room complex at both platform and concourse level and shall be clearly audible at all points in the room/area.

Beam detector or heat detector shall be installed at roof level, ceiling and floor cavity, whilst linear detecting cables shall be installed in under platform cable ducts and cable shafts.

Smoke probe units shall be installed in rooms/compartments. When an alarm point is operated, the fire pump shall start to operate automatically. A station fire control and indicating panel shall be provided an installed in the station controllers room, for the control, indication and monitoring of the whole detection and fire fighting systems. While designing the fire fighting system, the zone of Delhi Fire Services shall be taken into account for linking with the same.

c. Fire Control Measures

Control of the spread of fire and smoke will be achieved by Compartmentation of fire risk areas, planning for smoke extraction, and arrangement for smoke containment. Compartmentation is aimed at limiting the extent of a fire. The openings must be capable of being sealed in the event of fire. With the exception of station public areas, a fire compartment will not exceed 1500 m^2. Compartmentation of the public areas in stations is not practicable for operational reasons. The fire resistance period of these compartmented area should be about 3 hours.

d. Access for Fireman

A secondary access to the station, not used by passengers for evacuation, shall be available to fireman should the need arise. The entry point shall be easily accessible from the road. Access shall be available to all levels of the station. The minimum width of the stairs be 1.0 m and maximum height should not exceed 60 cms.

6.4.3 Ventilation Shafts

The Environmental Control system for underground stations requires ventilation openings between various plants, plant rooms and the atmosphere. Three independent shafts are required for exhaust air, fresh air intake and draft relief. The three shafts may be combined into one structure or separated into two or three structures depending upon the site constraints and the treatment required. The ventilation shafts may be independent or combined. The minimum cross-sectional area of each shaft will be 12 $m^{2.}$ Total length of each ventilation shaft from the station box to the atmosphere should not exceed 60m.

6.5 EPILOGUE OF ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The environmental impacts stemming out of the proposed project can be mitigated with simple set of measures, dealing with careful planning and designing of the metro alignment and structures, adequate provision of environmental clauses in work contracts and efficient contract management will eliminate or reduce significantly all possible problems. A common problem encountered during implementation of environmental

management plans of such projects is lack of environmental awareness among engineers and managers concerned with day to day construction activities, which can be solved through regular environmental training programs. A set of preliminary EMP is presented in **Table 6.8,** defines actions to be undertaken during the design stage, pre-construction, construction and operation stage of the project. The effectiveness of environmental considerations will, however, depend on appropriate inclusion of these in the work contracts.

The major concern during the construction stage is that the contractors, due to lack of enforcement, would not practice good housekeeping, may intend to get unauthorized use of the easily available natural resources and other available infrastructure like roads and water resources. This would result in degradation of ambient air quality, water resources and land environment around the construction sites and workers camp. Improper management of earthwork and bridge construction activities would disrupt the natural drainage and increase soil erosion. Improper management may result in spillage of explosives into the hands of unsocial elements. Finally the implementation of the mitigation actions requires that the project implementation unit would record an end-of-construction mitigation checklist, before releasing the final payment of any work contract.

Operation period mitigation would involve good housekeeping practice at railway establishments including effective solid waste collection and disposal, wastewater disposal, upbringing of plantations and green area. Protection of earth slopes in landslide prone area would be a very important task. During the operation period, the railway operating unit will be required to confirm receipt of the construction period mitigation report through the PIU and prepare a follow on timetable of actions.

TABLE 6.8: ENVIRONMENTAL MANAGEMENT ACTION PLAN (EMP)

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
DESIGN PHASE				
Metro Alignment	The proposed corridor alignment was selected to minimise the land disturbance to avoid archaeological sites, temples and other environmentally sensitive areas in least.	During Design	Design Unit	PIU/ Project Consultants
Flood	All the structures falling along the Yamuna river low lying area shall be for the 50-year flood frequency.	During Design	Design Unit Engineering Consultants	DMRC
PRE –CONSTRUCTION STAGE				
Displacement of people/land before construction	The people shall be displaced at proper location as per the policy decisions the people shall be informed well in advance. The resettlement and rehabilatioan policy rules shall be adopted during resettlement to minimize the social impact	Pre construction stage	PIU	PIU
Water requirement	The requirement of water shall be for construction purpose etc., shall be planned and shall be arranged in order to avoid digging o Tube wells.	Pre construction stage	Construction agency	PIU
Disposal of final treated effluent from treatment plat	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact of receiving bodies. As far as possible zero discharge rule may be adopted.	During design stage / and pre construction of treatment plant	PIU	PIU
CONSTRUCTION PHASE				
Environmental Management and Monitoring	This will include institutional requirements, training, environmental management and monitoring	During and after construction (seven years)	PIU Environmental Officer	PIU/DPCC
Dust	Water should be sprayed during construction phase, wherever it is required to avid dust.	During construction	Construction agency	PIU/EMP implementing

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
	Vehicles delivering materials should be covered to reduce spills and dust blowing off the load.			agency
Air Pollution	Vehicles and machinery are to be regularly maintained so that emissions conform to National and State AAQ Standards.	Beginning with and continuing throughout construction	Contractor	PIU/EMP implementing agency
Equipment Selection maintenance and operation	Construction plants and equipment will meet recognized international standards for emissions and will be maintained and operated in a manner that ensures relevant air, noise, and discharge regulations are met.	During construction	Contractor	PIU
Noise	Noise standard at processing sites, will be strictly enforced as per GOI noise standards. Workers in vicinity of strong noise will wear earplugs and their working time should be limited as a safety measure. At construction sites within 150m of sensitive receptors construction will be stopped from 22:00 to 06:00. Machinery of noise barriers (Stone walls and plantation) for silence zones including schools and hospitals.	Beginning and through construction	Contractor	PIU/EMP implementing agency
WATER				
Contamination from Wastes	All justifiable measures will be taken to prevent the wastewater produced in construction from entering directly into rivers and irrigation system	Throughout construction period	Contractor	PIU/EMP implementing agency
Wastage of water	Measures shall be taken to avoid misuse of water. Construction agency shall be instructed accordingly to follow strict procedures while using the water for construction and drinking purpose.	Beginning with and continuing throughout construction	Contractor	PIU/EMP implementing agency
Sewerage disposal during construction at Service Centres	A minimum distance of any sewage or toilet facility from water sources should be 200 meters	Throughout construction period	Contractor	PIU/EMP implementing agency
Sanitation and Waste Disposal in Construction Camps	Sufficient measures will be taken in the construction camps, i.e. provision of garbage tank and sanitation facilities. Waste in septic tanks will be cleared periodically. Drinking water will meet Indian National Standards. Garbage will be collected in a tank and disposed of daily. Special attention shall be paid to the sanitary condition of camps. Camps will be located at a minimum distance of 200 m from water sources.	Before and during building of construction camps	Contractor	PIU/EMP implementing agency
SOIL				
Quarrying	Quarrying will be carried out at approved and licensed quarries only.	During construction	Contractor	PIU
FLORA AND FAUNA				
Loss of trees and Avenue Plantation	Areas of tree plantation cleared will be replaced according to Compensatory afforestation Policy under the Forest Conservation Act. Trees will be planted against every tree cut as per norms.	After completion of construction activities	Forest Department	PIU/ Forest Department
SOCIAL				
Loss of Access	Temporary access should be built at the interchange and other roads.	During construction	Contractor	PIU/ traffic department
Traffic jams and congestion	If there are traffic jams during construction, measures should be taken to relieve the congestion with the co-ordination of transportation and traffic police department	During construction	Contractor	PIU/ traffic department

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
Safety with vehicles, people and livestock and signage	• Safety education and fines. • Allow for adequate traffic flow around construction areas • Provide adequate signage, barriers and flag persons for safety precautions. • Communicate to the public through radio, TV & newspaper announcements regarding the scope and timeframe of projects, as well as certain construction activities causing disruptions or access restrictions	During construction	Contractor	PIU/ traffic department
Increase in disease Water-borne Insect-borne Communicable diseases	• Make certain that there is good drainage at all construction areas, to avoid creation of stagnant water bodies. • Provide adequate sanitation and waste disposal at construction camps. • Provide adequate health care for workers and locate camps away from vulnerable groups	During construction At start-up Throughout construction	Contractor	PIU
Location of camps depots and storage areas	Location of camps depots and storage areas shall be as per the contract specifications.	Throughout construction	Contractor	PIU
OPERATION PHASE				
Noise	Suitable measures should be considered where warranted. The public shall be educated about the regulations of noise pollution and its implications.	After completion of construction	PIU	PIU
WATER				
Oil pollution	Suitable treatment shall be taken for treatment oil before discharging the wastewater specially in depot areas.	During operation of the treatment plant	PIU	PIU
Maintenance of Storm Water Drainage System	The urban drainage systems will be periodically checked and cleared so as to ensure adequate storm water flow.	Beginning and end of monsoon	PIU	PIU
Disposal of final treated effluent from treatment plat	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact of receiving bodies. As far as possible zero discharge rule may be adopted.	During operation of the treatment plant	PIU	PIU
SOCIAL				
Safety and noise disturbances	New buildings should be prohibited within 50 m of the edge of carriageway. No new schools and hospitals should be allowed within 200 m of carriageway.	Throughout and after project development period.	Planning Department /PIU	PIU
Displacement of people before construction	The people shall be displaced at proper location as per the policy decisions the people shall be informed well in advance. The resettlement and rehabilitation policy rules shall be adopted during resettlement.		Planning Department /PIU	PIU

CHAPTER - 7
ENVIRONMENTAL MONITORING PLAN

7.1 ENVIRONMENTAL MONITORING

Environmental monitoring programme is a vital process of any management plan of the development project. This helps in signaling the potential problems that resulting from the proposed project and will allow for prompt implementation of effective corrective measures. The environmental monitoring will be required for the construction and operational phases. The main objectives of environmental monitoring area:

- to assess the changes in environmental conditions,
- to monitor the effective implementation of mitigation measures,
- Warn significant deteriorations in environmental quality for further prevention action.

In order to meet the above objectives the following parameters need to be monitored:

- Rehabilitation and Resettlement Programme,
- Afforestation,
- Water Quality and Public Health,
- Air and Noise quality,
- Soil Conservation, and
- Sanitation and Waste Disposal

7.1.1 Rehabilitation and Resettlement Programme

The rehabilitation and Resettlement Programme needs to be monitored during the project construction phase. The entire programme is supposed to be completed before operation phase. Sufficient care needs to be taken to ensure that money reaches the project-affected people. The quality of life of rehabilitated people should not fall below their present status.

7.1.2 Afforestation and Ecology

Afforestation should commence with the start of project cycle. The Forest Department of Delhi Administration should implement the afforestation programmes. The MRTS should transfer the cost of afforestation to Delhi Administration. The trees need to be planted on the present routes so that the construction is over.

The river ecology specially from fisheries angles need to be monitored during construction phase. The monitoring should include qualitative and quantitative assessment of flora and fauna of river eco-system. The recommended parameters are: Phytoplankton, zooplanktons, benthic life and fish composition. These can be monitored every year for three years. A provision of Rs.3 lakhs will be appropriate.

7.1.3 Water Quality

Water quality and public health parameters shall be monitored for one year before and for at least three years after the completion of the project. Monitoring should be carried out at least four times a year to cover seasonal variations by any recognised private or Government agency. Water quality shall be analysed by applying the standard technique. The parameters for monitoring would be:

- pH
- Biochemical Oxygen Demand,
- Total Coliform Count,
- Total Dissolved Solids,
- Total Hardness,
- Chlorides,
- Sulphates,
- Nitrates,
- Fluorides,
- Total Nitrogen
- Total Phosphates and
- Residual Chlorine

The monitoring points could be river, ground and surface waters. The ground water sampling could be in Metro corridor. Surface and ground water need to be monitored near soil disposal sites depot area. River water quality needs to be monitored seasonally. The cost of water sampling is expected as Rs.2500/sample x4 times x 3 years x 6 locations, which is equal to Rs.1.80 lakhs.

A detailed epimidiological study related to water borne diseases should be carried out and the data should be compiled for every year in the project area. This shall be monitored for labour camps if any. The cost will be about Rs.1.0 lakhs per year with 10% increase for four years. The total cost will be Rs.4.64 lakhs.

7.1.4 Air Quality and Noise

The air quality is regularly monitored by Central Pollution Control Board at 10 places in Delhi. In addition to these, air quality should also be monitored near soil disposal sites, depot site and at places namely Green Park, Central Secretariat, Yamuna Depot etc. The parameters recommended for monitoring during construction are:

- Particulate Matter,
- Sulphur di-oxide,
- Nitrogen Oxides,
- Carbon monoxides, and
- Noise levels, dB(A),

Every year air quality need to be monitored for four stations twice a week, four weeks and four times in a season (4x2x4x4 = 64 days). The cost of one 8 hourly air/noise sampling is Rs.64x3000x3 = Rs.5.76 lakhs. Noise should be monitored during operation phase.

7.1.5 Soil Conservation

Soil erosion rates, slope stability of land faces, water sediments load, effectiveness of soil conservation measures, changes in soil texture and structure should be monitored at frequent intervals. This study could be done by the Environmental Management cell, twice a year. This should be studied for the entire length of alignment.

7.2 ESTABLISHMENT OF AN ENVIRONMENT DIVISION

It is strongly recommended that MRTS Project Authority establishes an Environment Division at the initial stage of the project itself. The division shall be staffed by an Environmental Engineer/Officer, a Technical Assistant (environment background) and

two other assistants (miscellaneous works). The task of the division would be to supervise and coordinate studies, monitoring and implementation of environmental mitigation measures, and it shall report directly to the General Manager. Progress of the division shall be reviewed by an Environmental Adviser every year. The Environmental Adviser would be an experienced Environmentalist familiar with environmental management in similar projects. Costs for the first ten years including 10% annual price increase) have been given below:

Costs per year:

-	Environmental engineer/officer		Rs.2,40,000
-	Technical assistant		Rs. 60,000
-	Indemnities, travel, etc.		Rs. 50,000
		Total	**Rs. 3,50,000**

Cost for 4 years

-	(10% annual price increase)	.	Rs. 15,23,000
	Overheads for Establishments		
-	@ 65% of salary cost		Rs. 9,14,000
		Total	**Rs. 24,37,000**

7.3 SUMMARY OF ENVIRONMENTAL MONITORING PROGRAMME

The environmental monitoring programs are presented in **Table 7.1 and** of this chapter. This section briefly highlights the summary of these programs along with parameter and frequency.

TABLE 7.1
SUMMARY OF ENVIRONMENTAL MONITORING PROGRAMME

S. NO.	ITEM	PARAMETERS	FREQUENCY	LOCATION
DURING PROJECT CONSTRUCTION PHASE				
1.	Effluent from septic tank	pH, BOD, COD, TSS, TDS	Once every month	Before and after treatment from each septic tank.
2.	Water related diseases	Identification of water related diseases, adequacy of local vector control and curative measure etc.	Three times a year	Labour camps and colonies.
3	Noise	Equivalent noise level	Once in three months	At major construction sites
4	Air quality	SPM, RPM, SO_2, and NO_x	Once every season	At major construction sites (total 4 stations)
DURING PROJECT OPERATION PHASE				
5	Water	pH, temperature, EC, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Total Hardness, Chlorides, Sulphates, Nitrates, DO, COD, BOD, Iron, Zinc, Manganese	Thrice a year	Ground/ surface source
6	Treated Effluent from STP/ETP	pH, BOD, COD, TSS, TDS	Once every week	Before and after treatment from STP/ETP
7	Erosion and siltation	Soil erosion rates, stability of bank embankment, etc.	Twice a year	
8	Ecology	Status of Afforestation programmes of green belt development	Once in 2 years	Depot Site/ Rail Corridor
9	Aquatic ecology	Phytoplanktons, zooplanktons, benthic life, fish composition	Once a year	1 km upstream 1 and 3 km downstream of discharge. Point from depot

CHAPTER-8
COST ESTIMATES

8.1 SUMMARY OF COSTS

All costs involved in Environmental mitigation and management and monitoring to be put on the account of MRTS Project Phase II. These costs are computed in **Chapter 6** and **Chapter 7.** A summary of these is presented in **Table 8.1.**

TABLE 8.1
ENVIRONMENTAL COSTS

S. NO.	ITEM	COST RS. MILLIONS
1.	Rehabilitation And Resettlement Of	330.20
2.	Compensatory Afforestation	1.542
3.	Water Supply Treatment	10.0
4.	Establishment Of Environment Division	2.44
5.	Training And Extension	0.43
6.	Sewage Effluent Treatment	10.0
7.	Drainage	0.30
8.	Rain Water Harvesting In Depot Area	1.0
9.	Green Belt Development	2.0
10.	Water Quality/ Epimidiological	0.64
11.	Air & Noise Monitoring	0.58
	TOTAL	**359.132**

The compensation for loss of lands, draining of water, noise and fire control and information systems have been incorporated in project costs.

The Environmental management plan should be implemented in phases so that optimum benefit could be achieved and should be synchronized with the construction schedules. The cost of land compensation will be about Rs.3505.1million. While environmental management and monitoring costs are Rs.359.132 million.

QUESTIONNAIRE FOR SOCIAL SURVEY

1. IDENTIFICATION

1.1 Name of City : _____

1.2 State : _____

1.3 Place/ Area : _____

1.4 Plot/ Shop No. : _____

2. GENERAL INFORMATION

2.1 Name of the head of the household _____

2.2 Name of the respondent _____

2.3 Relationship of respondent with household head _____

2.3.1.1 Religious Group: Hindu -1 Muslim - 2 Jain -3 ☐

Christian - 4 Others - 5

2.5 Social Group: SC -1 ST - 2 OBC -3 ☐

General -4

2.6 Family Pattern: Joint -1 Nuclear - 2 Individual -3 ☐

2.7 Size of Family: Small (2-4) -1 Medium) (5-7) - 2 Large (Above7) -3 ☐

3. FAMILY PARTICULARS

S. NO.	NAME OF THE MEMBER	RELATIONSHIP TO HH	SEX	AGE (YEARS)	MARTIAL STATUS	EDUCATION	OCCUPATION

4. HOUSEHOLD INCOME (ANNUAL)

4.1 Household Income

Below 25,000 -1 25,000-50,000 -2 50,000-1,00,000 -3 ☐

1,00,000-1,50,000 -4 1,50,000-2,00,000 -5 2,00,000&above -6

4.2 Source of major household income

a. _____

b. _____

5. HOUSING DETAILS

5.1 House : Owned -1 Rented -2 Encroached -3 ☐

5.2 If rented rent per month (Rs.) _____ ☐

5.3 Area of encroached _____ ☐

5.4 Type of construction Kutcha -1 Pucca -2 Semi Pucca -3 ☐

5.5 Year of construction _____

5.6 Stored of house Independent -1 Multiple Block -2 ☐

5.7 Is the house electrified Yes -1 No -2 ☐

5.8 Drinking water facilities Available near house -1 not available -2 ☐

6. COMMERCIAL/ SELF EMPLOYMENT ACTIVITIES

6.1 What is the type of business? 1. Individual 2. Partnership ☐

6.2 When was the business activity started in this structure? Year _____

6.3 Whether the business activity has license? Yes -1 No -2 ☐

6.4 Type of finished goods/ service sold:

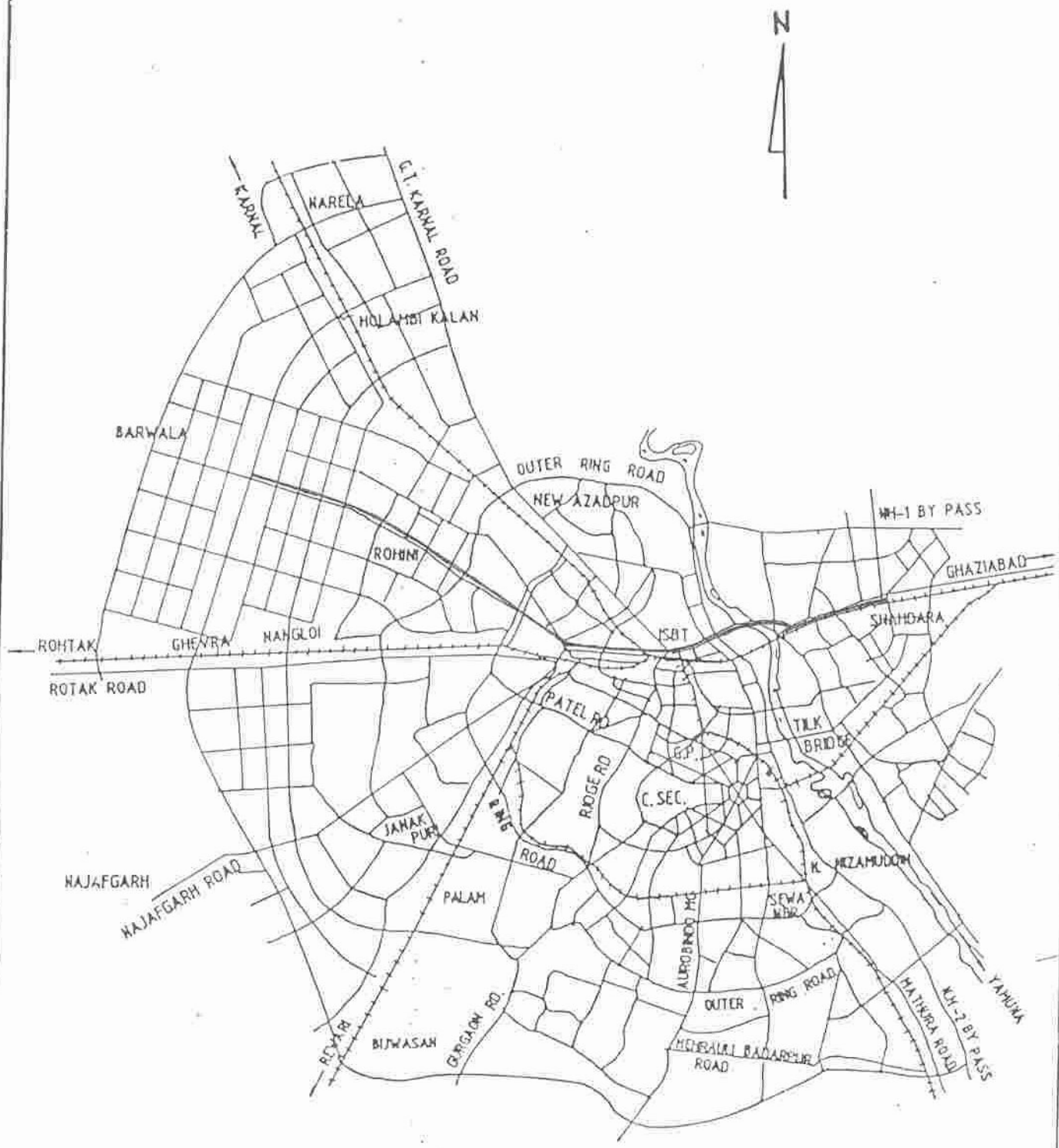
Grocery	-1	Pan Shop	-2
Vegetables, Fruits	-3	Tea, Coffee, Snacks (Hotel)	-4
Fancy Items	-5	Bicycle/ Scooter/ Car repairing	-6
Cloth/ Dresses	-7	Tailoring	-8
Clinic	-9	School/ College	-10
Welding/ Electrical Work	-11	Tyre Repairing	-12
Manufacturing (specify the product)	-13	Others (specify)	-14

☐

7. TYPE OF EFFECTS/ LOSS

7.1 **Type of Effects**

a. Losing Entire house –1
b. Losing part of house-2
c. Losing part of house & economic base-3
d. Losing entire house & economic base-4
e. Losing economic base-5



MASS RAPID TRANSPORT SYSTEM FOR DELHI	DELHI ADMINISTRATION RITES	EXISTING RAIL AND ROAD NETWORK IN DELHI	FIG. NO. 2.1

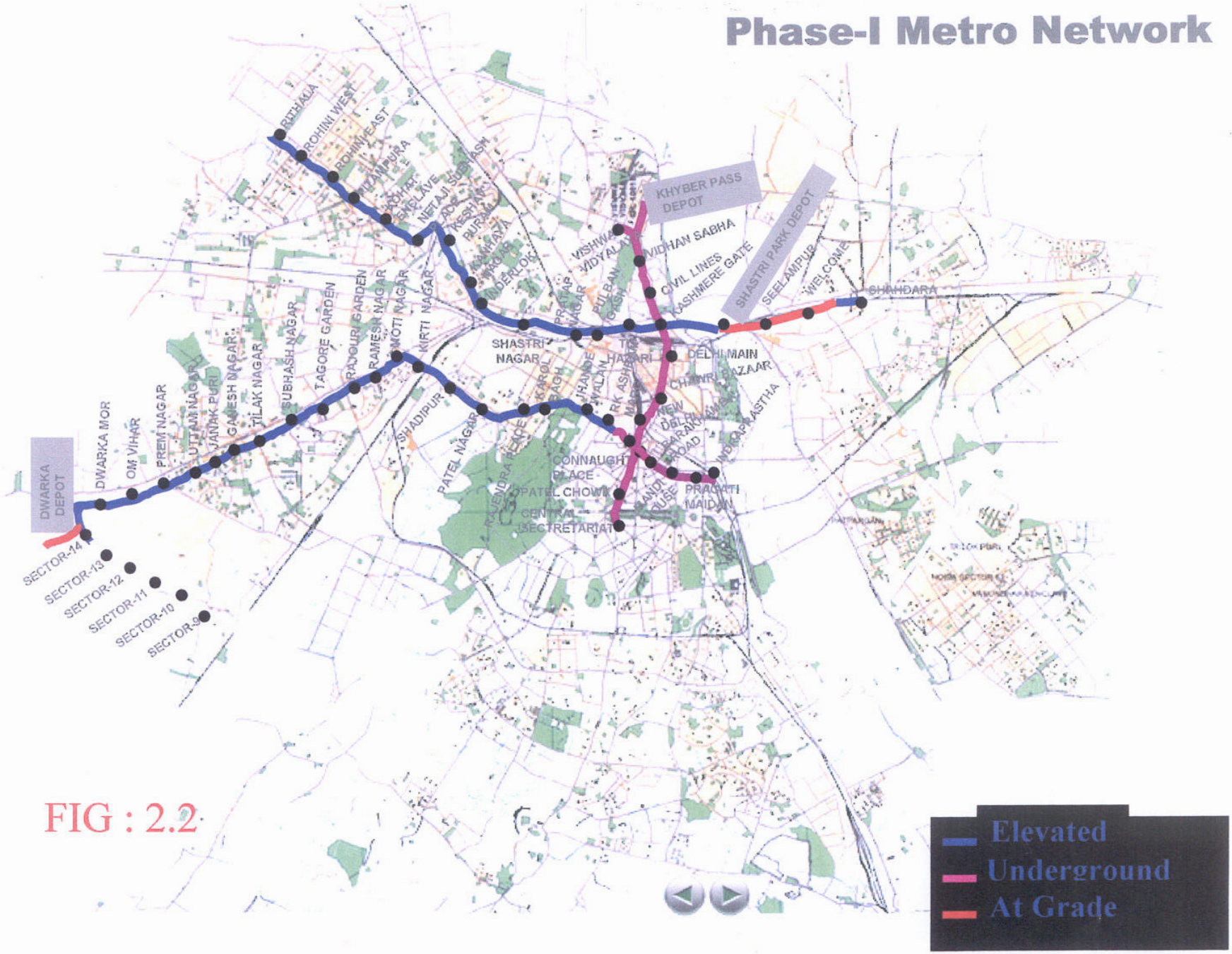

Phase-I Metro Network
KHYBER PASS DEPOT
SHASTRI PARK DEPOT
DWARKA DEPOT
DWARKA MOR
OM VIHAR
PREM NAGAR
UTTAM NAGAR
JANAK PURI
GANESH NAGAR
TILAK NAGAR
SUBHASH NAGAR
TAGORE GARDEN
RAJOURI GARDEN
RAMESH NAGAR
MOTI NAGAR
KIRTI NAGAR
SHADIPUR
PATEL NAGAR
SHASTRI NAGAR
KAROL BAGH
JHANDEWALAN
RK ASHRAM MARG
CONNAUGHT PLACE
PATEL CHOWK
CENTRAL SECRETARIAT
DELHI MAIN BAZAAR
CHAWRI BAZAAR
NEW DELHI
BARAKHAMBA ROAD
MANDI HOUSE
PRAGATI MAIDAN
INDRAPRASTHA
VIDHAN SABHA
CIVIL LINES
KASHMERE GATE
SEELAMPUR
WELCOME
SHAHDARA
PRATAP NAGAR
PULBANGASH
VISHWA VIDYALAYA
ROHINI WEST
ROHINI EAST
PITAMPURA
KOHAT ENCLAVE
NETAJI SUBHASH PLACE
KESHAV PURAM
AZADPUR
MAJLIS PARK
SECTOR-14
SECTOR-13
SECTOR-12
SECTOR-11
SECTOR-10
SECTOR-9
Elevated
Underground
At Grade

FIG : 2.2

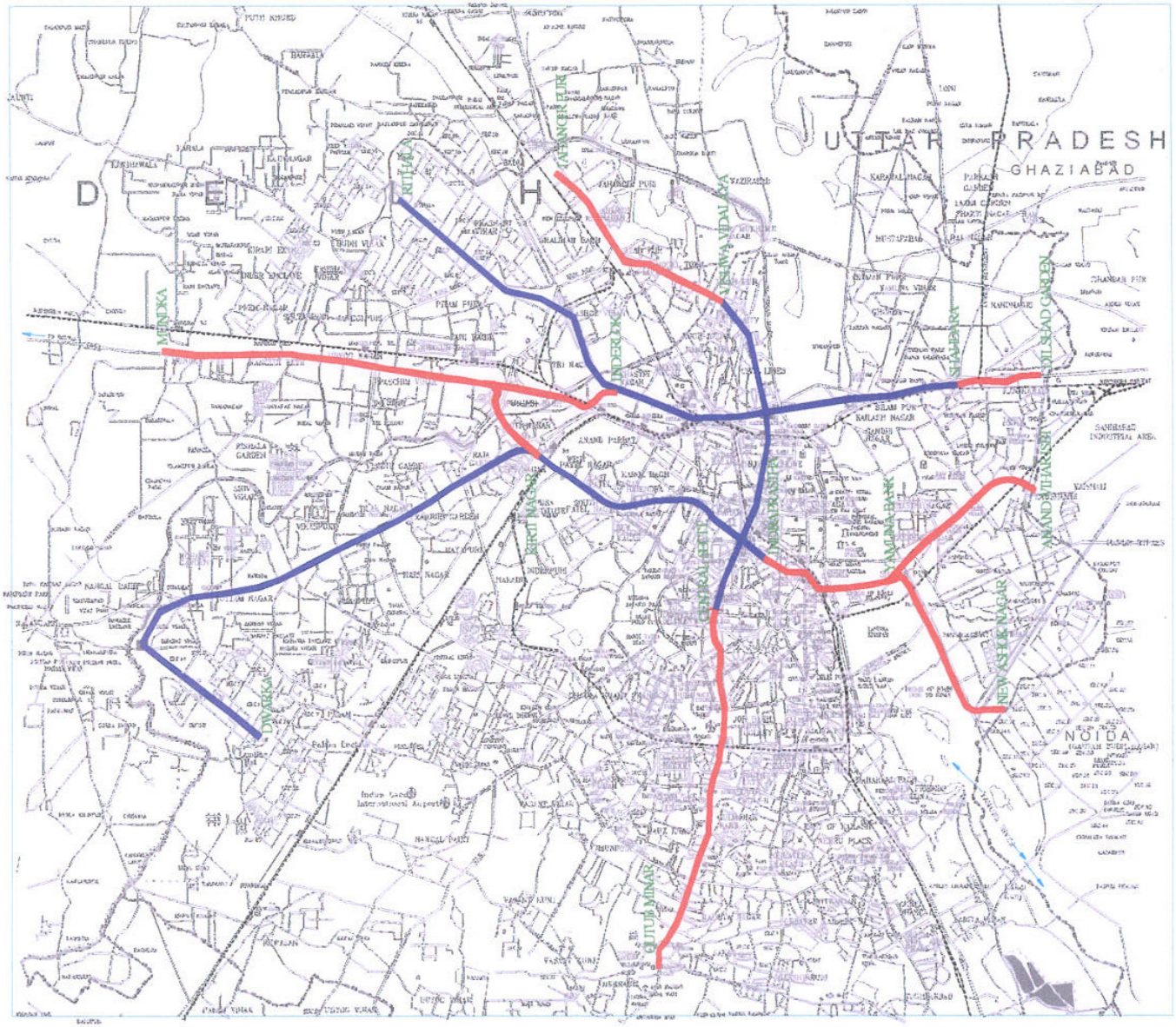


Fig. 2.3 DELHI METRO PHASE-I & II CORRIDORS

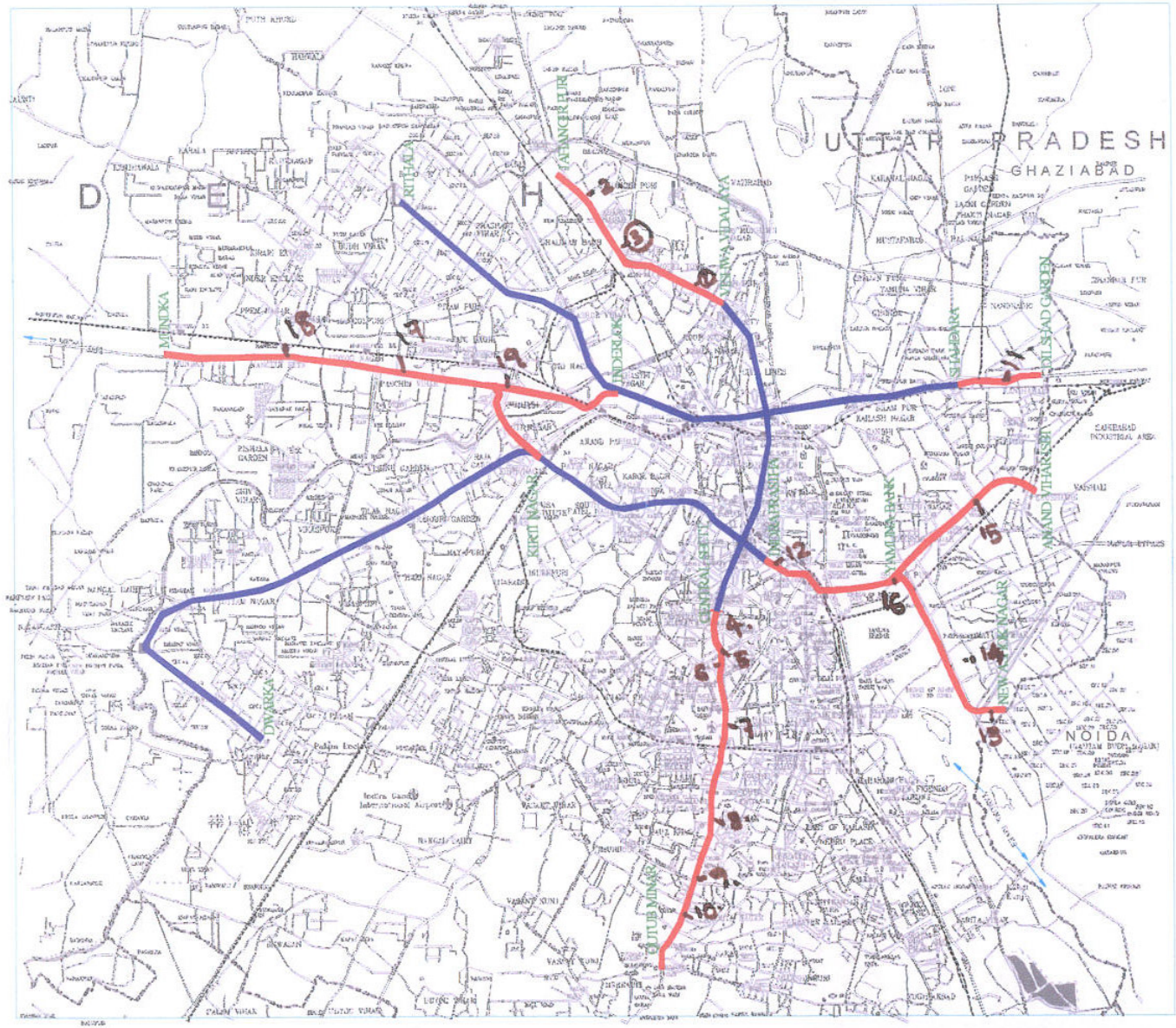
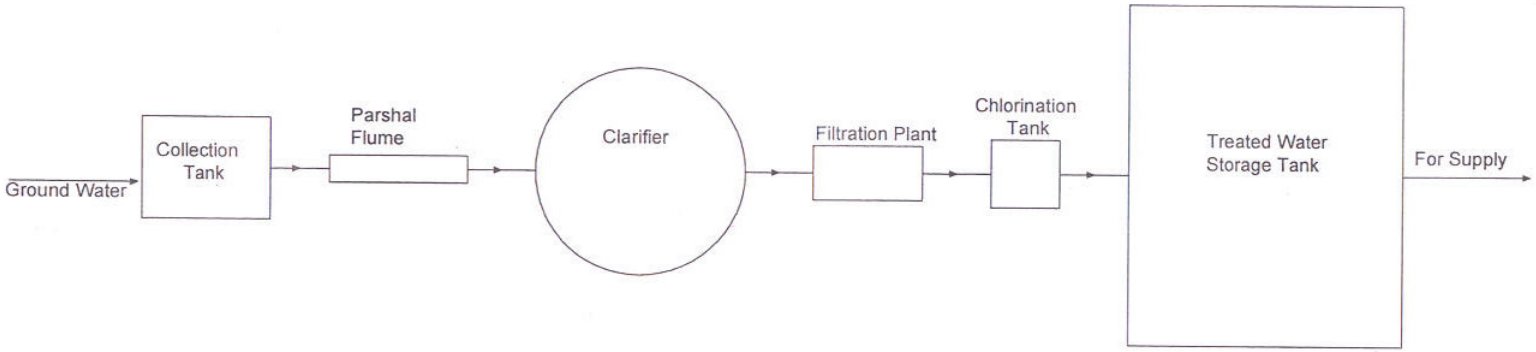


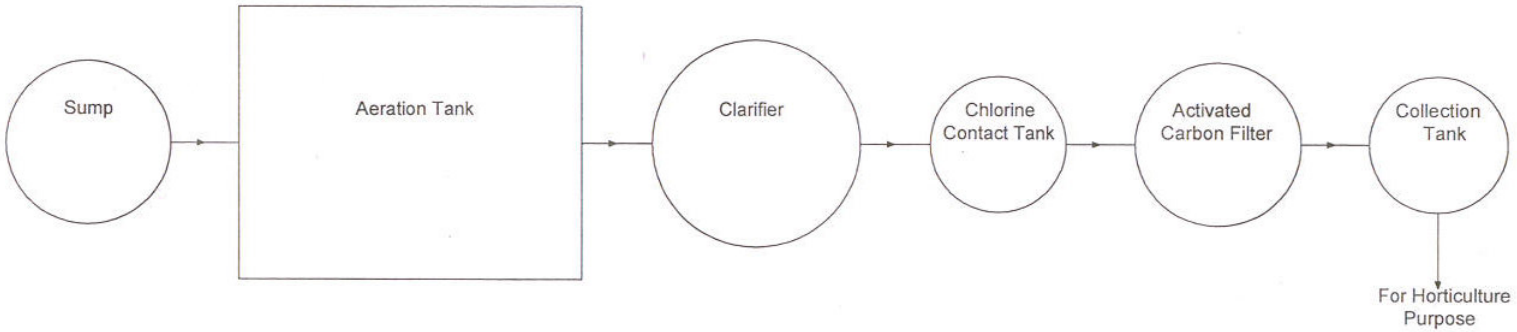
Fig. 3.1 AIR QUALITY MONITORING LOCATIONS

FIGURE 6.1 : FLOW CHART FOR WATER TREATMENT PLANT



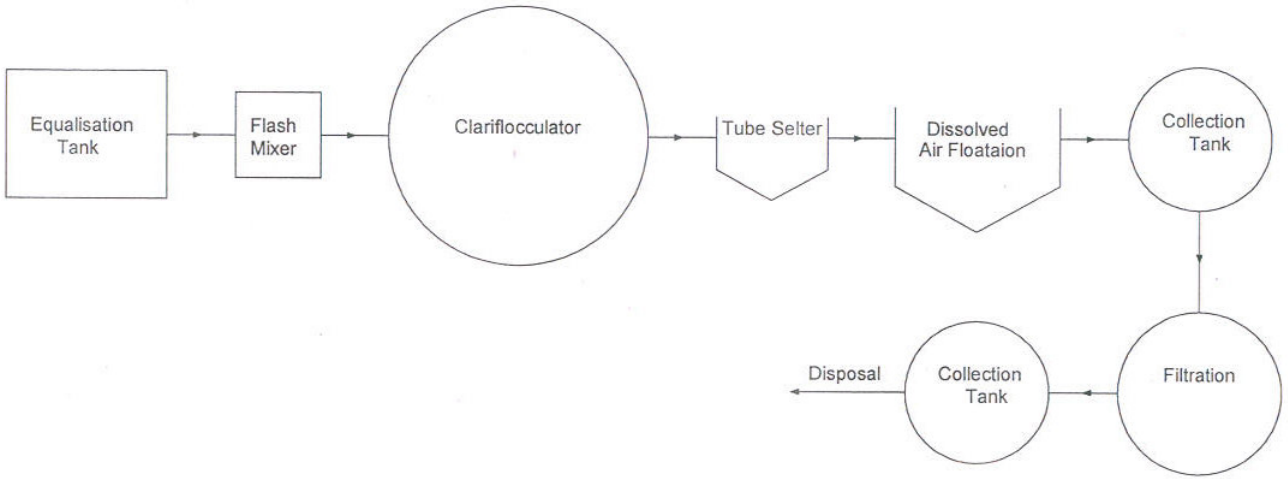
Scale : Not to Scale

FIGURE 6.2: FLOW CHART FOR SEWAGE TREATMENT PLANT



Scale : Not to Scale

FIGURE 6.3: FLOW CHART FOR EFFLUENT TREATMENT PLANT



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