THE PREPARATORY STUDY ON THE DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 5) IN BANGLADESH

FINAL REPORT
(SUMMARY)

OCTOBER 2018

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ALMEC CORPORATION
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
NIPPON KOEI CO., LTD.
KATAHIRA & ENGINEERS INTERNATIONAL

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Exchange Rate (April 2018)

1USD=107JPY

1USD=83BDT

1BDT=1.29JPY

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ABBREVIATIONS

ADB	Asian Development Bank
AFD	Agence Francaise de Developpement
BBA	Bangladesh Bridge Authority
BIWTA	Bangladesh Inland Water Transport Authority
BIWTC	Bangladesh Inland Water Transport Corporation
BR	Bangladesh Railway
BRT	Bus Rapid Transit
BRTA	Bangladesh Road Transport Authority
BRTC	Bangladesh Road Transport Corporation
BUET	Bangladesh University of Engineering and Technology
C&B	Construction & Building
CASE	Clean Air and Sustainable Environment
CNG	Compressed Natural Gas
DAP	Detail Area Plan
DCC	Dhaka City Corporation
DF/R	Draft Final Report
DFID	Department for International Development
DHUTS	Dhaka Urban Transportation Network Development Study
DMA	Dhaka Metropolitan Area
DMDP	Dhaka Metropolitan Development Plan
DMP	Dhaka Metropolitan Police
DMTA	Dhaka Metropolitan Transport Authority
DMTC	Dhaka Mass Transit Company
DNCC	Dhaka North City Corporation
DPP	Department of Printing and Publications
DRTM	Directorate of Road Transport Maintenance
DSCC	Dhaka South City Corporation
DTCA	Dhaka Transport Coordination Authority
DTCB	Dhaka Transport Coordination Board
ECNEC	Executive Committee of the National Economic Council
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
F/R	Final Report
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GIBR	Government Inspector of the Bangladesh Railways
GOB	Government of Bangladesh
GOJ	Government of Japan
GPS	Global Positioning System
HIS	Household Interview Survey
IC/R	Inception Report
IT/R	Interim Report
JICA	Japan International Cooperation Agency
LDC	Least Developed Country
LGD	Local Government Division
LGED	Local Government Engineering Department

MOC	Ministry of Communication
MOHPW	Ministry of Housing and Public Works
MOR	Ministry of Railways
MRT	Mass Rapid Transit
NGO	Non-Governmental Organizations
OD	Origin and Destination
ODA	Official Development Assistance
PPPO	Public Private Partnership Office
PT	Project Team
RAJUK	Rajdhani Unnayan Kartripakkha
RD	Record of Discussions
RHD	Road and Highway Department
RTC	Regional Transport Committee
SC	Steering Committee
SEA	Strategic Environmental Assessment
SPA	Survey and Plan Area
STP	Strategic Transport Plan for Dhaka
TDM	Traffic Demand Management
TOR	Terms of Reference
UMRT	Urban Mass Raid Transit
WB	World Bank
WG	Working Group

1 Introduction

1.1 Background

Dhaka City is the capital of the People's Republic of Bangladesh. The Dhaka Metropolitan Area (DMA) has a population of 9.3 million as of 2011. Currently, urban transportation in DMA relies mostly on road transport, such as car, bus, auto-rickshaw, rickshaw, etc. All those creates serious traffic congestion in addition to health hazards caused by traffic pollution including air pollution. With the rapid national economic growth, the urban population is expected to increase and so will the number of privately-owned automobiles. Therefore, improvement of the urban (public) transportation system in the DMA has become critical to ease traffic congestion and stop further environmental deterioration.

Given the situation, the Government of Bangladesh (GOB) formulated the "Strategic Transport Plan (STP) for Dhaka" in cooperation with the World Bank (WB) in 2005. Since the STP was officially approved by the GOB, it is expected that each donor will hereafter provide the assistance based on this STP to improve the urban transportation situation. Japan International Cooperation Agency (JICA) also conducted the Dhaka Urban Transportation Network Development Study (DHUTS) Phase 1 in March 2009 with Dhaka Transport Coordination Authority (DTCA) as its counterpart agency. The study's objectives were to conceptualize the basic urban development scenario for DMA by 2025 and to select priority projects that would help build the scenario. Its recommended priority project is the MRT Line 6. As a result, JICA conducted the feasibility study on MRT Line 6 under DHUTS Phase 2. Following these studies, GOB and JICA concluded the loan agreement on the "Dhaka Mass Rapid Transit Development Project" in February 2013 to construct MRT Line 6. Meanwhile, WB finished the feasibility study and basic design of BRT Line 3 and is now preparing the detailed design of the project. On the other hand, the Asian Development Bank (ADB) already completed the basic design of the BRT Line 3 extension project (from the airport to Gazipur) and, since April 2013, has conducted activities for the detailed design stage.

The STP identified three BRT lines (i.e. BRT Lines 1, 2, and 3) that were supposed to commence before 2010, but the other projects stated in the plan except for MRT Line 6 and BRT Line 3 have not yet started. Therefore, the STP needs to be reviewed and updated. JICA then conducted in May 2014 the Project on the Revision and Updating of the Strategic Transport Plan for Dhaka (RSTP) with DTCA as its counterpart agency.

It is under these circumstances that GOB and JICA made several preliminary discussions in order to identify priority projects in the transport sector and agreed to prepare for the Dhaka Mass Rapid Transit Development Project (MRT Lines 1 and 5). Accordingly, JICA dispatched a mission for the project to GOB on 7 March 2016 in order to develop scope and implementing arrangements of a further survey that would study the feasibility of the project.

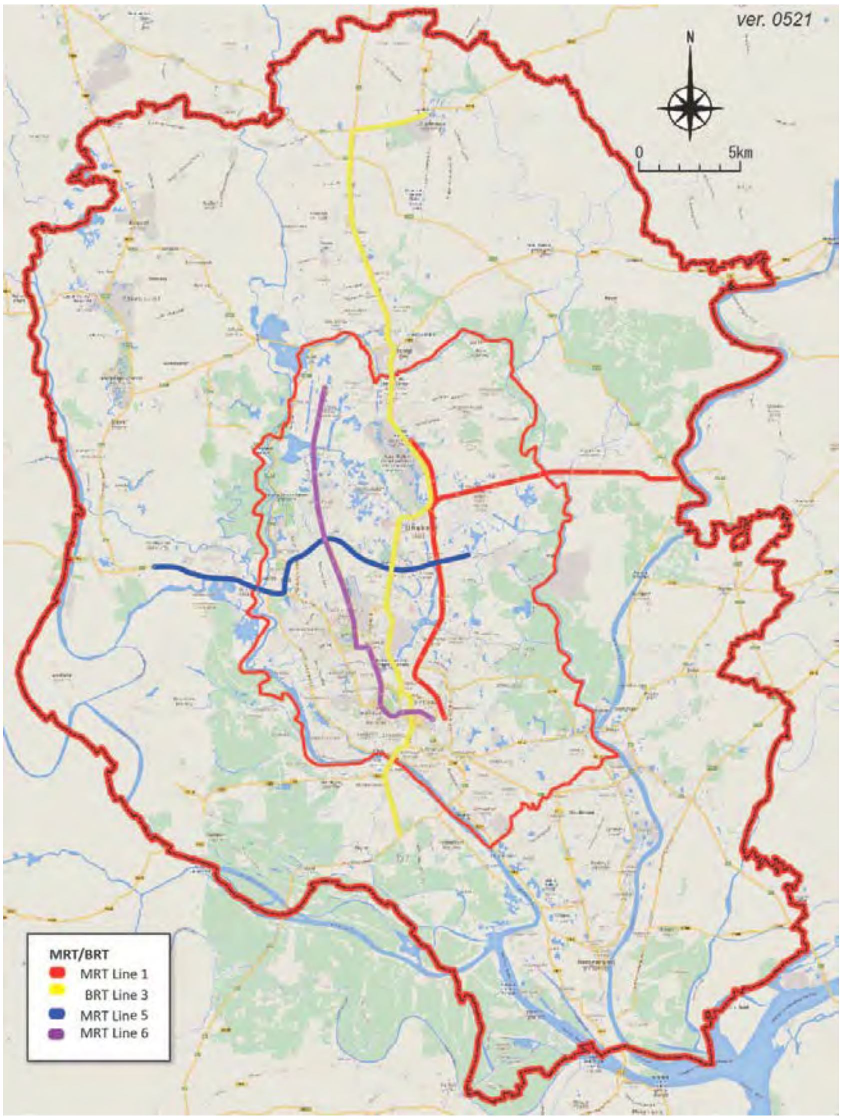
1.2 Objectives of the Project

The objectives of the project are to alleviate traffic congestion and improve air pollution in Dhaka City by constructing mass rapid transit system, thereby contributing to the economic and social development of Greater Dhaka Region and improving the urban environment.

MRT Line 1 (1st phase) and MRT Line 5 (1st phase) were identified as the high priority projects of RSTP. In this project, the feasibility study of MRT Line 1 (1st phase) and MRT Line 5 (1st phase) to be implemented and set up feasible project plan and project implementation plan considering of technical, economic and budgeting, and environment and social aspects.

1.3 Scope of the Project

As mentioned in the objectives of the study, when MRT Lines 1 and 5 will be nominated as ODA projects, such as Yen-loan project, the project implementation plan and consultation plan will require appraisal by international-financing agencies. The following are essential for the appraisal.



Source: JICA Study Team

Figure 1.3.1 MRT and BRT Routes in RAJUK Area

1) **Project Site**

The project site is located on the districts of Dhaka, Gazipur, Manikganj, Narayanganj, Munshiganj, and Narsingdi.

Source: JICA Study Team

Figure 1.3.2 Project Site

2) **Executing Agencies**

The executing agencies are DTCA and Dhaka Mass Transit Company Limited (DMTCL).

1.4 Basic Policy and Points of the Study

1) **Key Points of the Study**

Outputs of this study will be the basic information to evaluate the MRT lines as Japan's yen-loan projects. The following needs to be considered with the JICA Guidelines when compiling the results.

1. Methods of procurement and construction (including terms of reference for Basic Design and Detail Design).

2. Project costs (including MM of consultant services).

3. Capacity of implementation and operations and maintenance.

4. Indicators of operation and evaluation.

2) **Schedule of ECC**

This project is the feasibility study of MRT Lines 1 and 5. The environmental Impact Assessment (EIA) and Resettlement Action Plan (RAP) will be made for each MRT lines.

3) **Consistencies with the MRT Line 6**

Standardization of MRT system is required for quality improvement and safety. The RSTP also proposed networked MRT Lines. Therefore, the system of MRT Lines 1 and 5 should be the same with MRT Line 6.

(1) Integration of System, Regulations, and Standards

MRT Lines 1, 5, and 6 will have shared tracks and stations in the future, so the MRT systems, regulations, and standards need to be integrated.

(2) Integration of Automated Fare Collection System

The automated fare collection system of MRT Lines 1 and 5 will be installed with the same system as MRT Line 6 in order to adopt a connected ride discount system across MRT lines and other public transportation.

(3) Connectivity of MRT Line 1 with MRT Line 6 at Motijheel Area

In the current situation, the planned Motijheel Station of MRT Line 6 will be far from the proposed Kamalapur Station of MRT Line 1. The connectivity between those stations needs to be considered in this project.

4) **Development around the station**

A transit-oriented development (TOD) typically includes a central MRT station surrounded by a high-density mixed-use area with lower-density areas spreading out from the centre. A TOD is also typically designed to be more walkable than other built-up areas through the use of smaller block sizes and reduction of land area dedicated to automobiles.

TOD allows the transport operator to benefit from alternative revenue and increased ridership. In turn, this provides opportunity for better services to be offered to the public.

2 Characteristics of the Project Area

2.1 Location of the Project Area and Spatial Structure

2.1.1 Location

MRT Lines 1 and 5 were prioritized as high priority projects by RSTP. In this project, the feasibility study of MRT Lines 1 and 5 are supposed to be implemented. The location of Lines 1 and 5 is shown in Figure 2.1.1. The location and depo area are tentative and will be determined in this study.

Figure 2.1.1 Location of MRT Line 1 and Line 5

2.1.2 Administrative Units and Land Areas

MRT Lines 1 and 5 are located in Greater Dhaka Area (GDA). The survey area covers the whole GDA that consists of Dhaka, Gazipur, Manikganj, Munshiganj, Narayanganj, and Narshingdi districts. The total area is 7,500 sq. km with 24.4 million or more residents since 2011. The more developed 1,500-km^2 Rajdhani Unnayan Kartripakkha (RAJUK) has 14.8 million residents. In contrast to the low population density of the entire GDA (31 person/ha), RAJUK has a very high density at 111 person/ha. The center of RAJUK can also be expected to have a much higher population density than that of the entire RAJUK.

The project area is generally low, flat, fertile, and flood-prone. While most of the developed area within RAJUK is at an elevation of 6–8 m above sea level, the elevation of Dhaka City Corporation (DCC) varies from 2 to 13 m above sea level. Due to the topographical and geological characteristics of GDA, it is inevitable to experience floods and overflow during the rainy season. There were water channels, natural drainages, and low land areas in and around Dhaka in the past, which contributes to the retention and discharge of rain water. However, the acceleration of urban sprawl has interrupted those water retention areas.

As of 2005, 25% of the national gross domestic product (GDP) was contributed by the gross regional domestic product (GRDP) of GDA. The GRDP of Dhaka City contributes 15% to the national GDP as it is a capital and economic centre of Bangladesh. The agricultural sector is still dominant outside RAJUK, while industrialization has been promoted within it.

There are also two export processing zones (EPZs) in Savar in Dhaka District and Narayanganj City in Narayanganj District. Moreover, the informal economic sector provides significant number of job opportunities in Dhaka.

Like other parts of Bangladesh, GDA is largely dominated by agricultural land use; whilst residential areas spread along the main road and river networks. The large industrial areas and commercial/business areas can be found only in RAJUK. The residential or housing development in RAJUK mainly focus on rich households; therefore, many immigrants from outside RAJUK and low-income households are forced to live in slums where there is no access to the required basic infrastructures. One of the many reasons of urban development delay outside RAJUK area is because of the lack of transport infrastructures. Without transport networks, people and goods cannot be mobilized.

The provision of basic infrastructures varies by GDA district. The electrification rate of GDA, however, is only 63% while 97% of the households in Dhaka district has access to electricity. Coverage of piped drinking water varies between 37–95%. Narayanganj district has the highest coverage in GDA. Provision of sanitary water (with water seal) is very low with only 38% are provided in GDA.

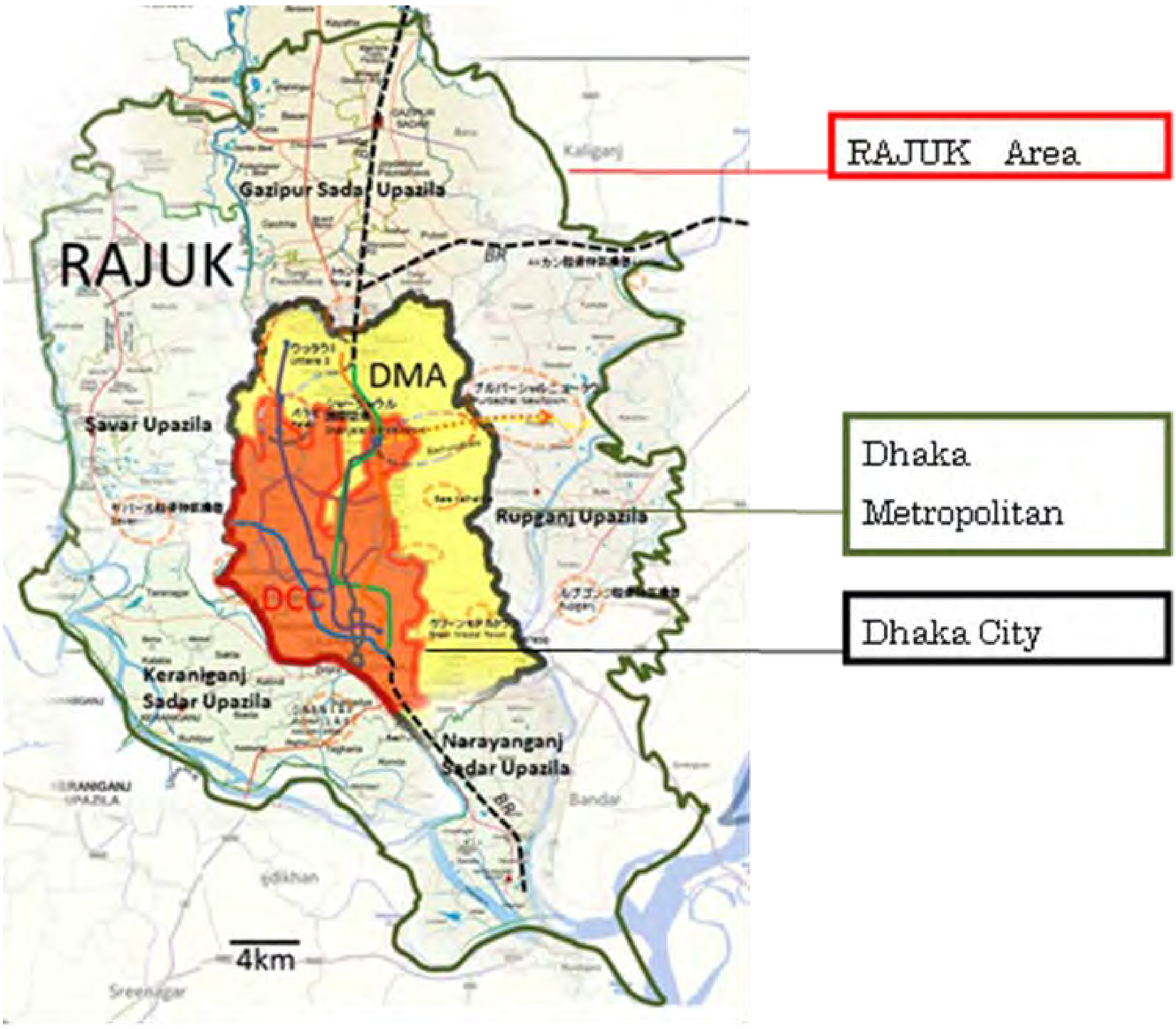


Figure 2.1.2 Study Area

2.2 Socio-Economic Profile

2.2.1 Population

1) Population

The total population of GDA in 2011 was approximately 23.5 million, which was 15.6% of the national population. Among the districts, Dhaka has the largest population with 51.3% of GDA; however, Gazipur showed the most rapid increase of population in the period of 2001–2011 and has the second largest population among all the districts. On the other hand, the populations of Manikganj, Munshiganj, and Narsingdi grew slowly compared to GDA, which suggests centralization of population (see Table 2.2.1).

Table 2.2.1 Population and Area of GDA District

District		Area (sq.km)1)	Population		AGR (%/year)
			2001	2011	
GDA	Dhaka	1,463.6	9,036,647	12,043,977	2.91
	Gazipur	1,806.4	2,143,200	3,403,912	4.73
	Manikganj	1,384.7	1,343,749	1,392,867	0.35
	Munshiganj	1,004.3	1,353,483	1,445,660	0.66
	Narayanganj	684.4	2,300,514	2,948,217	2.51
	Narsingdi	1,150.1	1,983,449	2,224,944	1.15
	TOTAL	7,492,5	18,161,042	23,459,577	2.59
% to National		5.1	13.9	15.6	-
National		147,568.9	124,355,263	149,772,364	

1) Area data from Statistical Year Book Bangladesh 2015
Source: Population and Housing Census 2011

RAJUK planning area covers some parts of Dhaka and Gazipur Districts as well as Narayanganj with 20.1% of the GDA. As per population, RAJUK area has 14.9 million in 2011, and the share of its share to GDA increased from 55.3% in 2001 to 60.7% in 2011 due to its rapid population increase (see Table 2.2.2).

On the contrary, the exterior of RAJUK area recorded lower growth ratio of population, except Gazipur District. RAJUK area which does not fall within the DCC South and North has been developing intensively for urbanization and population. The shape of expanding urbanized area becomes elongated from the north to south.

Table 2.2.2 Population and Area of RAJUK Area

	Area (km^2)	Population		AGR (%/year)
		2001	2011	
RAJUK Area	1502.3	10,037,120	14,819,160	3.99
Outside RAJUK Area	5,990.2	8,123,970	9,585,030	1.39
TOTAL	7,493	18,161	24,404	3.00

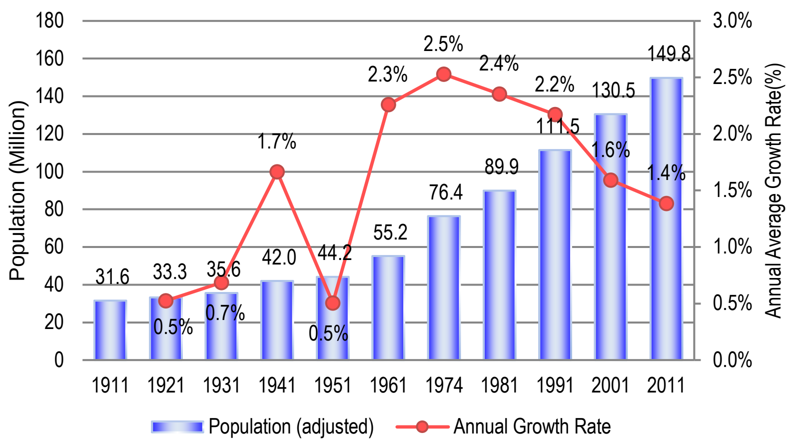
Source: Population and Housing Census 2011

2) Population Growth

The Bangladesh Bureau of Statistics has been carrying out the Population and Housing Census since 1872. As shown in Figure 2.2.1, the average annual population growth rate (population AAGR) increased from 0.5% in 1921 to 2.5% in 1974 except between 1941 to 1951 due to World War II and starvation. More than 3 million people was assumed to have died due to starvation and malnutrition. However, after 1974, the population AAGR decreased from 2.5% to 1.4% in 2011.

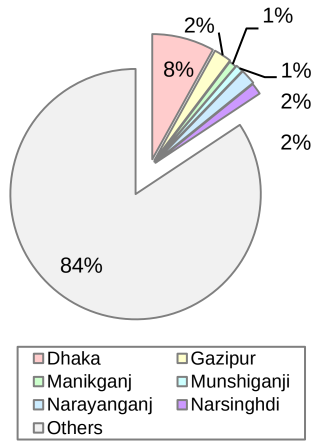
In 2011, the population of GDA is 15.7% of the population of Bangladesh and has a population AAGR of 3.2% against a large number of social growth where only covers 5%

land area of Bangladesh as shown in Table 2.4. Among the GDA districts, the population of Dhaka covers more than half the GDA population. While Gazipur and Narayanganj's population are lower than Dhaka's, their population AAGRs are higher than convenient locations, which makes commute to Dhaka easy and they have a relatively lower land value.



Note: Adjusted population.
Source: Statistical Yearbook of Bangladesh 2012, BBS

Figure 2.2.1 Population and Average Annual Growth Rate



Source: Population and Housing Census 2011, BBS

Figure 2.2.2 Population Distribution in GDA (2011)

Table 2.2.3 Population Growth Rate in the Study Area

	Area (sq. km.)	Population ('000)		Population Share (%)		Growth Rate (%)	Population Density ('000 person/sq.km)	
		2001	2011	2001	2011	2001-2011	2001	2011
Bangladesh	147,570	130,523	149,772	100.0%	100.0%	1.4%	884	1,015
GDA	7,492	17,112	23,460	13.1%	15.7%	3.2%	2,284	3,131
- Dhaka	1,464	8,511	12,044	6.5%	8.0%	3.5%	5,814	8,227
- Gazipur	1,806	2,032	3,404	1.6%	2.3%	5.3%	1,125	1,885
- Manikganj	1,384	1,205	1,393	0.9%	0.9%	1.5%	871	1,007
- Munshiganji	1,004	1,294	1,446	1.0%	1.0%	1.1%	1,289	1,440
- Narayanganj	684	2,174	2,948	1.7%	2.0%	3.1%	3,178	4,310
- Narsinghdi	1,150	1,896	2,225	1.5%	1.5%	1.6%	1,649	1,935
Rajuk Area	1,429	10,804	15,853	8.3%	10.6%	3.9%	7,561	11,094

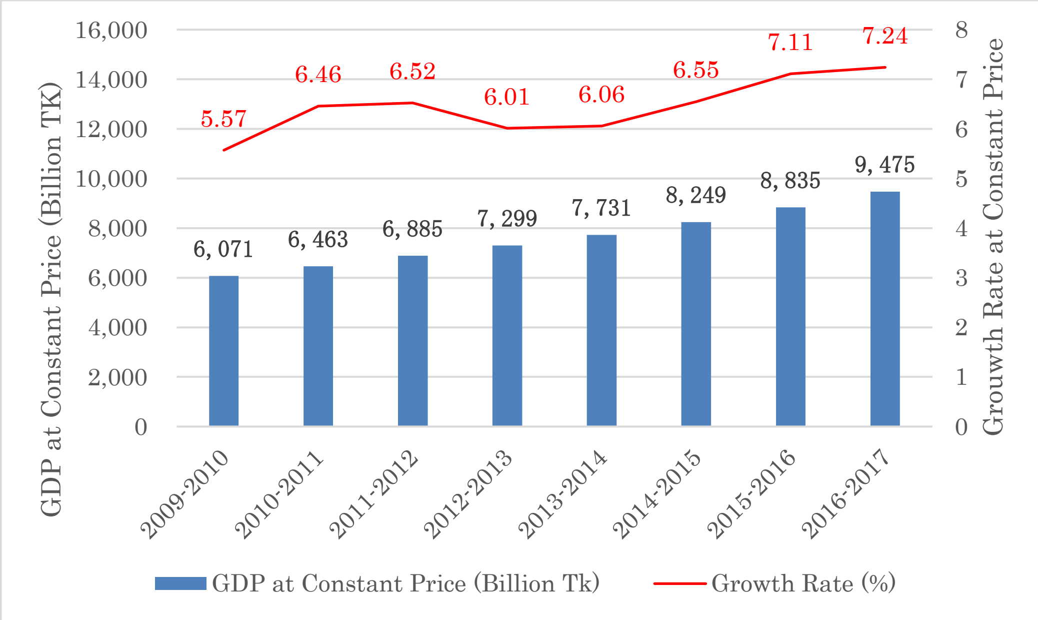
Source: Population and Housing Census 2011, BBS

2.2.2 GDP

1) National GDP and GDP Growth

Since 2009, Bangladesh has been consistent in continuing to achieve high GDP with almost more than 6% growth rate despite the impact of world recession, the European financial crisis in 2007–2008, and especially the growth rate at constant price since 2015 has been more than 7%.

The International Monetary Fund (IMF) published in the "World Economic Outlook, September 2014" the forecasted GDP growth rate of Bangladesh that will increase up to 7.0% by year 2017 based on economic development and potential. The GDP in Bangladesh has even exceeded the forecast in the report. Bangladesh has a high evaluation from international finance institutions that, in 2005, it was regarded as one of the Goldman Sach's Next11 recognizing its potential of becoming one of the world's larger economies after the BRICs (Brazil, Russia, India, and China) and JP Morgan's Frontier in 2007.



Source: GDP of Bangladesh 2013-2014, 2014-2015, 2015-2016,2016-2017, BBS

Figure 2.2.3 GDP Growth of Bangladesh (2009–2017)

Table 2.2.4 GDP Growth of Bangladesh (2009–2017)

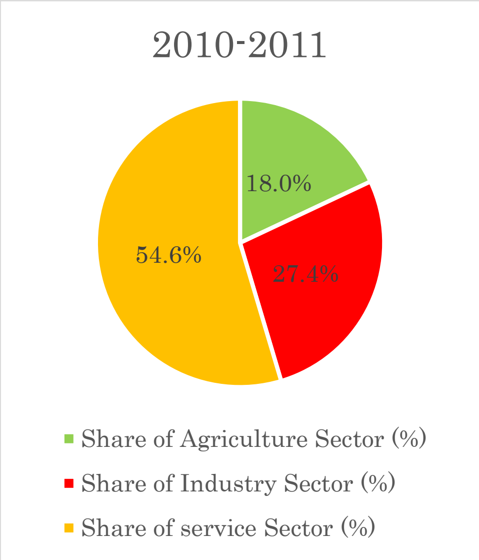
	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017
GDP at Constant Price (billion Tk)	6,071	6,463	6,885	7,299	7,731	8,249	8,835	9,475
Growth Rate (%)	5.57	6.46	6.52	6.01	6.06	6.55	7.11	7.24
Population (million)	147.8	148.7	151.6	153.7	155.8	157.9	159.89	161.75

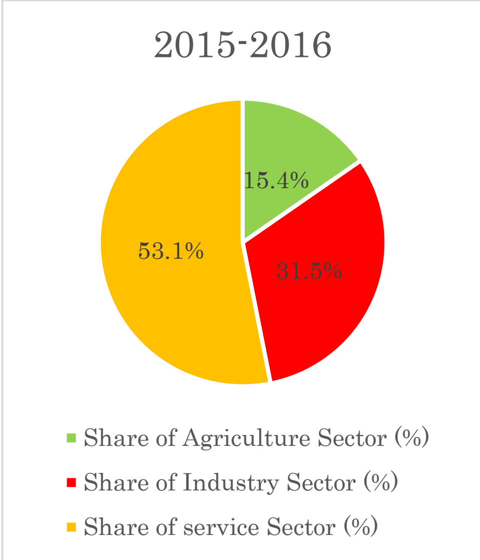
Note: Constant Price base year is 2005–2006.
Source: GDP of Bangladesh 2013–2014, 2014–2015, 2015–2016,2016–2017, BBS

2) Sectoral Share of GDP

Figure 2.2.4 and Table 2.2.5 shows the proportion of each sector from years 2009 to 2017. During this period, the share of agriculture in GDP has gradually decreased from 18.0% to 15.4%. Contrary to the decrease, the share of industry has changed from 27.4% to 31.5%.

With the underlying “Perspective Plan of Bangladesh 2010–2021 (Vision 21), 2012”, the Government of Bangladesh has set a goal to become a middle-income country by year 2021. Accordingly, the target total GDP growth rate was set to 8% in 2015 and gradually increase to 10% by 2021. In addition, the government aims to increase the industrial sector GDP up to 37% in 2021, which is being assessed through the yearly achievement report.





Note: * Provisional Constant Price base year: 2005-2006
Agriculture: Agriculture, Forestry, Fishing
Industry: Mining, Quarrying, Manufacturing, Electricity, Gas, Water supply, Construction
Service: Wholesale, retail trade, repair of motor, hotel, restaurant, transport, storage, communication, financial intermediations, real estate, renting and business activities, public administration, defence, education, health, social works, etc.
Source: GDP of Bangladesh 2013-2014, 2014-2015, 2015-2016,2016-2017, BBS

Figure 2.2.4 Comparison of GDP between 2010-2011 and 2015-2016

Table 2.2.5 GDP by Industry Sector at Constant Price of Bangladesh (2009–2017)

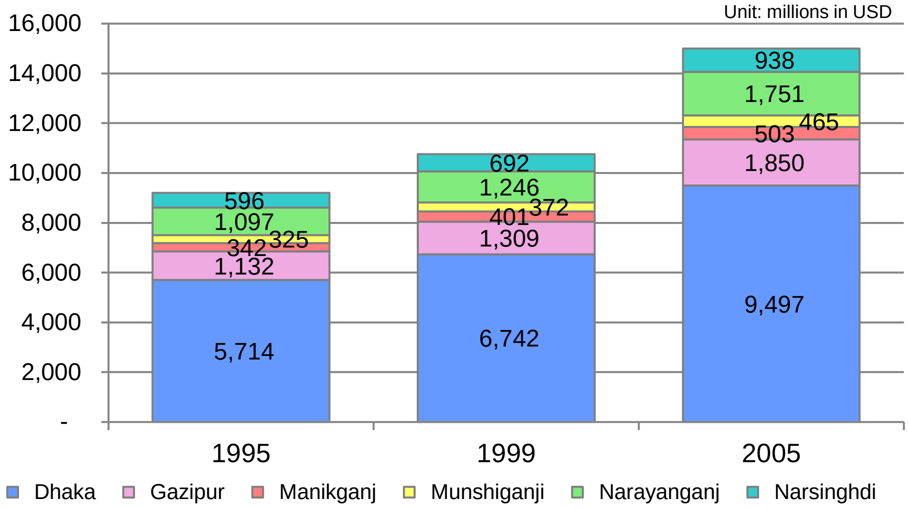
	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017 (p)
GDP of Agriculture Sector (billion TK)	1,065	1,113	1,146	1,174	1,226	1,266	1,302	1,346
GDP of Industry Sector (billion TK)	1,551	1,692	1,852	2,030	2,196	2,408	2,675	2,956
GDP of Service Sector (billion TK)	3,177	3,375	3,597	3,795	4,008	4,241	4,505	4,799
Share of Agriculture Sector (%)	18.4	18.0	17.4	16.8	16.5	16.0	15.4	14.8
Share of Industry Sector (%)	26.8	27.4	28.1	29.0	29.6	30.4	31.5	32.5
Share of service Sector (%)	54.8	54.6	54.5	54.2	53.9	53.6	53.1	52.7

Notes: * Provisional
Constant price base year in 2005–2006
Source: GDP of Bangladesh 2013–2014, 2014–2015, 2015–2016,2016–2017, BBS

3) GRDP in Study Area

The study area (GDA) is known to be the most developed and urbanized area in Bangladesh. As shown in Figure 2.2.5 and Table 2.2.6, the GRDP of the study area has taken 25% of the national GDP. Dhaka, which is the center of Bangladesh economy, contributes about 15% of national GDP and with the highest growth rate (AAGR = 5.9). Subsequently, Gazipur, Narayanganj, and Narsinghdi have a high growth rate of more than 5% per year.

According to Cambridge University survey (2014), the GRDP of Dhaka reached to US$37 billion, accounting for 35% of Bangladesh's economy.



Source: Growth, Income Inequality and Poverty Trends in Bangladesh: Implications for Development Strategy by Center for Policy Dialogue (CPD)

Figure 2.2.5 GRDP in the Study Area

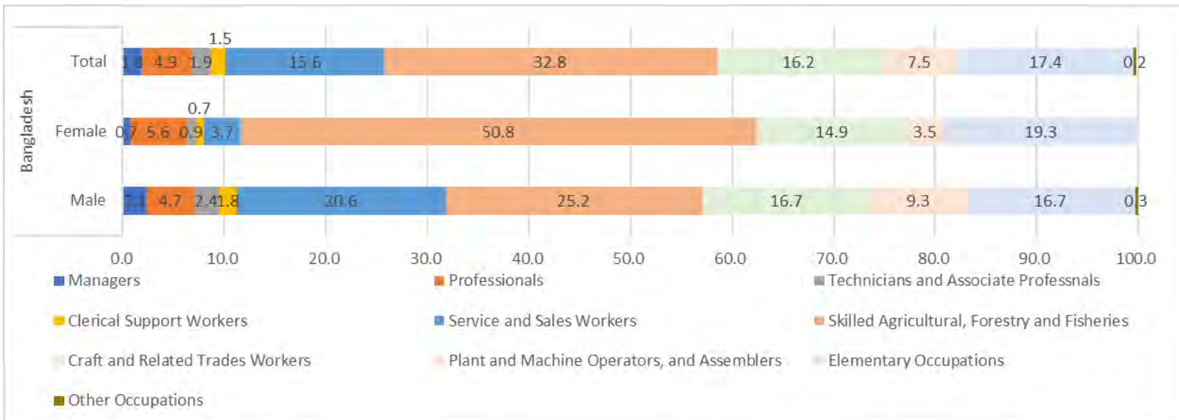
Table 2.2.6 GRDP in the Study Area

	GDP at Current Market Price (Million $US)						AAGR (%)	
	1995		1999		2005		1995-1999	1999-2005
	Million $US	National %	Million $US	National %	Million $US	National %	AAGR (%)	AAGR (%)
Bangladesh	39,065	100.0%	45,447	100.0%	59,748	100.0%	3.9%	4.7%
Study Area	9,206	23.6%	10,762	23.7%	15,004	25.1%	4.0%	5.7%
- Dhaka	5,714	14.6%	6,742	14.8%	9,497	15.9%	4.2%	5.9%
- Gazipur	1,132	2.9%	1,309	2.9%	1,850	3.1%	3.7%	5.9%
- Manikganj	342	0.9%	401	0.9%	503	0.8%	4.1%	3.8%
- Munshiganji	325	0.8%	372	0.8%	465	0.8%	3.4%	3.8%
- Narayanganj	1,097	2.8%	1,246	2.7%	1,751	2.9%	3.2%	5.8%
- Narsinghdi	596	1.5%	692	1.5%	938	1.6%	3.8%	5.2%

Source: Growth, Income Inequality and Poverty Trends in Bangladesh: Implications for Development Strategy by CPD

2.2.3 Labour and Employment

The share of employed population records are available in the Labor Force Survey. Though one-third of employment in Bangladesh engage in skilled agriculture, forestry, and fisheries, their proportion of employment in the urban area accounts for only 9.9%. On the other hand, the rate of manager, professionals, service, and sales workers in the urban area is higher than that in rural area (see Tables 2.2.6 and 2.2.7). There is a great difference between urban and rural areas in terms of distribution of employed persons (see Figure 2.2.7 and Table 2.2.8).



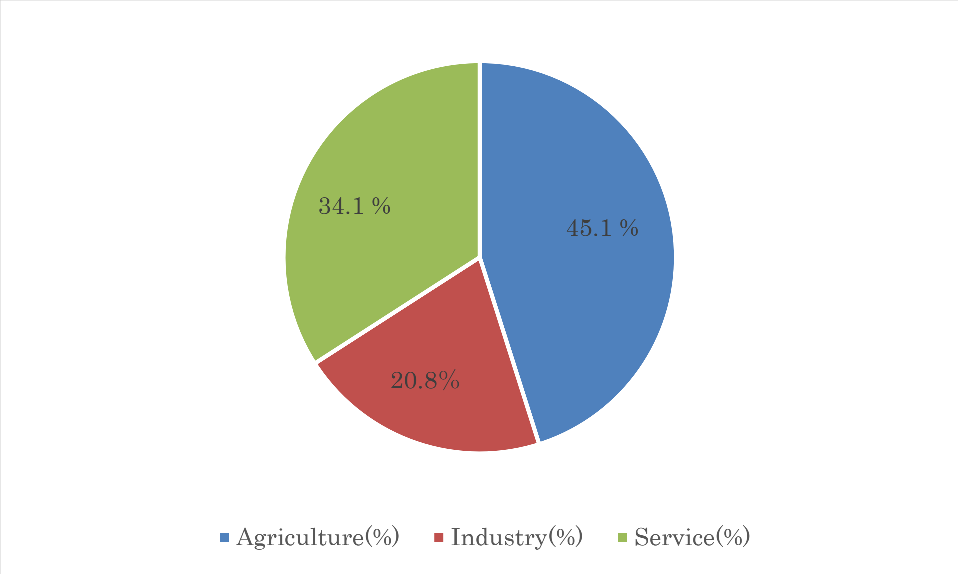
Source: Quarterly Labor Force Survey Report 2015–2016, BBS

Figure 2.2.6 Employment by Occupation and Industry (Age 15 or Older)

Table 2.2.7 Employment by Occupation and Industry (Age 15 or Older)

Occupation	Rural			Urban			Bangladesh		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Managers	1.1	0.3	0.8	5.4	2.1	4.5	2.3	0.7	1.8
Professionals	3.8	3.3	3.7	6.9	12.3	8.3	4.7	5.6	4.9
Technicians and Associate Professionals	1.7	0.6	1.3	4.1	1.8	3.5	2.4	0.9	1.9
Clerical Support Workers	1.3	0.4	1.0	3.1	1.6	2.7	1.8	0.7	1.5
Service and Sales Workers	17.4	2.5	12.7	28.6	7.3	22.9	20.6	3.7	15.6
Skilled Agricultural, Forestry, and Fisheries	32.5	62.0	41.6	7.4	16.9	9.9	25.2	50.8	32.8
Craft and Related Trades Workers	15.2	10.8	13.8	20.5	27.5	22.3	16.7	14.9	16.2
Plant and Machine Operators, and Assemblers	8.3	1.9	6.3	11.6	8.2	10.7	9.3	3.5	7.5
Elementary Occupations	18.6	18.3	18.5	11.9	22.3	14.7	16.7	19.3	17.4
Other Occupations	0.3	0.0	0.2	0.5	0.0	0.4	0.3	0.0	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Quarterly Labor Force Survey Report 2015–2016, BBS



Source: Quarterly Labor Force Survey Report 2015–2016, BBS

Figure 2.2.7 Distribution of Employed Persons by Broad Economic Sectors

Table 2.2.8 Distribution of Employed Persons by Broad Economic Sectors

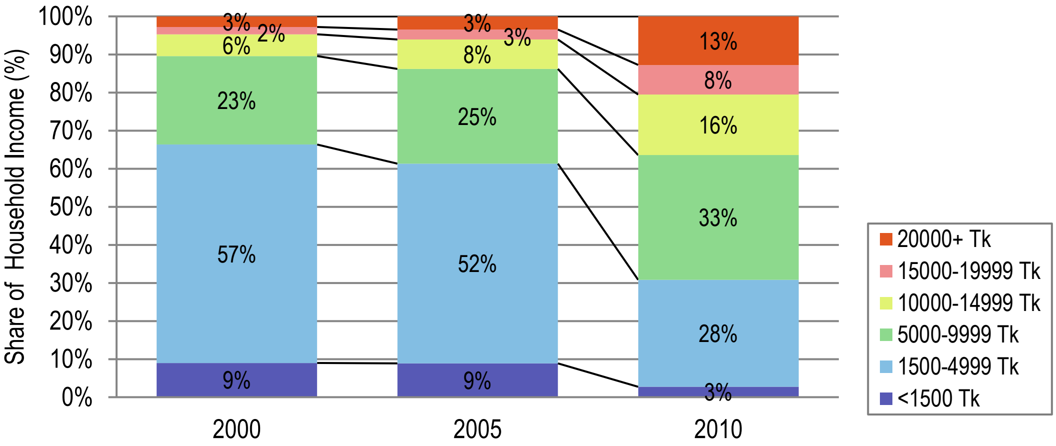
Economic Sector	Rural			Urban			Bangladesh		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Agriculture (000)	15,650	7,920	23,570	1,532	1,088	2,620	17,182	9,008	16,190
Industry (000)	4,880	2,598	7,477	3,201	1,395	4,596	8,081	3,993	12,073
Service (000)	9,088	1,783	10,870	6,876	2,063	8,939	15,964	3,846	19,809
Total (000)	29,618	12,300	41,918	11,609	4,546	16,155	41,227	16,846	58,073
Agriculture (%)	52.8	64.4	56.2	13.2	23.9	16.2	41.7	53.5	45.1
Industry (%)	16.5	21.1	17.8	27.6	30.7	28.5	19.6	23.7	20.8
Service (%)	30.7	14.5	25.9	59.2	45.4	55.3	38.7	22.8	34.1
Total (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Quarterly Labor Force Survey Report 2015–2016, BBS

2.2.4 Income Levels and Poverty

1) Distribution of Household Income and Expenditure

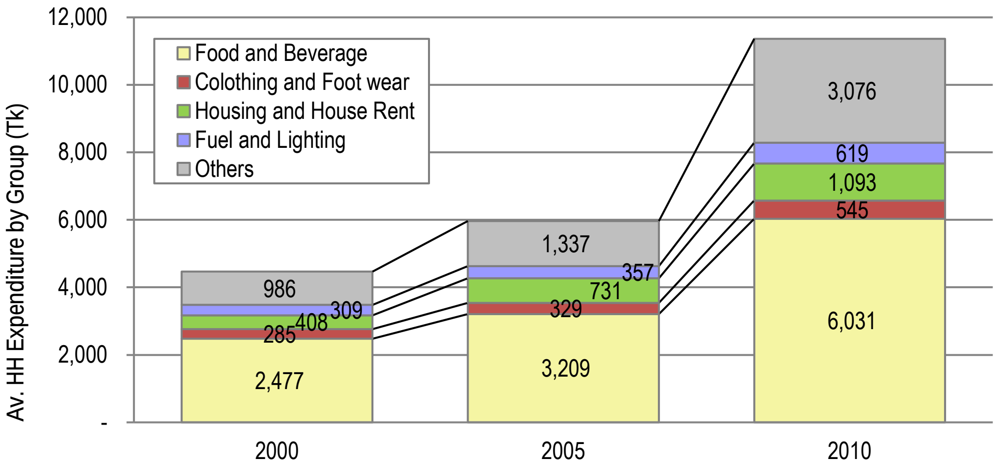
Household income and expenditure in Bangladesh have also increased in 2000–2010 against economic development. As per the Household Income and Expenditure Survey, the average household income was almost BDT12,000 in 2010. As shown in Figure 2.2.8, the share of low-income households (with monthly household income of less than BDT5000) was decreasing while high monthly income households (with monthly household income of more than BDT5000) was increasing every year.



Source: Household Income and Expenditure Survey, 2000, 2005, and 2010, BBS

Figure 2.2.8 Share of Household Income from 2000 to 2010

Figure 2.2.9 shows an increasing rate of average household expenditure that went up to BDT11,003 monthly in 2010 at the national level. The monthly average consumption in 2010 increased by 84.5% compared to year 2005 and by 142.5% with year 2000. Expenditure in food and beverage in particular, shows a tremendous increase.



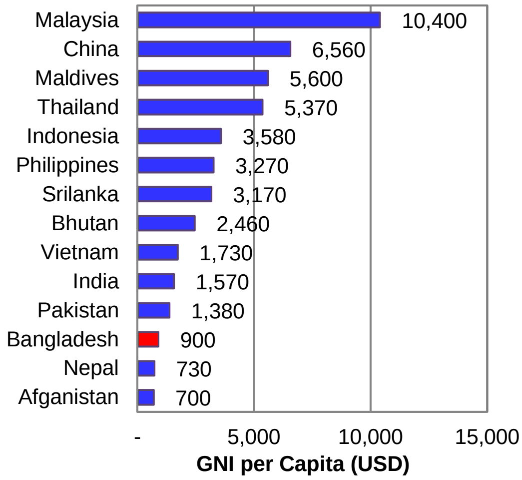
Source: Household Income and Expenditure Survey, 2010, BBS

Figure 2.2.9 Increasing Trend of Household Expenditure in Bangladesh

2) Poverty Indices

(1) Gross National Income (GNI) per Capita among Asian Countries

The Bangladesh economy recently shows a rapid growth; however, the country still remains as one of the poorest in the world. According to World Bank, the GNI per capita of Bangladesh in 2013 was in the third lowest position in South Asia with almost 60% difference from India and less than 30% from Sri Lanka. In order to curb the economic condition, the Government of Bangladesh resorted to increase minimum wage. For instance, the minimum monthly wage of garment workers received an increase from BDT1,661 in 2006 to BDT3,000 in 2010, and continuously went up to BDT5,300 in 2014.



Source: World Bank

Figure 2.2.10 GNI per Capita of Asian Country (2013)

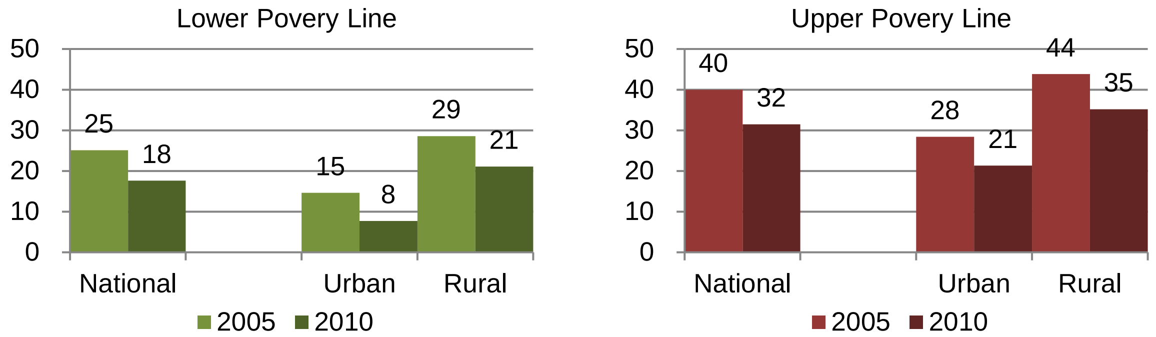
(2) Population of the Poor

The GNI of Bangladesh is quite low due to a large number of poor population. In order to estimate the number of poor people, Bangladesh Bureau of Statistics has been using the Cost of Basic Needs (CBN) method since 1995–1996. In this method, the two poverty lines estimated are lower poverty line (extreme poor) and upper poverty line (moderate poor).

Lower Poverty Line (Extreme Poor). Households with total expenditures on combined food and non-food items equal or less than the food poverty line (less than 2,122 kcal per person in a day) are considered to be under the extreme poor bracket.

Upper Poverty Line (Moderate Poor). Households with total expenditures equal to or less than the upper poverty line (summation of food and non-food poverty lines) are known as moderate poor.

As stated in the Perspective Plan, the government aims to reduce the number of upper poverty population from 32% to 13.5% by year 2021. In reference to Figure 2.2.11 data, the percentage of lower and upper poverty line people has decreased from 2005 to 2010.



Source: Upper Poverty Line: Household Income and Expenditure Survey, 2010 and Target: Perspective Plan of Bangladesh, Planning Commission Bangladesh, April 2012, BBS

Figure 2.2.11 Change of Percentage of Poor People in National Level

(3) Slum Population

People unable to afford their livelihood in the rural areas venture to Dhaka or a sub-urban area to get any job where they eventually engage into a low-skill job such as day labourer, rickshaw puller, luggage carrier, and the like. According to "Slums of Urban Bangladesh, Mapping and Census 2005," slum is defined as a neighbourhood or residential area with a minimum of 10 households or a mess unit with at least 25 members having four of the following conditions prevailing within the area.

- Predominantly poor housing;
- Very high population density and room crowding;
- Very poor environmental services, particularly water and sanitation facilities;
- Very low socio-economic status for the majority of residents; and
- Lack of security of tenure.

According to the above assumption, the number of slum population in Dhaka Metropolitan Area doubled from 1995 to 2005 (from 1.5 to 3.4 million people), while the number of slum communities increased by roughly 70% (from 3,007 to 4,966). Also, the share of slum population increased from 20% to 37%.

2.3 Land Use

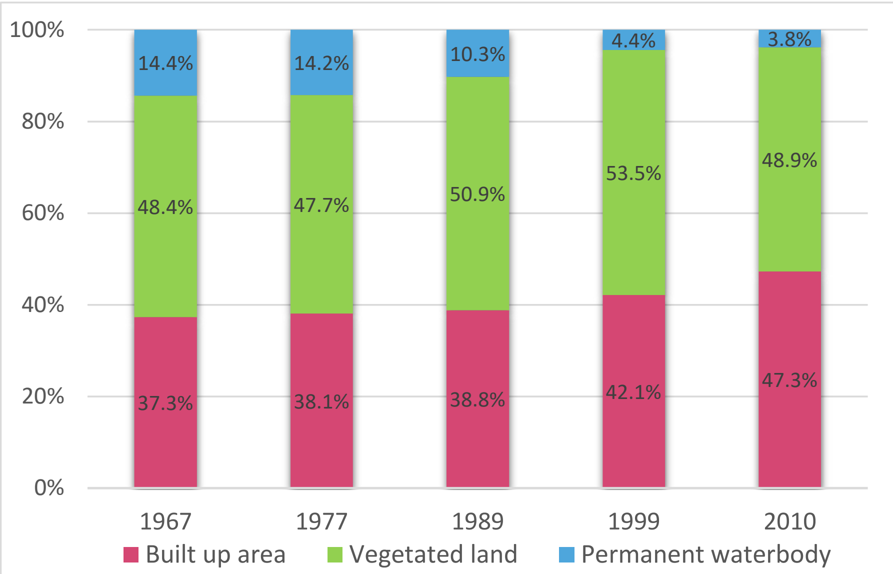
2.3.1 RAJUK Area

1) Overview

Similar with other developing cities, the growth of Dhaka's land use has been changing since 1967. While the vegetation area is almost fixed at 70,000 ha in the past 40 years, the current water body became a quarter since 1967, which is 5,520 ha in 2010 from 206,868 ha in 1967 as shown in Figure 2.3.1. Thus, the waterbody has been converted to built-up area. The lack of growth management and planned urbanization causes extensive urban poverty of low-income people who use the waterbody as domestic use and the fields for agriculture and fishery, recurrent episodes of flash flooding, substantial growth of slums, and exploitation of resources and the mismanagement of limited land resources.

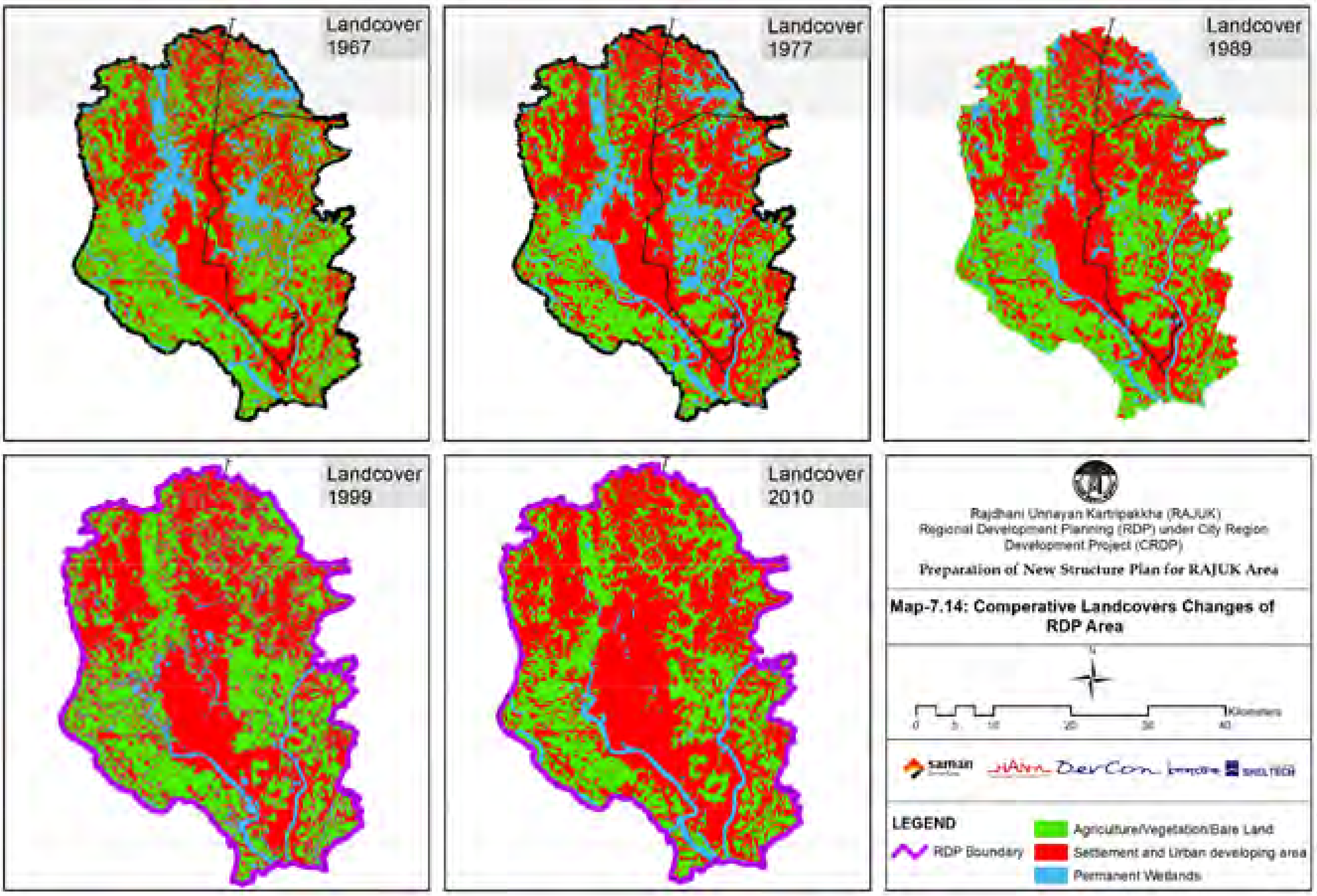
In 1967 to 1989, the built-up area increased gradually from 53,727 to 55,921 ha with 0.2% of the annual increase rate. After that period, urbanization has accelerated. The built-up area increased by about 5,000 ha in 1989–1999 and by 7,500 ha in the period of 1999–2010.

Figure 2.3.2 indicates the speedy expansion of built up area within RAJUK area through transformation of permanent water bodies and vegetation areas. The expansion of built up area mainly occurred to the northern region of RAJUK area specifically towards Savar, Ashulia and Uttara areas.



Source: Japan International Cooperation Agency (JICA) Study Team worked out based on Regional Development Planning (RDP) Survey Report (RAJUK, 2014)

Figure 2.3.1 Land Cover Changes between 1967 and 2010



Source: RDP Survey Report (RAJUK, 2014)

Figure 2.3.2 Land Cover in 1967, 1977, 1989, 1999 and 2010

RAJUK area is further divided into six regions, namely Dhaka Central Region, Northern Region, Eastern Region, Western Region, Southern Region, and South-Western Region. Below is the coverage of each region.

Dhaka Central Region. The existing Dhaka City consisting of 41 Thanas of DMA.

Northern region. All the unions (except Mirzapur union) of Gazipur Sadar Upazila and the entire area of Gazipur City Corporation.

Eastern region. Two Parushava (Kanchan and Tarabo) and six union of Rupjanj Upazila, and one Parushava (Kaliganj) and two unions of Kaliganj Upazila.

Western region. Savar Parushava and 11 unions of Savar Upazila.

Southern region. Two Parushavas (Narayanganj and Siddhiraganj) and seven unions of Narayanganj Sadar Upazila, one Parushava (Kadam Rasul Parushava) and five unions of Bandar Upazaila, and one Parushava (Sonargaon) and seven unions of Sonargaon Upazila (part).

South-Western region. Eleven unions of Keraniganj Upazila of Dhaka District.

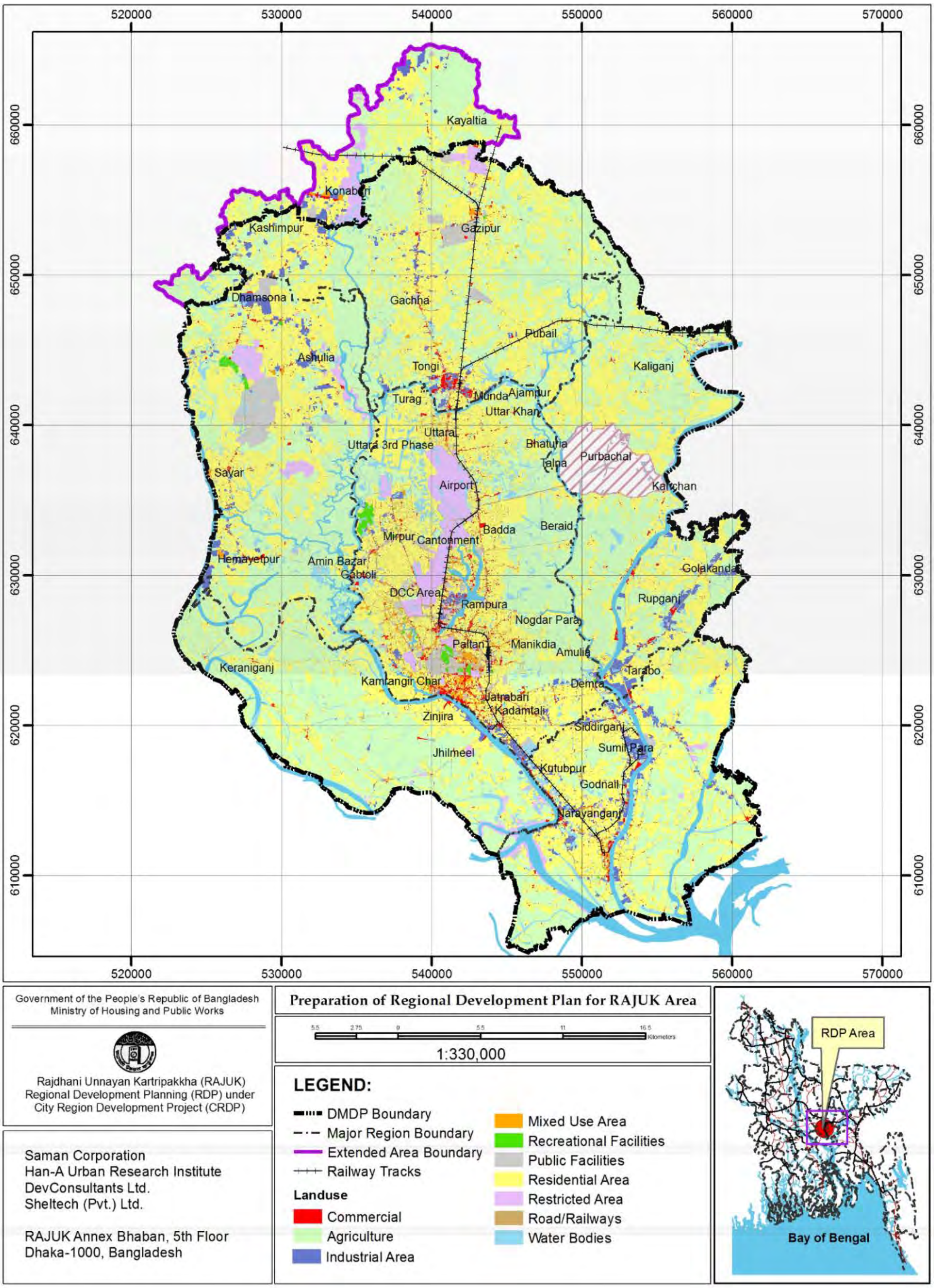
The total RAJUK area is 152,000 ha in which the northern region accounts the largest with 23.4% of the area, followed by Dhaka Central Region with 19.8%, and western region with 16.6%. In terms of land use type, the agricultural use is still dominant at more than 40% of the total area in RAJUK. These agricultural lands expand towards the north and west regions. Residential area is the second largest with 56,024 ha, which has been developed in Dhaka Central and northern regions. The development direction of the residential areas is the same as the urban expansion. Other urban land use, such as commercial and mixed-use, can also be found mainly in Dhaka Central and northern regions.

On the other hand, industrial areas are more concentrated in the northern and southern regions. The western region has relatively high share of public facilities and recreational area.

Table 2.3.1 Existing Land Use of the RDP Area

Land Use Type	Area (ha)							Share (%)						
	Region						Total	Region						Total
	DCR	NR	ER	WR	SR	SWR		DCR	NR	ER	WR	SR	SWR	
Agriculture	7,105	16,560	9,813	11,156	8,095	10,997	63,713	11.1	26.0	15.4	17.5	12.7	17.3	100.0
Industrial Area	541	864	557	727	909	144	3,810	14.5	23.1	14.9	19.4	24.3	3.9	100.0
Commercial	694	291	134	139	242	71	1,572	44.2	18.5	8.5	8.8	15.4	4.5	100.0
Mixed Use Area	612	128	4	82	124	21	971	63.0	13.1	0.4	8.5	12.7	2.2	100.0
Residential Area	12,988	14,248	7,022	8,852	8,759	4,154	56,024	23.2	25.4	12.5	15.8	15.6	7.4	100.0
Purbachal New Town	6	0	2,392	0	0	0	2,379	0.3	0.0	99.7	0.0	0.0	0.0	100.0
Public Facilities	1,294	780	90	1,178	337	89	3,767	34.3	20.7	2.4	31.3	8.9	2.4	100.0
Recreation al Area	289	4	0	87	9	0	390	74.1	1.0	0.0	22.4	2.4	0.0	100.0
Restricted Area	2,030	931	30	754	321	303	4,302	46.5	21.3	0.7	17.3	7.4	6.9	100.0
Road/Railw ays	1,859	553	212	418	423	192	3,657	50.8	15.1	5.8	11.4	11.6	5.3	100.0
Waterbody	2,643	1,203	1,273	1,902	2,416	1,966	11,758	23.2	10.6	11.2	16.7	21.2	17.2	100.0
Total	30,061	35,562	21,528	25,296	21,635	17,937	152,343	19.8	23.4	14.2	16.6	14.2	11.8	100.0

Note: DCR = Dhaka Central Region, NR = Northern Region, ER=Eastern Region, WR = Western Region, SR = Southern Region, SWR = South-western Region
Source: JICA Study Team worked based on RDP Survey Report (RAJUK, 2014)



Source: RDP Survey Report (RAJUK, 2014)

Figure 2.3.3 Land Use of RAJUK Area, 2013

2) Dhaka Central Region

A large portion of the Dhaka Central Region is already urbanized with 60% of the area as built-up. Majority of the built-up area is residential area with 43% followed by commercial area with 2.3%, mixed use with 2.0%, and industrial area with 1.8% (see Table 2.3.2). This region also covers Motijheel, Panthapath, and Gulshan, all of which are usually referred to as the central business district (CBD) of Dhaka. The land and property prices in this region increased incredibly between the period of 2000–2010.

About 13,000 ha of residential area is occupied mainly by middle- and high-income groups, and other residential areas developed spontaneously that are occupied by the low-income group. The spontaneous or unplanned development of residential areas in the region has increased urban problems.

There are 540 ha of industrial area, which are mainly in Pallabi, Mirpur, and Hazaribag Thanas, and 690 ha of commercial area in the southern side of DCC. Main commercial area is the old part of Dhaka City, such as Kotwali, Lalbag, and Sutrapur Thanas. Other commercial areas can also be found in Motijheel, Ramna, Tejgaon, and Khilgaon Thanas in the central part of DCC, and Gulshan, Mirpur, Badda and Uttara Thanas are in the northern part of DCC. All major commercial activities are situated along the major roads.

Besides the urbanized area, the agricultural land of 7,100 ha are spread in the peripheral area near the DMA boundary. Agricultural lands are mostly located in Uttar Khan, Beraid, Starkul, Badda, Demra, Sabujbag, and Khilgaon areas. Since the urban areas of the region are highly dense, these agricultural lands and water bodies have been converted for private housing projects.

This region also has 2,030 ha of restricted area occupied by military or government establishments. Important establishments include the President's Office and Residence at Banga Bhaban, Prime Minister's Office and Residence, National Parliament Building, Hazrat Shahjalal International Airport, Secretariat near Paltan, and Old Airport Area at Tejgaon. These restricted areas are located at a significant valuable land in an urban development aspect and became a constraint for the transport development. Besides the restricted area, large public facilities including government offices and universities also occupy prime land and cause congestions. Moreover, the share of recreational area and transport facilities are still insufficient to provide better living conditions for residents and to ensure sustainable development.

Table 2.3.2 Land Use Composition in Dhaka Central Region

Land Use Type	Ha	%
Agriculture	7,104.9	23.6
Industrial Area	541.4	1.8
Commercial	694.2	2.3
Mixed Use area	611.9	2.0
Residential Area	12,987.9	43.2
Purbachal RA	6.3	0.02
Public Facilities	1,293.6	4.3
Recreational Area	289.0	0.96
Restricted Area	2,030.0	6.8
Road/Railways	1,858.8	6.2
Waterbody	2,643.4	8.8
Total	3,0061.4	100.00

Source: RDP Survey Report (RAJUK, 2014)

3) Northern Region

Since most of the northern region is high land, the urbanization of Dhaka Central Region expanded to the north. The total 17,200 ha urbanized land is the second largest in RAJUK area. The Dhaka Central Region has 18,000 ha urbanized land. The agricultural area is still dominant in the region with 47% of the total area, but the residential area is also more than 40% (see Table 2.3.3).

About 14,000 ha of residential area is a mix of urbanized housing areas in Gazipur and Tongi Pourashava and rural homestead areas around the agricultural land. In general, urbanized housing areas have been developed for middle-income group, and the rural homestead areas are for low-income group. New planned residential areas are also being developed as private housing projects.

This region is known as one of the industrial cities of Bangladesh. Some industrial development can be seen along the Dhaka–Mymenshing Highway. In particular, Tongi is a major industrial area composed of many garment factories. The high land along this highway has increased in industrial development, but consequently caused disorder in residential and commercial developments that resulted with large slums. Another industrial zone is in the eastern side of the Upazila in Kashimpur Union and Konabari Union. Beximco Industrial park is situated near the Zirani Bazar. Small industrial areas are also scattered along the rivers and major roads where industrial establishments can have good accessibility for logistics.

Similarly, commercial areas were developed mainly along Dhaka–Mymenshing Highway. Gazipur and Tongi are the major commercial centers in this region. The latter, in particular, has the most commercial activity within the region.

Large part of the agricultural land is considered to be relatively of “high-value agricultural land.” In addition to the agricultural area, some seasonal crops also grow in the waterbody during dry season. The swampy areas used for agriculture are situated by the side of the Turag River in the south-eastern and eastern parts of the region.

Restricted land of 860 ha is mainly occupied by the Army Machine Tools Factory in the northern side of the region, Bangladesh Ordnance Factory (BOF), and Security Printing Press. Public facilities area has several research institute and universities.

Table 2.3.3 Land Use Composition in Northern Region

Land Use Type	Ha	%
Agriculture	16,560.0	46.6
Industrial Area	931.0	2.6
Commercial	291.5	0.8
Mixed Use area	127.7	0.4
Residential Area	14,247.8	40.1
Public Facilities	780.3	2.2
Recreational Area	4.1	0.01
Restricted Area	863.5	2.4
Road/Railways	552.8	1.6
Waterbody	1,203.1	3.4
Total	35,561.8	100.0

Source: RDP Survey Report (RAJUK, 2014)

4) Eastern Region

The eastern region is a predominantly agricultural area that occupies more than 45% of the entire region. The built-up area, which is mainly residential (see Table 2.3.4), occupies only 36%. The 9,800 ha of agricultural land is mostly the eastern fringe area with low-lying land. Part of the waterbody with 1,300 ha is also used for agriculture during the dry season.

The residential area is 7,000 ha or 33% of the total land. Since the eastern region is located at the peripheral area of DMA, sub-urban housing areas are situated on both sides of the roads within this area. Other residential areas are rural homestead area that is situated beside the agricultural land and occupied by the low-income group. Purbachal New Town, which is developed by RAJUK, is in this region as well (see Chapter 2.5). More urbanization would occur surrounding the peripheral semi-urban area of this zone being within the vicinity of the urbanized area.

Since the road network is not fully developed, the industrial development that covers less than 3% of the total area is concentrated by the river side of Balu, Shitalakhaya River, and Bhulta area. Along the national and regional highways and some important feeder roads are where the other industrial areas are. While the residential development increased, the commercial area occupied only 0.6% of the total area. Similar to the industrial area, commercial activities were developed mainly by the side of the national and regional highways and some important feeder roads. The industrial and commercial developments along the major roads also contributed to the additional unplanned development in those areas.

Table 2.3.4 Land Use Composition in Eastern Region

Land Use Type	Ha	%
Agriculture	9,813.5	45.6
Industrial Area	557.3	2.6
Commercial	134.3	0.6
Mixed Use area	3.9	0.02
Residential Area	7,022.3	32.6
Purbachal RA	2,391.5	11.1
Public Facilities	89.8	0.4
Restricted Area	30.2	0.1
Road/Railways	212.1	1.0
Waterbody	1,273.5	5.9
Total	21,528.5	100.0

Source: RDP Survey Report (RAJUK, 2014)

5) Western Region

The land use composition of the western region is similar to the eastern region (see Table 2.3.5). The main difference is that the western region has more public facilities and recreation areas, while the eastern region has a relatively large area for Purbachal New Town Development. More than 50% of the total land of the western region is agricultural land or waterbody that is considered as flood prone. In general, Keraniganj Upazila is low-lying and a flood prone area while Savar Municipality is relatively high land. Therefore, Savar Municipality has been developed as an urban center with residential, industrial, and commercial uses.

About 9,000 ha of residential area is mainly located along the roadside of Dhaka-Aricha Highway, Nabinagar-Tangail Road, Ashula Road, and Dhaka-Keraniganj Road. Urbanized residential area is generally developed for the middle-income group. The remaining rural homestead areas are for low income people.

About 700 ha of the industrial area includes the Savar Export Processing Zone located along the Nabinagar-Tangail Road. Some other industrial establishment is located along Dhaka-Aricha Highway, Hemayetpur-Singair Road, and Ashulia Road. The total area is small, but the western region has the third largest industrial area among six regions of RAJUK area.

Similarly, commercial land is also small at 140 ha. It has the smallest share of the land in the region (0.6%). The major commercial activity areas are the Hemayetpur, Savar Bazar, Nabinagar, Ganak Bari, and Zirani. There is also some commercial activity located along the river side of Buriganga and the Dhaka-Keraniganj Road.

Public facilities area includes Jahangir Nagar University, Savar Dairy Farm, Public Administration Training Center (PATC), City University, Daffodil University, BRAC Training Center, Bangladesh Atomic Energy Commission, Bangladesh Livestock Research Institute, etc. The area covers about 1,200 ha. There are also about 750 ha of restricted areas including Savar Cantonment which is a prime restricted area.

There is some high value agricultural land as well as some low-lying areas. Besides that, about 8% of the total area is waterbody, which can be used partially for growing some seasonal crops in dry season.

Table 2.3.5 Land Use Composition in Western Region

Land Use Type	Ha	%
Agriculture	11,156.2	44.1
Industrial Area	727.2	2.9
Commercial	138.8	0.6
Mixed Use area	82.4	0.3
Residential Area	8,852.0	35.0
Public Facilities	1,177.8	4.7
Recreational Area	87.3	0.4
Restricted Area	753.7	3.0
Road/Railways	418.4	1.7
Waterbody	1,901.8	7.5
Total	25,295.5	100.0

Source: RDP Survey Report (RAJUK, 2014)

6) Southern Region

Residential land use is central in the southern region as it occupies more than 40% of the total land (see Table 2.3.6). This is followed by agricultural land with 37%. Urbanized housing areas are located in Kadam Rasul, Sidhhirganj, and Narayanganj Pourashavas (NCC Area), Fatullah, Kanchpur, Madanpur, Islamia Bazar, Bandar Upazila head quarter, Mugrapara, etc. In addition, almost all are rural home stead areas for the low-income group that resulted from the lack of approved detailed plan.

The southern region has the largest industrial area of 910 ha in RAJUK, especially Narayanganj that is known as the industrial city of Bangladesh. Industrial activities have been mainly developed along the Shitalakhhaya River, Buriganga River, Old Brahmaputra River, Dhaka-Chittagong Highway, and Dhaka-Sylhet Highway. The Adamjee Export Processing Zone (EPZ), which was established in 2006, has 99.2 ha of the land and is located 15 km away from Dhaka City center. There are 61 companies with Bangladeshi main investors located in EPZ that generate more than 36,000 jobs. Other industries are located eastern side of Shitalokhhaya River in Bandar Upazila by the Brahmaputra River on Sonargaon Upazila and by the Buri Ganga River on Keraniganj Upazila.

The commercial area of 240 ha is all located in the City Corporation area along the Buriganga and Shitalakhhaya Rivers. Mugrapara, Islamia Bazar, Katchpur, Ekuria Bazar, Fatulla, Kutubpur, Shimulpara, Narayanganj, Kadam Rashul, and Siddhirganj are the main commercial activity centers in this zone.

About 8,800 ha of agricultural land and 2,400 ha of waterbody contribute to the agricultural activities of the region. The agricultural area is spread around the southern portion of Narayanganj Sadar Upazila, Bandar, and Sonargaon Upazila with low-lying parts.

Table 2.3.6 Land Use Composition in Southern Region

Land Use Type	Ha	%
Agriculture	8,094.6	37.4
Industrial Area	909.1	4.2
Commercial	242.1	1.1
Mixed Use area	123.7	0.6
Residential Area	8,758.8	40.5
Public Facilities	336.9	1.6
Recreational Area	9.4	0.04
Restricted Area	321.1	1.5
Road/Railways	423.1	2.0
Waterbody	2,416.5	11.2
Total	21,635.4	100.0

Source: RDP Survey Report (RAJUK, 2014)

7) South-Western Region

Although the south-western region is bounded by the urbanized area of the Dhaka Central Region, agriculture is its dominant land use. More than 60% of the total area is occupied by agricultural land and about 10% are waterbody. In addition, some parts of the region were converted into brick field.

Residential area shares the second highest with 23% of the total area. RAJUK's Jheelmil New Town and the urbanized residential area for the middle-income group has been developed by the roadside of Dhaka-Keraniganj and Dhaka-Mawa roads. The remaining area is the scattered and unplanned rural homestead for low-income group.

Other urban land uses in this region, such as industrial and commercial, are insignificant since they only occupy 0.8% (145 ha) and 0.4% (71 ha) of the total area, respectively. Moreover, commercial area is located along the side of Buriganga River and Shitalakhhaya Rivers.

Table 2.3.7 Land Use Composition in South-Western Region

Land Use Type	Area(ha)	%
Agriculture	10,996.9	61.3
Industrial Area	144.5	0.8
Commercial	71.4	0.4
Mixed Use area	21.2	0.1
Residential Area	4,153.8	23.2
Public Facilities	88.6	0.5
Recreational Area	0.0	0.0
Restricted Area	302.9	1.7
Road/Railways	192.4	1.1
Waterbody	1,965.6	11.0
Total	17,937.3	100.0

Source: RDP Survey Report (RAJUK, 2014)

2.3.2 Hazards

1) Flood and Inundation Characteristics

Basic inundation process that occur in Dhaka is when water levels rise in the three major rivers that cause back flows in the tributaries which, in turn, make it difficult to drain the surface water. Thus, this results in inundation in the wetlands and surrounding areas in the surroundings.

A major inundation (called *banna* in Bengali) that causes damages to human lives, properties, agriculture, etc. is when discharge from the three major rivers increase and river water of rising level flows into parts of the city with lower elevation; thus, inundating an extended area.

In recent years, major inundations occurred in 1988 and 1998 that brought about significant damages. During these inundations, water level of Buringanga River in the western part of Dhaka exceeded 7.0 m.

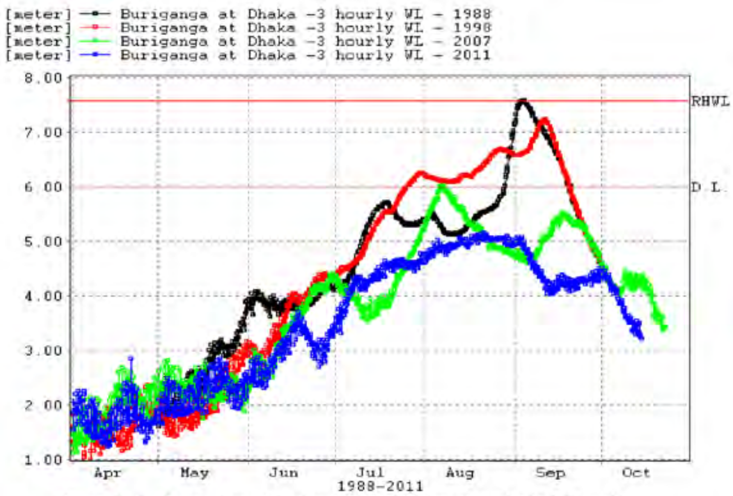


Figure 3.6 : Comparison of Hydrograph on Buriganga at Dhaka(Milbarak)

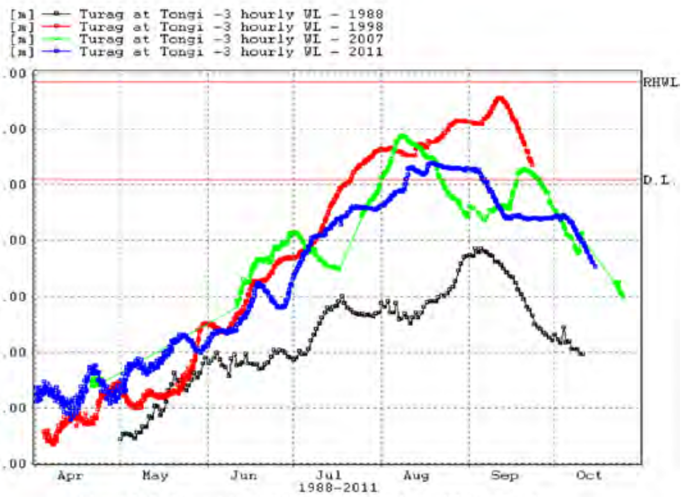


Figure 3. 7 : Comparison of Hydrograph on Tongi Khal at Tongi

Source: Annual Flood Report 2011, FFWC, BWDB

Figure 2.3.4 Water Levels in Rivers around Dhaka during Major Inundations in Recent Years

Dhaka City was built on a delta formed by rivers. Its ground is believed to be formed almost solely from silt and fine sand. As a result, river banks are subjected to erosion because of fluctuating water level and flowing river water.

Inundation by river water in Dhaka is characterized by a very slow process of flood water to recede, resulting in an elongated period of inundation. Typical duration of inundation in the last 50 years is from 15 to 45 days, during which the residents suffer directly and indirectly.

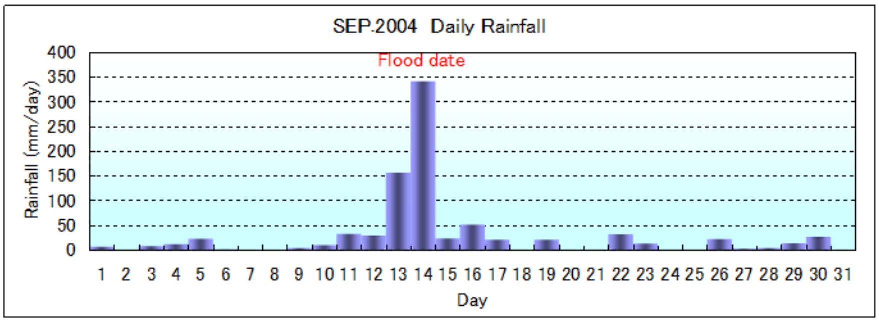
Another form of inundation that affects Dhaka is inundation by inside water. In case water levels in rivers rise when there has been a torrential rain, inundation damage by inside water occurs because the flood water cannot be drained into rivers. Flood caused by inside water is usually shallow and there is no risk of losing many lives. The 2006 Halcrow Report 2006 claims that an inundation due to drainage failure that causes damage to properties is brought about by a deluge having probability of occurrence once in ten years.

A recent case of inundation by inside water affected a large part of urban Dhaka in 2004.

This occurred when rising water levels in the rivers caused Balu River in the eastern Dhaka to overflow and then flooding the lowland areas of the city. In western Dhaka, overflow from Turag River flooded the inside land through culverts and opened regulators.

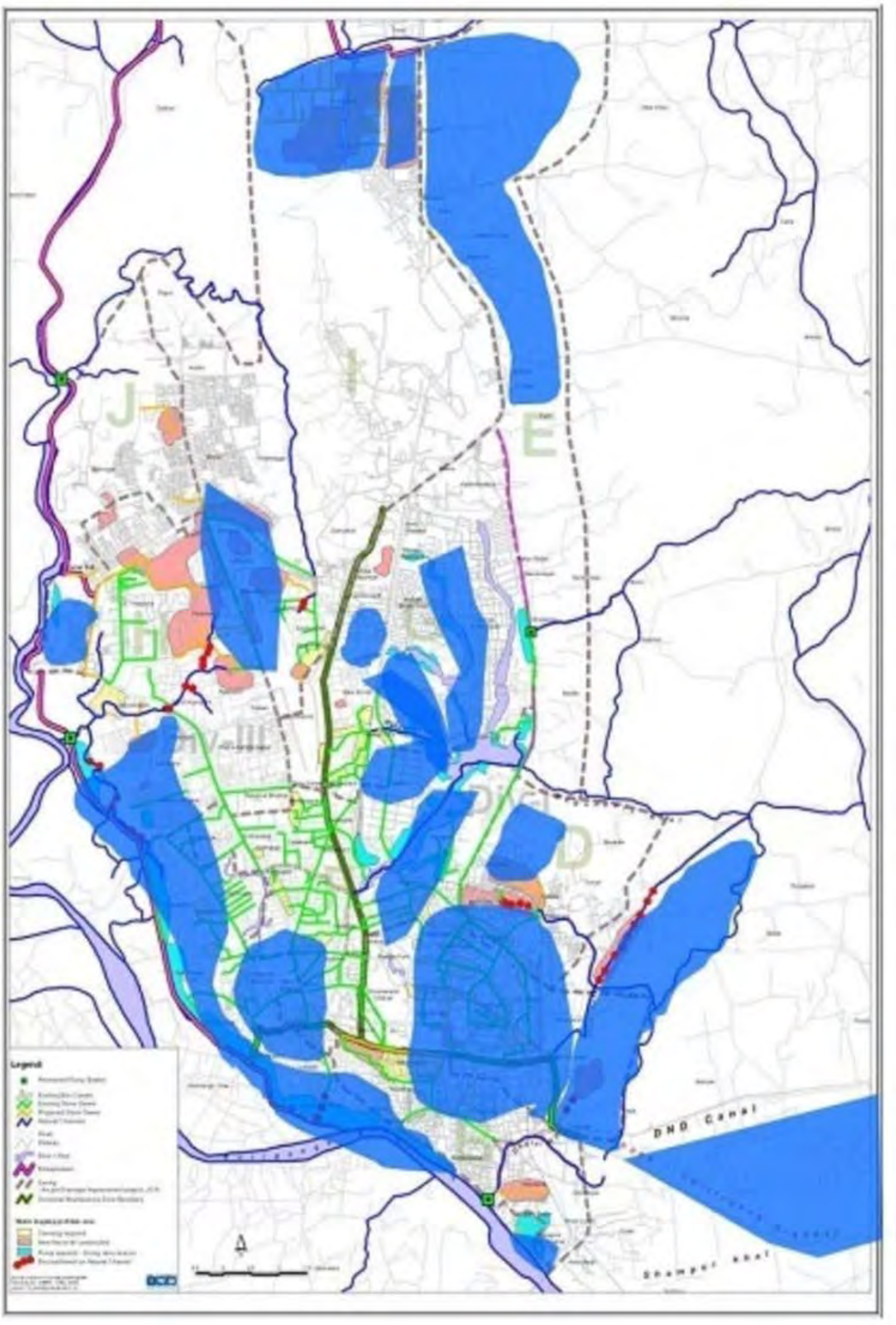
The inundation damage by inside water was caused by an intense rainfall in Dhaka when the regulator was closed so as to protect the urban Dhaka from the flooding river water.

Daily rainfall recorded in Dhaka in September 2004 when the inundation occurred was 341 mm. This means that such amount of rainfall occurred in one day exceeded the mean monthly precipitation of 284 mm recorded during rainy season (June to September) in the recent five years, and the large amount of rainwater remained in the urban area without being drained. An estimated 40% of the urbanized area in the western Dhaka was waterlogged by the inside water.



Source: Halcrow Report

Figure 2.3.5 Daily Rainfall in September 2004



Source: Survey Report (RAJUK 2014)

Figure 2.3.6 The Inundation map of Greater Dhaka, 2004

There were water channels, natural drainages, and lowland areas in and around Dhaka in the past that contributed to the retention and discharge of rain water. However, rapid sprawl of the urban district in recent years has decreased the water retention areas, leading to a loss of water-retaining capability of the urban district. In addition, haphazard urban development carried out in disregard of the topography coupled with the failure of timely building storm water drainages and negligence of maintenance services has been aggravating the problem of rainwater remaining in the urban district.

Rain water that remains over an extended period of time not only causes inconvenience to the residents' lives, traffic, and other activities, but also environmental and hygienic problems such as odor and health hazards.

Source: Survey Report (RAJUK 2014)

Figure 2.3.7 Water Logging Condition (Purba Jurain of Dhaka City)

Source: JICA Study Team

Figure 2.3.8 Street without Drainage (left) and Drainage Clogged with Garbage (right)

2) Flood control policy of Dhaka City

The flood control policy of Dhaka City was established as part of FAP in 1990s with the idea of preventing inundation by river water through building an embankment and draining rain water from the urban area by pumping. The flood control policy is intended to prepare for disasters with a probability of occurring once in one hundred years. Construction of the storm water drainage system in the city, on the other hand, was planned for disasters with a probability of occurring once in five years.

Under this policy, the western embankment (with a crown height from 7.5 to 10 m) and three pump stations (with a total discharge capacity 44.5 m^3/s) are now under construction. In the existing urban district, there are retarding basins, such as Gulshan Lake, and a new one was built in Tejgaon district to receive and retain drained rain water.

With regard to the embankment and the pump stations on the eastern edge, revision and F/S of the plan were completed, but the prospect to commence construction has not been obtained. Currently, DIT Road serves as a flood protection line and functions as an embankment that prevents overflows from rivers in the east from infiltrating the city (height of road surface is said to be around 8 m). For this reason, channels that cross the DIT Road are equipped with gates while two have pumping stations built alongside.

In the central part of the city, a project is now being implemented to construct a multipurpose waterfront that includes flood control.

3) Challenges facing the flood control policy in the eastern Dhaka development project

Dhaka is one of the most densely populated cities in the world. The trend toward nuclear families also makes it increasingly difficult to meet the demands for housing within the existing urban district. To tackle this problem, projects to develop housing lands have been carried out by the public and private sectors, making the urban district continue to sprawl. There has been a restriction on housing development in the eastern part of Dhaka because it is a lowland with elevation of 5 to 6 m. However, demands for housing development in this district have been growing because it is located near the urban district.

The most challenging about the housing development in the eastern part of Dhaka is the need for flood control measures. As described above, a project to construct embankment and reservoirs to keep inside water and pumping stations was put into place in the eastern Dhaka under the revised Eastern Bypass Study (2006). The following problems have been pointed out for this project.

(1) Setting the embankment crown height

In the past inundations, water levels in the three major rivers rose to 15 m or higher and Buriganga and Balu Rivers that surround Dhaka rose to almost 8 m. Since the ground height in eastern Dhaka is about 5 to 6 m, it was feared that building the embankment with a crown height of 8 m would lead to increased flooding energy in the event of dyke break, resulting in significant damages.

(2) Timing of embankment construction

Risk of inundation damage increases if building of an embankment lags the urban development works, If building of embankment in the downstream proceeds ahead of building in the upstream, overflow from the upstream would be prevented by the downstream embankment from returning to the river, so as to be retained in the inside over an extended period of time.

(3) Protection against bank erosion

The embankment should be protected with revetment installed over the height range of the varying water level. River sand will be used as embankment material when the actual conditions surrounding the project are considered. If this is the case, the surface behind the revetment must be installed with a soil draw-out prevention material to prevent the sand behind the revetment from being drawn out, giving rise to the danger of collapsing revetment and fragile embankment.

(4) Drainage of inside water

Building an embankment makes it difficult to drain the inside water. To drain the inside water, it is necessary to install pumps, sluice gates, and other facilities. Well-defined rules for operating these facilities and a reliable system must be put in place that can ensure correct operation and management of the facilities.

(5) Loss of wetlands

Eastern Dhaka has wetlands scattered that are valuable, not only for flood control as buffer and water retention in case of river overflow, but also for their contribution to the preservation of diversity in the natural environment. Water in the wetlands comes mainly from the overflow from rivers, ground water, and rain water. Construction of embankment would stop the harmless, ordinary flooding (barsha) from occurring; thus, causing wetlands to diminish and weaken their functions with the supply of water and fishes from rivers interrupted.

4) Development in eastern district by landfill

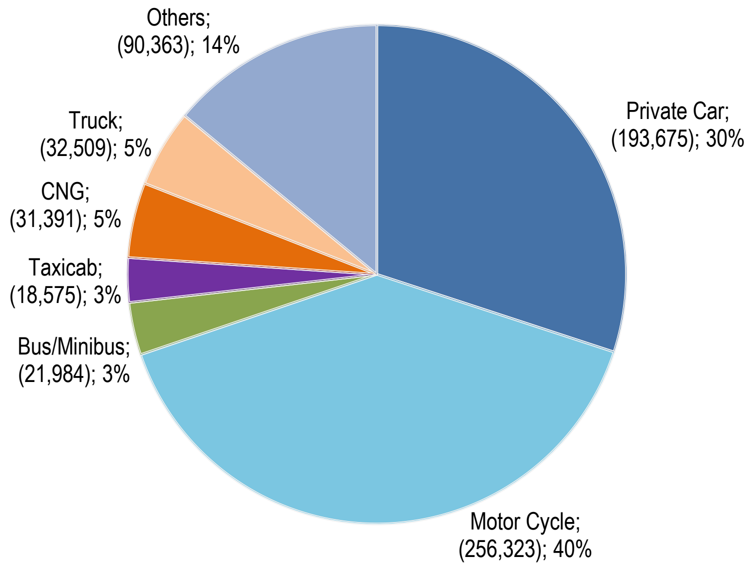
First Dhaka Eastern Bypass study was undertaken in 1998 under World Bank Technical Assistance. The study was updated in June 2006 with a new name “Updating/Upgrading the Feasibility Study of Dhaka Integrated Flood Control Embankment cum Eastern Bypass Road Multipurpose Project.”

Its main objective is to provide flood protection for the eastern part of Dhaka to mitigate damage and loss as a result of flooding by the Balu River and from internal flood water. The project will also deliver transport benefits, but they are secondary to flood defense. Total project cost in 2005 constant prices and excluding physical contingencies was estimated at BDT19 billion ($233 million) in the report.

2.4 CURRENT URBAN TRANSPORT SYSTEM

2.4.1 Introduction

At present, major modes of transport in GDA are motorcycles, private cars, microbuses, trucks, minibuses, and taxis. The number of registered public transport is quite less compared to private transport. In this section, various types of existing transports and performance as well as issues on public transport system in GDA are described.



Source: BRTA

Figure 2.4.1 Share of Total Newly Registered (2001–2013) Vehicles in GDA

2.4.2 Pedestrian & Non-Motorized Transports

1) Pedestrian

Walking is the common mode of transportation of the majority of people in Dhaka City. According to DHUTS in 2009, almost 20% of the people in the city walk. One of the reasons to some of the people is the financial incapability to use public transport. Also, quite a lot of garment workers commute to factories in the morning and by foot in the evening. Some people walk to access public transport like buses.

Even though a large share of people are pedestrians, facilities for pedestrians are not properly ensured. Convenience is not considered for the pedestrians whenever a road or an intersection is constructed or renovated in Dhaka City. There are around 66 pedestrian foot-over bridges and 4 underground pedestrian crossings in the city to ensure safe crossing of the users. In some locations, pedestrians attempt to cross the road with many motorized vehicles due to insufficient facilities for crossing. However, it has been also observed that some pedestrian foot-over bridges are not being used by pedestrians.

There are several on-going projects under DCC that focus on pedestrian walkway improvement. As a matter of fact, construction of footpath already start before construction works for drainage pipe installation, internet cable installation, etc. However, some of the re-constructed footpath are improperly done like unlevel construction with rough surface where children and elderly people find difficult to walk on. In Bangladesh, there is hardly any consideration for the handicapped in their footpath designs. This calls for a development of barrier-free walkways or crossing facilities. Moreover, footpath's height practically varies from 15 to 60 cm as there is no predetermined height of the walkway. In March 2014, Dhaka North City Corporation (DNCC) inaugurated the construction of the first ever foot-over bridge with escalator (upward direction only) in Bangladesh located at the intersection of Banani Road Number 11 and Airport Road. DNCC has a plan of constructing seven more of this bridge type if they get a positive outcome.

2) Bicycle

Bicycle is a useful and environment-friendly transport, which plays an important role as access for commuting in developed countries. However, only 2% bicycle trips were found on arterial roads in Dhaka City. In the past, bicycle was used mostly in rural areas to commute to school and to office. Due to religious conservativeness, many women still do not use a bicycle.

Some problems of using bicycles in Dhaka City are:

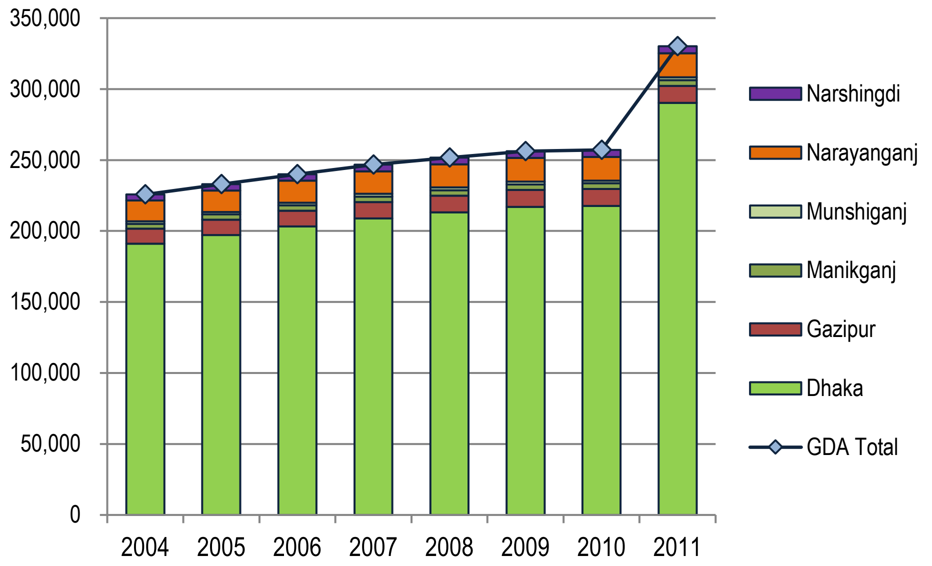
- Absence of dedicated bicycle lane that makes biking quite dangerous.
- No parking facilities for bicycle that makes it difficult to use even to access other modes of transport.
- Possibility of theft due to lack of parking facilities.
- Due to high initial cost of a good quality bicycle (approximately BDT15,000), it is an unaffordable to low-income people.

3) Rickshaw

Dhaka City is known to be a city of rickshaws. The registered number of rickshaws in the city, according to DNCC and Dhaka South City Corporation (DSCC), is around 100,000.[1] In many reports, it has been published that quite a number of unregistered rickshaws operate in Dhaka. Nobody actually knows the exact number of rickshaws that run in the city. The total number of registered rickshaws from 2004 to 2011 in the urban area of GDA is 330,143.[2] Out of all the districts of GDA, Dhaka holds 88% of the rickshaws while Narayanganj and Gazipur districts come in second and third, respectively.

[1] DHUTS.

[2] Statistical Yearbook of Bangladesh 2010 and 2012.



Source: Statistical Year Book of Bangladesh 2010 and 2012, BBS

Figure 2.4.2 Trend of Registered Rickshaws in the Urban GDA

People in Dhaka City mostly use rickshaw for travelling short distances of 1–3 km, and students and businessmen use more than 90% of these rickshaw trips.[3] The share of trips made by rickshaw was 38% in 2009.

4) Others (Rickshaw van, Thela etc.)

In GDA, many people use rickshaw van and *thela* to transport goods due to low fare charges. Rickshaw van or *thela* is a better option for people if they need to transport small amount of commodities; however, Dhaka Metropolitan Police restricted their use. According to DCC, there are around 8,000 registered rickshaw vans in Dhaka City.[4] The number of *thela* is not available as there is no registration system for this transport. It has also been observed that rickshaw vans were used as a temporary vendor shop for vegetables, chickens, etc.

2.4.3 Private Car, Motorcycle& Truck

1) Private Car

In GDA, private cars are mainly classified into three types: sedan car, four-wheeled jeep, and 6- to 10-seater microbus. Basically, private cars are used by middle- and high-income people with some families that own more than one vehicle. Although private cars were accounted for about 30% of vehicle share in Dhaka in 2010, the occupation rate of private cars has decreased by about 23% in 2016. However, the number of private cars has increased, and one of the increase is the low operating cost by using compressed natural gas (CNG). Since CNG is being produced locally, its cost is quite low compared to other types of fuel like octane that needs to be imported. According to Navana CNG, a renowned CNG conversion company in Bangladesh, 1 m^3 CNG is equivalent to 1.23 L of octane. Considering the over-all cost, (assuming yearly travelling distance of 60,000 km) a 1800 CC CNG driven-sedan car can save around BDT0.30 million every year.

[3] DHUTS

[4] Rickshaw Cycle Drivers in Dhaka: Assessing Working Conditions and Livelihoods.

Table 2.4.1 Number of Registered Motor Vehicles in Dhaka by Year

Type of Vehicles	Up to 2010	2011	2012	2013	2014	2015	2016	Grand Total
Ambulance	1,374	137	114	190	254	358	321	2,661
Auto Rickshaw	7,664	112	111	60	56	428	721	8,972
Auto Tempo	1,662	1	1	0	0	0	0	1,664
Bus	16,783	1,501	1,218	971	1,364	2,221	3597	26,756
Cargo van	3,231	477	278	676	603	398	908	6,344
Covered Van	4,277	1,910	1,170	1,850	2,352	1,855	2,485	15,278
Delivery Van	11,990	839	577	709	901	1,464	1,902	17,907
Human Hauler	2,718	569	145	115	109	502	870	4,811
Jeep(Hard/Soft)	19,520	1,698	1,241	1,107	1,582	3,109	4,457	31,600
Microbus	46,202	3,540	2,643	2,227	3,842	4,569	5,433	67,098
Minibus	9,490	136	103	83	135	103	153	10,165
Motor Cycle	210,081	34,708	32,810	26,331	32,894	46,764	52,178	422,722
Pick Up (double/single cabin)	20,481	7,258	5,149	4,908	7,295	7,916	8,176	59,139
Private Passenger Car	163,004	11,423	8,187	9,231	12,972	18,422	18,588	237,180
Special Purpose Vehicle	759	60	28	78	50	66	217	1,204
Tanker	817	152	90	136	163	146	173	1,634
Taxicab	36,011	52	43	4	302	54	1	36,467
Tractor	9,923	4,169	2,841	1,634	1,443	1,637	2,528	23,543
Truck	26,922	4,205	2,824	3,522	5,767	4,424	4,370	50,942
Others	168	0	0	660	967	1307	2233	47
TOTAL	593,077	72,947	59,573	54,492	73,051	95,743	109,311	1,030,864

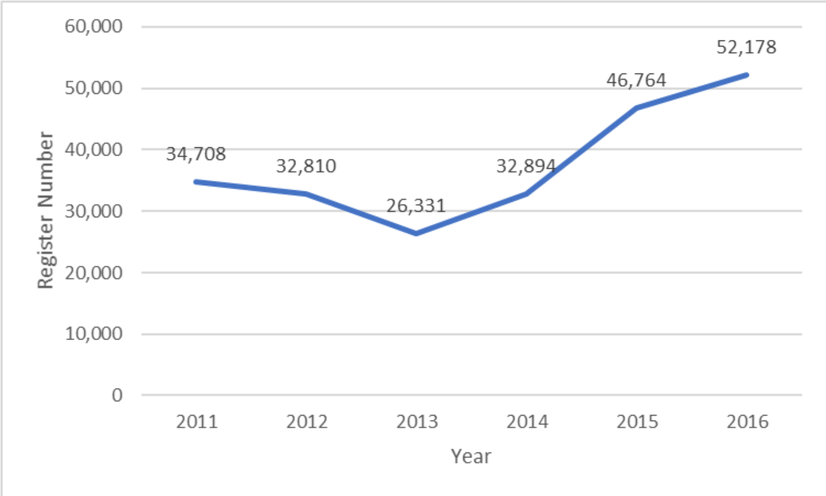
Source: BRTA(2017)

The government is trying to control the number of these types of vehicles by imposing different types of duties and taxes since 2009. There was a restriction on importing reconditioned cars of that are more than 5 years old. Importing reconditioned car duties are applicable depending on its age. To import a car in Bangladesh, several types of taxes are imposed such as import duty (5%), value added tax (15%), advance income tax (5%) and advance trade vat (3%). Aside from these, a supplementary duty is also applied that varies from 30% to 500% depending on vehicle type, engine capacity, etc. Therefore, over-all tax burden in importing a private car may vary from around 100% to 600% that is the reason of the sudden decline in the number of newly registered private cars since 2010.

2) Motorcycle

Motorcycle is becoming a popular mode of transport in Dhaka City as it can be driven through a narrow space and considered a useful transport to reach the destination in the midst of the city’s traffic congestion. Its fuel consumption is quite low compared to other private vehicles.

The number of registered motorcycles has increased from 2013 to 2016 sharply. Bangladesh used to import motorcycles like Honda, Yamaha, etc. from Japan, but most of the motorcycles recently are imported from India and China. There are few local companies like Walton and Runner that assemble motorcycle parts and sell at lower price. In 2011, the government increased up to 45% the supplementary duty of importing a complete unit of motorcycle that resulted to a decreasing number of new motorcycles. The government initiated a policy to encourage motorcycle assembly industry, but most people prefer an imported motorcycle.

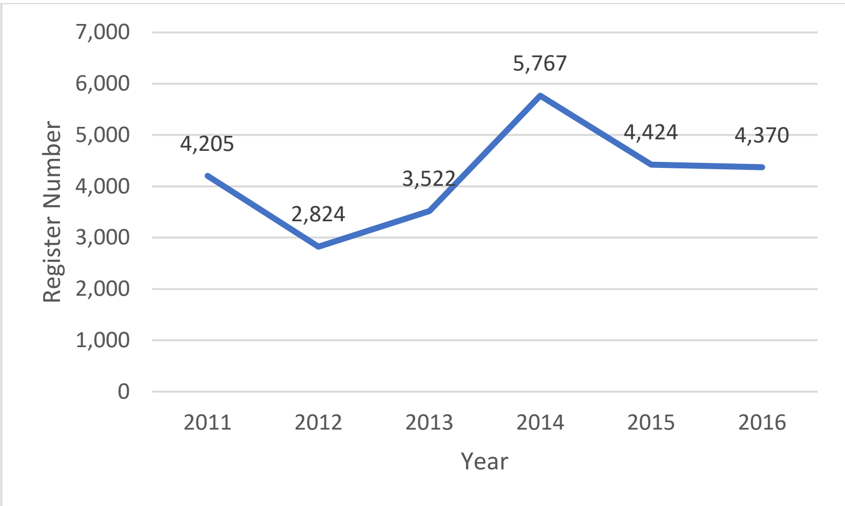


Source: BRTA

Figure 2.4.3 Trend of Yearly Newly Registered Motor Cycles in Dhaka

3) Truck

Truck is an important mode to transport goods within the districts of Bangladesh. In 2004–2005, modal split of freight transportation was around 90% by road whereas only 3.7% by rail and 6.5% by water between two most important districts of Bangladesh: Dhaka and Chittagong (Source: DHUTS). There are different types of trucks in Bangladesh depending on carrying capacity: 1.5 ton, 3 ton, 5 ton and 10 ton. Aside from these trucks there are also covered van and trailer truck which are used for carrying containers. These vehicles are operating within Dhaka, Chittagong and other major districts to transport goods.



Source: BRTA

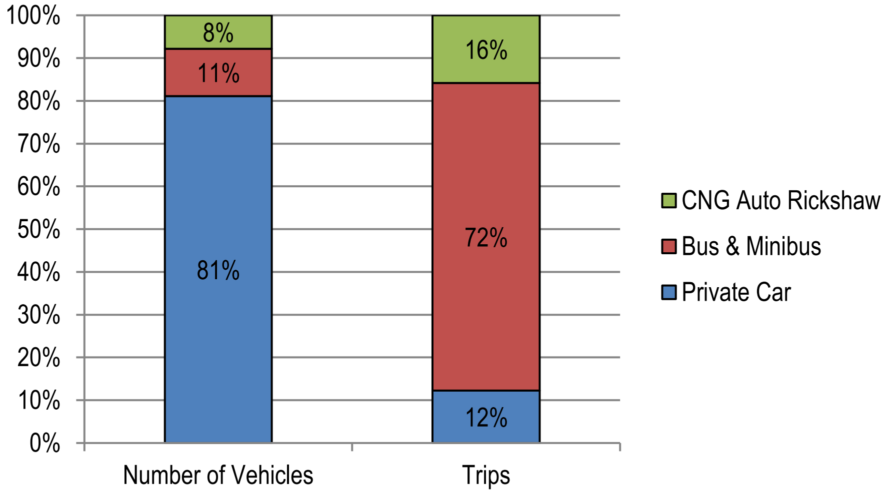
Figure 2.4.4 Trend of Yearly Newly Registered Tracks

The number of truck trips within Dhaka city is increasing every year. In 2009, a total of 28,706 trips were calculated within 24 hours (Source: DHUTS). Due to traffic congestion, Dhaka Metropolitan Police issued an order last July 2012, restricting trucks from entering

Dhaka city on a specified time table, thus trucks can only enter inside DMP area between 21:30 and 8:00. Meanwhile, DMP provides special permission to some trucks considering national importance like carrying government products. Trucks involved in construction work for government infrastructure projects are also allowed anytime inside the city. While trucks carrying export products can anytime use DIT road of Dhaka for going out and entering the city.

2.4.4 Public Transport

Main mode of public transport in GDA are bus, human hauler, train, water vessel, taxi cab, CNG and rickshaw. Recently, a new type of vehicle locally known as 'easy bike' which is basically battery operated rickshaw is also included to the public transport fleet in some areas.Trips by private cars, different types of buses and CNG in 2009 are shown with registered vehicles of each type. Buses and minibuses are generating 72% of person trips with only 11% of the share in registered vehicles.



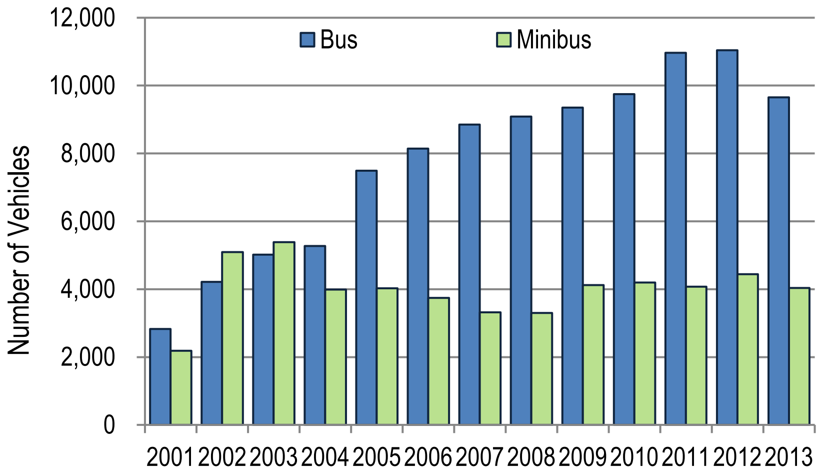
Source: DHUTS & BRTA

Figure 2.4.5 Modal Share and Generated Trips of Motorized Vehicles in 2009

1) Bus and Minibus

Currently, bus and minibus are the main mode of transport for dwellers of GDA. The number of bus routes is increasing every year to meet the travel demand of the people. However, the number of trips is still insufficient to meet the present demand. One of the reasons of low bus trips in GDA is inability to complete the planned daily trips due to traffic congestion.

According to Bangladesh law, 'Mini-bus' means any motor vehicle constructed or adapted or used to carry not more than 30 persons excluding the driver. If the number of passengers exceeds 30 persons excluding the driver then it is considered as bus. The number of registered buses is increasing than the mini-buses. In 2003, minibus has a bigger share compared with bus however the number has totally changed as the government encourages the introduction of large buses into the public transport system of Dhaka. In particular, importing of CNG driven buses has been encouraged in the national budget for the last few years.



Source: BRTA

Figure 2.4.6 Difference of Bus and Minibus

In Dhaka City, there are three inter-district bus terminals where buses depart towards different districts of Bangladesh: Sayedabad, Mohakhali, and Gabtoli. Aside from these, in Gulistan there is a bus stand where passengers can take buses towards south east direction from Dhaka. Some inter-district buses also start from Fakirapul, Kalabagan, Kallayanpur and Abdullahpur (near Uttara). Ten years ago, all inter-district buses were allowed to enter Dhaka city and take passengers from these locations. But presently bus companies provide mini-buses to carry passengers from here to main terminal. There is no designated bus terminal for city buses in Dhaka city which creates traffic hazards as most of the buses are parked along the road. Meanwhile, BRTC has five bus depots in different location of Dhaka city.

Table 2.4.2 Summary of the Inter-District Bus Terminals

Name	Area	Capacity	Daily Trips	Number of routes
Sayedabad	App. 40,500m^2	App. 500	App. 2000	87
Mohakhali	App. 36,400 m^2	App. 300	App. 800	60
Gabtoli	App. 123,400 m^2	App. 700	App. 2200	61

Source: DNCC, DSCC, & BRTA

2) Human Hauler

Human hauler, which is smaller than buses, is another type of public transport in Dhaka. Like for bus regulation, BRTA also issues route permission to human hauler services. As per BRTA records (March 2014), there are 106 planned routes for human haulers within Dhaka City and, out of these, only 34 routes currently operate with at least 1,733 human haulers on service. Different types of human haulers are Tempoo, Bondhuparibahan, Laguna, Champion, etc. Seating capacity of Tempoo and Laguna is around 10 to 12 persons while Bondhuparibahan and Champion have 14 to 20.

3) Train

Cost and safety are the two main reasons why Bangladeshi use train. Train's fare is cheaper than that of buses and it is considered as a safer mode of transport since the number of accidents and casualties is lower compared to buses. However, some people are hesitant to take the train due to sudden delay as most of the rail network in Bangladesh is single track. If any accident occurs, all train operations are affected.

Train service of Bangladesh is basically divided into categories intercity and mail. Commuter train is listed under mail train. These trains have several types of seating capacity depending on the route and train. Most exclusive one is the air-conditioned room which has sleeping arrangement and fare is almost 13 times higher than the cheapest class on the same route.

In GDA, people of Gazipur and Narayanganj use train quite often for commuting to Dhaka city. At present, a total 16 pair of commuter trains between Dhaka and Narayangonj and 4 pairs of commuter trains between Dhaka and Joydevpur are operating on weekdays. Between Dhaka and Joydevpur there are also other trains carrying passengers from Dhaka to Joydevpur. However, these trains do not stop at all the stations.

Table 2.4.3 Summary of Commuter Train Fare of RAJUK Area

Commuter Route: Dhaka (Kamalapur) –Joydevpur					
From	To	Distance	Regular Fare	Special Fare	Stations
Kamalapur	Airport	22 Km	10 Taka	BDT35; Intercity Train*	Tejgaon, Dhaka Cantonment
Kamalapur	Joydevpur	39 Km	15 Taka		Tejgaon, Dhaka Cantonment, Tongi, Dhirasram
Commuter Route: Dhaka (Kamalapur)–Narayanganj					
From	To	Distance	Regular Fare	Special Fare	Stations
Kamalapur	Cahra	14.5 Km	8 Taka	BDT15; Diesel Electric Multiple Unit (DEMU)Train	Gandaria, Fatullah
Kamalapur	Narayanganj	16.1 Km	10 Taka		Gandaria, Fatullah, Cahra

*Intercity trains do not stop at all the stoppages

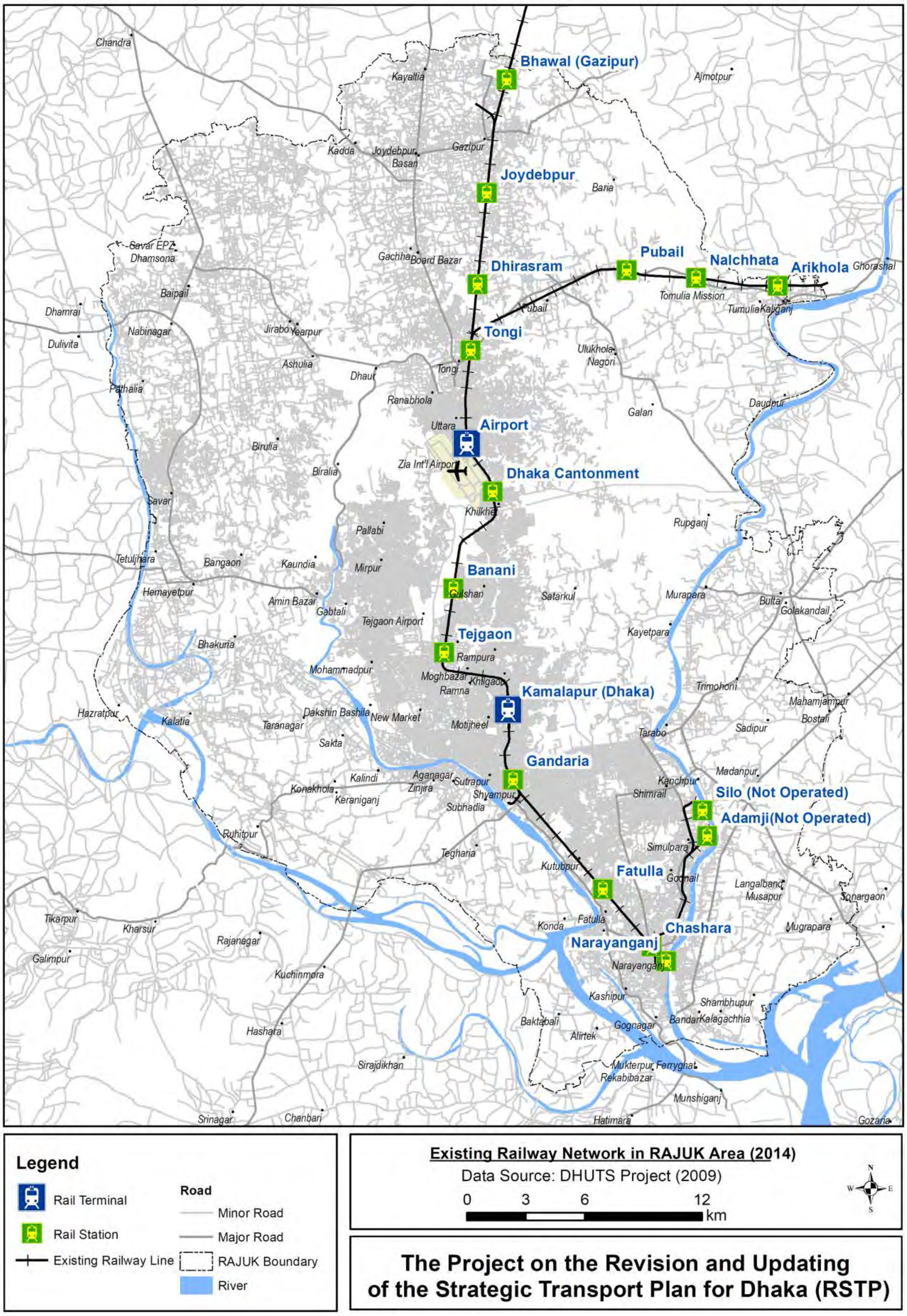


Figure 2.4.7 Existing Railway Network in RAJUK area

4) Water Transport

In Bangladesh, transport via water plays an important role, particularly for people from the southern district who uses different types of water transports like launch, ferry, steamer, etc. to come to Dhaka.

All long-distance water vessels towards Dhaka arrive at the main water terminal called Sadarghat. At present, there are 48 different long distance routes from Sadarghat to other districts in Bangladesh. Out of these 48 routes, 3 are for both private- and government-operated water vessels, 7 are only for government-operated vessels, and 38 are for private-operated water vessels. Bangladesh Island Water Transport Authority (BIWTA) is responsible for issuing the route permit and fare regulation, while Bangladesh Island Water Transport Corporation (BIWTC) is responsible for operating government-owned water vessels.

5) Taxi cab

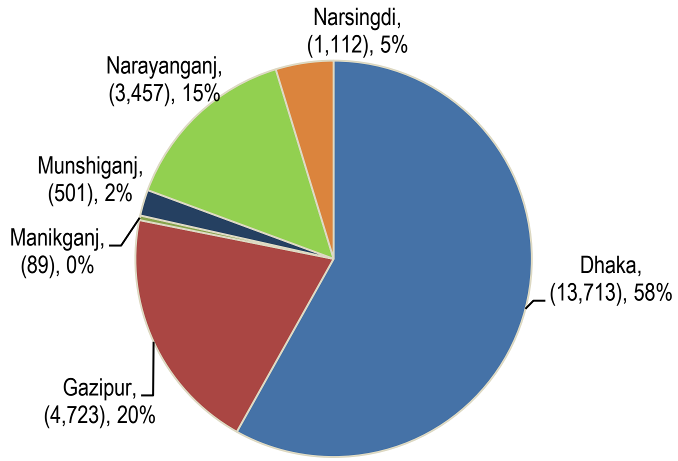
Taxi-cab service launched in Dhaka City almost 16 years ago. The two types of taxi cabs are airconditioned (A/C) and non A/C. All the A/C taxicabs are yellow-colored and the non-A/C cabs are black- or blue-colored. Most of the old taxicabs are in very poor condition, low service quality, and/or mostly are non A/C. Many of the old taxi cabs are now already off-road due to poor maintenance service. Some dilapidated cabs are still running in the roads with a pale gesture. As per BRTA, there were around 9000 taxi-cabs in Dhaka City in 2013.

In April 2014, a new taxi-cab service was introduced in Dhaka City under Trust Transport Services and Toma Group. These taxi-cabs have different types of modern features such as: A/C, radio communications, video recording, automatic vehicle tracking, on-call service, receipts, etc. However, the fare of this service is more expensive than any other public transport services in the past.

6) ”CNG” (Three-wheeler Auto-Rickshaw)

Three-wheeler auto-rickshaw plays a vital role in the public transportation system of Dhaka. Basically, the two major types of rickshaws are compressed natural gas-powered (CNG) rickshaws and Mishuk. Mishuk is a special type of three-wheeler made in Bangladesh and driven with petrol. Nowadays, Mishuk has become very rare. A maximum two persons can sit comfortably in Mishuk while three persons can in a CNG.

Before 2002, there were around 40,000 auto-rickshaws driven by two stroke petrol engines and was known as “baby-taxi.” Due to the huge air pollution emitted by a baby-taxi, the government decided to have it replaced. In 2002, the Government of Bangladesh introduced 12,000 three-wheelers in Dhaka City that will run using CNG. The three-wheeler auto-rickshaw is now known as “CNG.” It will also be used in this report to describe this type of vehicle, since it is driven using CNG. In 2013, there are around 23,500 CNGs that operate in GDA as per BRTA. Around 14,000 units are registered in Dhaka district, while Gazipur and Narayanganj also have significant numbers of CNG among the other districts of GDA.



Source: BRTA

Figure 2.4.8 Share in CNGs (2013) among GDA Districts

The life span of CNGs was predicted 8 years from the time of introduction. However, in 2011, the government extended the life span by another 3 years and was supposed to have ended in 2013. But due to some protests from the owners and drivers, the government decided to increase the life span to 15 years unless the vehicle meets the conditions set by Bangladesh University of Engineering and Technology (BUET). These conditions are full-overhauled engine, replacement of hood cover and seats, necessary repairs of body, and suspension and break transmission.

CNGs are basically owned by an individual unlike the taxicab. The owner leases his CNG to a driver for 8 hours and can officially charge 600 takas, but most drivers complain that they have been charged 800 to 1000 takas. Another common practice by CNG owners is to lease the CNG to two different drivers in a day for an 8-hour shift that will make him earn twice from the same CNG.

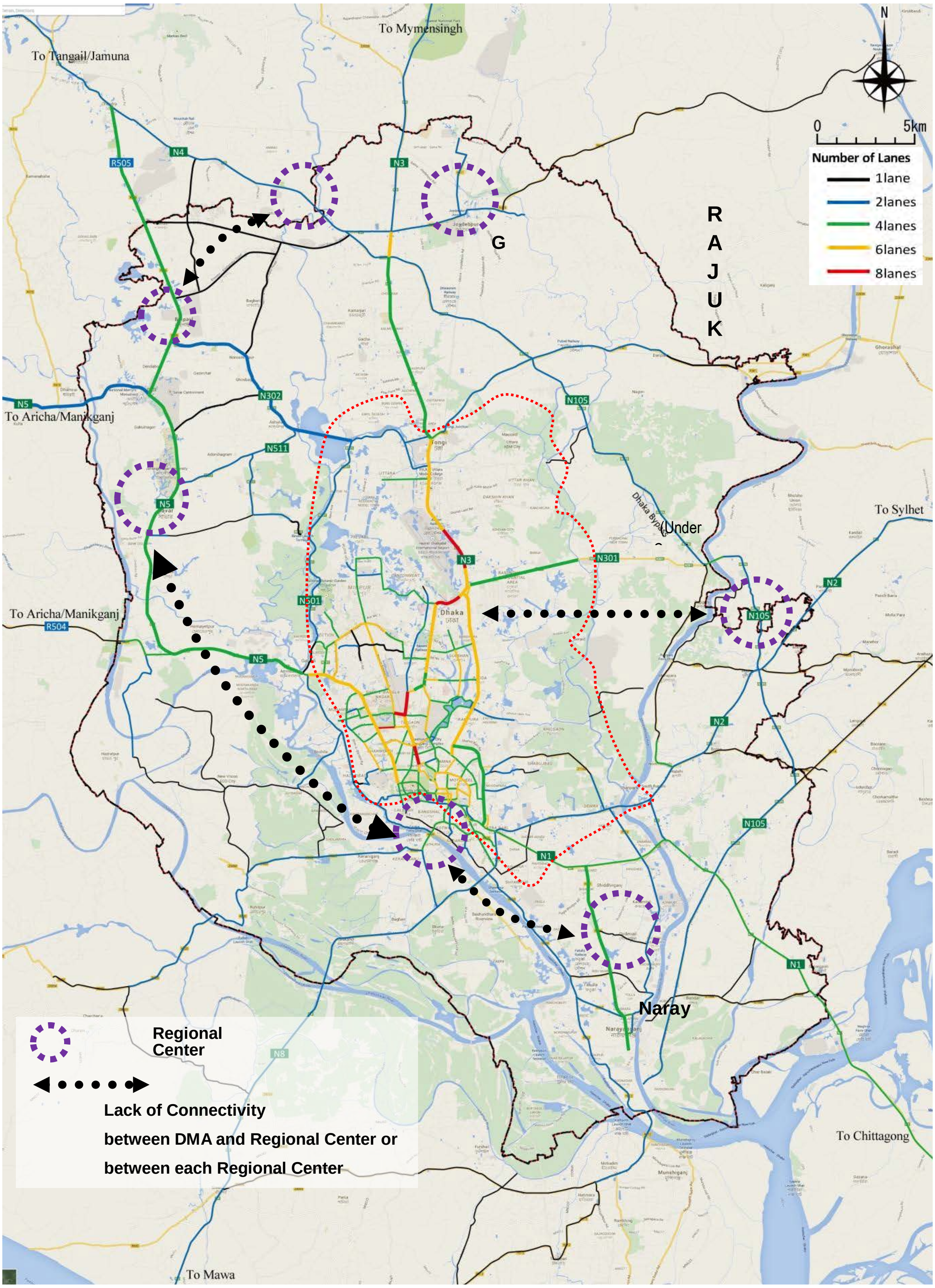
2.4.5 Urban Road Network

The road network system in the study area can be divided into two major areas as shown in Figure 2.4.10. One is the urban network that serves the traffic movement among the urban centers (DMA). The other is the regional network that serves regional traffic movement in the suburban area (RAJUK area out of DMA).

DMA is situated in the middle of RAJUK surrounded by Buriganga, Turag, and Balu Rivers. Although the major roads in DMA are multi-lane and the current pavement conditions are generally good as reported in DHUTS, there is still severe traffic congestion due to insufficiency of functional road classification, some missing links, and inadequate traffic management.

As for the road network in the suburban area, its road density is lower than in the urban area and connectivity to some adjacent regional centers is unavailable. Such situation is assumed to hamper regional partnership and to promote intense concentration of population and advanced urban functions to DMA.

Although Bangladesh governments formulated policies to resolve problems, such as exclude rickshaw from specific areas and restrict entry on cargo vehicles, the effect of policies is limited due to lack of implementation. Therefore, it is necessary to impose alternatives to road transportations.



Source: JICA Study Team

Figure 2.4.9 Major Road Network in RAJUK Area

2.4.6 MRT Line 6

1) Background

JICA conducted the Dhaka Urban Transportation Network Development Study (DHUTS) Phase 1 in March 2009 with the DTCA as its counterpart agency. The study's objectives were to conceptualize basic urban development scenarios for the DMA up to 2025 and to select priority projects that would be integrated into the scenarios. That study recommended the prioritization of constructing MRT Line 6. As a result, JICA conducted the feasibility study on MRT Line 6 under DHUTS Phase 2. Following this study, the GOB and JICA concluded in February 2013 the loan agreement on the Dhaka Mass Rapid Transit Development Project that was the blueprint for the construction of an MRT Line 6.

2) Existing Situation

Dhaka Mass Transit Company (DMTC) was established under the Ministry of Road Transport and Bridges as the MRT Company in 2013. Since September 2014, the General Consultant has been implementing the design works and has been preparing tender documents for MRT Line 6. At the same time, Institutional Development Consultant (IDC) for the Dhaka MRT Line 6 has started.

3) Progress of Construction Work (September, 2018)

There are eight kinds of bid, six packages for civil works, one package for system, and one package for locomotive.

CP-01: contract package CP-01 is for the land development of depot area which is completed and handing over to CP-02 contractor.

CP-02: contract package CP-02 is depot civil and buildings which are stabling yard, central store for maintenance and overhauled materials, space for overhaul and train maintenance, main workshop, operation control center, train inspection, generator and electrical building, train wash station, manual train washing, multi-storied building for DMTC head office, and green space. Presently, construction of retaining, sonic logging test at test pile, check boring, static load test on test pile, service pile, permanent pile and raft construction of building are going on.

CP-03 and 04: construction of viaducts and nine elevated stations between Uttara North and Agargaon and boring, construction of permanent pilling, pile cap, column and pier head, and precast segment are going on all along the corridor.

CP-05 and 06: package CP-05 is for the construction of viaducts and elevated stations from Agargaon to Karwan Bazar and package CP-06 is for the construction of viaducts and elevated stations from Karwan Bazar to Motijheel. The contractors have been taken access to and possession of the site and construction yards is under construction.

CP-07 and 08: package CP-07 is for electro-mechanical system and CP-08 is for rolling stock & depot equipment. Contractors are discussing about demarcation of communications system with PDCB, ESS dimensions and interface issues. The CP-08 contractors are discussing with CP-02 and CP-07 teams and reviewed the progress.

The periodic monitoring, reviewing, reporting of Environmental and Social Environment (WG-6) of CP-02, CP-03 & 04 is going on.

2.4.7 BRT Line 3

1) Background

The BRT Line 3 corridor project in Dhaka is under the Greater Dhaka Sustainable Urban Transport Project (GDSUTP). Asian Development Bank (ADB) sponsored the BRT route of the northern section that connects Gazipur and Uttara (international airport). World Bank sponsored the BRT route of southern section that connects Uttara (Airport)–Mohakhali–Ramna–Gulisthan–Keranigonj (Jhilmil). BRT Line 3 corridor in Dhaka has different sponsor, however. It is a single BRT route that connects the northern and southern areas. So, BRT Line 3 corridor must have a design with an equal service pattern for public transit users. The completion date should have been in 2016. Planning and joint implementation should be coordinated, and the northern and southern projects should become one BRT system upon completion.

Therefore, considering coordinated BRT system, this detail design work for BRT Line 3 corridor (Airport–Keraniganj) will have to be the service pattern with same bus fleets and same infrastructures such as bus-way, station, and etc. However, after preparation of detail design, the project was out of project list by the World Bank because of the proposed RAJUK Flyover Project. It made the BRT Line 3 Project impossible to be implemented at the same transport corridor.

2) DTCA Proposal

In this situation, DTCA made a proposal to World Bank to implement the project under phasing with the justifications. The proposed phases were as follows:

<u>Phase 1:</u>

Airport to Mohakhali section: Construction of 10-km BRT corridor from airport to Mohakhali including construction of five BRT stations, Mohakhali flyover, Mohakhali terminal, and Keraniganj Depot. Prepare and implement shuttle service plan from Mohakhali to Keranigaj (Jhilmil).

- Construct airport to Mohakhali.
- Construction of Mohakhali and Keraniganj Depot.
- Commence BRT service.
- Establish Shuttle service.

<u>Phase 2:</u>

Mohakhali to Gulistan section

- Construct Mohakhlai to Gulistan.
- Expand BRT service.

<u>Phase 3:</u>

Gulistan to Jhilmil section

- Construct final stage to Jhilmil.
- Operate full BRT service.

3) DTCA's Justifications

- It is a proactive measure to manage traffic and travel demand during BRT construction that demonstrates good planning and management initiative during the traffic chaos due to BRT construction. Public opinion of the BRT project is likely to be improved.

- Provides an essential transport connection to Mohakhali and Farmgate should the ADB BRT northern section of the airport be completed earlier than the World Bank section.
- A traffic management measure during BRT construction is to offer motorists a good alternative than be stuck in traffic and introduce the use of the bus service prior to BRT.
- Allows restrictions to be placed on cars on the basis that good public transport alternatives are provided (with traffic priority for buses).
- The interim shuttlebus service will pilot key elements of the BRT such as establish system management (the BRT Co.), engage operators under contract, initiate fleet procurement, and commission the system.
- Triggers early engagement with affected bus operators and establishes the operations of the future BOC consortium of BRT Line 3, introducing them to a performance-based contract regime prior to start of BRT.
- Establishes the operations of the BRT company; giving them a trial run in bus operations, providing services and managing contractors.
- Facilitates an early introduction of e-ticketing system prior to BRT with revenue collected by the Dhaka BRT Co. (BOC is paid on km basis) giving the BRT Company time to familiarize and trial the system.

4) The Mission

In this context, a World Bank team carried out an Exploratory Mission for the proposed Dhaka BRT Line 3 on 23–27 April 2017. The main objectives were to assess the modified project proposal from the original proposal in 2013, namely on the line length and the arrangement for the implementing agencies, and to understand if the new proposal is technically sound and if an effective coordination mechanism is in place for the stakeholder agencies.

5) The Features of the Project

The mission identified the following features of the new proposed proposal:

- Corridor. The proposed project is for the Phase 1 section (10.5-km from airport to Mohakhali) of the BRT Line 3 corridor. The Line 3 Corridor was originally proposed in the Strategic Transport Plan (STP) that was developed with support through the WB-funded Dhaka Urban Transport Project (DUTP) and approved by the government in 2008. The corridor is also included in the Revised Strategic Transport Plan (RSTP), approved during the August 2016 Cabinet meeting as a part of 2 BRTs and 6 Mass Rapid Transit (MRT) networks.
- Connection with BRT Line 3 North. The Government of Bangladesh is in the implementation phase of GDSUTP that is funded by ADB, AFD, and GEF. The GDSUTP ‘will contribute to developing a sustainable urban transport system in DNCC and Gazipur City Corporation (GCC) areas, which form part of north Greater Dhaka, through the delivery of a 20-km BRT corridor; BRT line 3-North will start from Gazipur BRT Line 3-North and Line 3-South is connected at the airport station. The plan is to have a single operation for the entire corridor with buses operating continuously across Airport Station, managed by the same Dhaka BRT Company.
- BRT Operation. The Line 3 Corridor will run articulated 18m-long buses on the dedicated lane by the median. The BRT lanes will have physical barrier (high-curb or

fencing) to prevent mixed traffic and pedestrians from coming in. There are seven stations (Airport, Khilkhet, Kuril, Cantonment, Kakoli, Amtali, Mohakhali Terminal), which will be on the median side and not the curve side. Stations will be accessible via foot-over-bridges or pedestrian subways with universal access or at-grade road crossing. BRT buses will run mainly at grade, but also on existing Banani Flyover (between Cantonment and Kakoli), and the proposed Mohakhali Flyover, which will be constructed in the North–South direction to the east side of the existing Mohakhali Flyover.

- Implementation Arrangement. Two project implementation units (PIUs) at RHD and DNCC were proposed and supported by project coordination unit (PCU) at DTCA. DMP will work closely with PIUs/PCU on traffic management matters and will have another PIU once its technical unit is established.
- Project Activities. Based on the request letter and preliminary discussions with the clients, the following activities were envisaged at this stage:
  - BRT Corridor Construction (implemented by RHD). At grade corridor, Mohakhali Flyover, and stations.
  - Feeder Road Construction (by DNCC). Feeder road, sidewalk, street lighting, drainage
  - Terminal and Depot Construction (by DNCC, RHD). Mohakhali Multi-story Terminal (by DNCC), Keraniganj feeder Bus Depot (by RHD)
  - Traffic Management (by DNCC for DMP, or Bangladesh Police HQ).
  - Regular Bus Restructuring (by DTCA/DNCC/RHD). Bus depot, bus stops, signs, fleet renewal -program, etc. This needs further clarification on activities and responsible agencies.
  - Studies and Technical Assistance (by DTCA).
- Project Cost: $250 million.

6) Technical Aspect

Overall, the mission found the proposed project to be technically sound and will have a significant impact in improving the traffic situation in Dhaka. While truncation into Phase 1 would pose operational challenges for the feeder bus service from Mohakhali to possible BRT passenger destinations like Farmgate and Gulistan, it is deemed feasible with the proposed number of buses and service plan. However, detailed observations of the mission on the technical aspects were as follows:

- Project Outline. The proposed construction of the RAJUK elevated road made it impossible to construct the BRT Line 3 Southern Section from airport to Keraniganj as originally planned. An alternative approach whereby the line is modified and completed in sections/phases was proposed by GOB. Funding for the first phase from airport to Mohakhali Bus Stations was requested and is the subject of this current assessment. This section is 10.5-km in length and is planned to form a single corridor with the ADB-funded Line 3 northern section that runs from Gazipur to the airport. Some of its aspects are now under construction. The original project envisaged three BRT services (S1–S3) that operate from the northern to the southern sections with two services that terminate at Gulistan and one service continue across the river to Keraniganj. A fourth service, S4, was also planned to operate between Uttara and Farmgate that joins the

BRT reserved lanes at House Building and leaving again from BG Press to travel in mixed traffic to Farmgate.

- Project Impact. The proposed project will benefit commuters that use this corridor and choose to switch to BRT. Travel time between the airport and Mohakhali by BRT is anticipated to be less than 30 minutes in contrast to the current travel time that is generally about one hour or can often be more. BRT Line 3 North and South is expected to carry about 300,000 daily passengers, most of which are likely to come from buses. As a result, bus traffic on the corridor will be greatly reduced, congestion will be reduced, and air quality will improve. The provision of safe, clean, and reliable public transport will also greatly benefit the tens of thousands of female workers at the garment factories along the corridor.
- BRT Route Truncation. As a result of the truncation of the BRT infrastructure at Mohakhali (which also has a BRT depot adjoining the BRT station at this point) all passengers on Services S1–S3 wishing to travel to Gulshan will be required to interchange to feeder buses at Mohakhali. Passengers on S4 to Farmgate will be unaffected by the truncation as the BRT ramp down from the Mohakhali elevated section will be constructed enabling the S4 to re-join the street system to travel to Farmgate. Passengers on S1–S3 who wish to go to Farmgate will interchange at Amtali to the S4 as was planned in the original design. All buses on S1–S3 will enter the Mohakhali Depot, make a turn in the depot, and re-join the BRT corridor starting again from Mohakhali Station. The S1–S3 service operates at 3-minute intervals with the S4 operating at 4-minute intervals. DCTA estimates this would require peak vehicle requirement of 66 buses on S1–S3 and 27 buses on S4. Assuming 10% spares, this suggests a fleet size for these services of 103 buses.
- Feeder Service Plan. The feeder service is expected to operate from Mohakhali, making use of the depot to turn around. Assuming separate feeder routes are used (rather than BRT buses simply continuing in mixed traffic), passengers from Gulshan would be dropped off at Mohakhali Station and the feeder buses would turn in the depot then return to Mohakhali Station to pick up southbound passengers. Current plans prepared by DTCA propose that the feeder route operates at 90 second intervals between Mohakhali and Keraniganj. That would require 106 buses in service plus 11 spares making a total of 117 buses. They are assuming the feeder buses are high-floor, 18-m long, and of140-capacity similar to the BRT buses with low-level doors on the left-hand side to enable boarding/alighting at regular bus stops.
- Importance of Phase 1 to BRT Line 3 North. If the southern section of Line 3 is not built and the northern section terminates at the airport, this will force all passengers to transfer to local buses with an estimated 10,000 passengers per hour at peak. This will not be attractive to passengers, will place huge transfer demands at the airport station, and will severely affect the viability of the northern section. Therefore, there are significant grounds to proceed with the southern section.

7) Next Steps of BRT Line3

- Operational risk assessment of Roads and Highways Department (RHD) by World Bank on 30 September 2017.
- Procurement and contract management capacity and risk assessments of DTCA, RHD, and Dhaka North City Corporation (DNCC) by World Bank on 30September 2017.
- Request WB for project preparation advance by DTCA, RHD, DNCC, and ERD on

31December 2017.

Source: BRT and Corridor Restructuring Implementation Study and Preliminary Design work for the Uttara–Mohakhali–Ramna–Sadar Ghat Corridor in Dhaka.

Figure 2.4.10 BRT Line 3 Network

8) Progress of BRT Line 3 (September, 2018)

(1) Southern Part – funded by the World Bank

As per present scope, a 10km BRT Line 3 (southern part) would be constructed along with seven stations from Airport to Mohakhali Bus Terminal rather than 22km from Airport to Keraniganj. The southern part of BRT will link with northern part BRT Line 3 at the airport. The southern BRT line will mix of at-grade and elevated. Airport to Kakoli is at-grade section and Kakoli to Mohakhali is elevated section and the bus terminal will also elevated at present Mohakhali Bus Terminal. The BRT Line 3 is renamed as “Dhaka Public Transport Improvement Project”. The project presently is preparing Technical Assistance Project

Proposal (TAPP) for (i) revision of design, (ii) social safeguard and resettlement action plan, and (iii) environmental study to get the updated cost estimation. The project office will engage the TAPP consultants and will prepare Development Project Proposal (DPP) as per the costs and review findings.

(2) Northern Part – funded by Asian Development Bank

The detail design and construction supervision of the project was started since October 2013 and construction was started since July 2016.The summary of progress is up to September 2018.

Table 2.4.4 Progress of Northern Part of BRT Line 3

Work	Contract 01		Contract 02		Contract 03	Contract 04
	Required	Achieved	Required	Achieved		
Sub-soil investigation (nos. of boreholes)	92	92	200	129	24 out of 74 roads to be constructed have been taken up for works.	Gazipur bus depot with parking are and maintenance facility. 82.21% work completed
Pile (nos.)	800	87	2000	5 9test piles)	8 kitchen markets need to be developed/ constructed. No work taken up yet	
Pile cap (nos.)	105	6	287	0		
Piers (nos.)	105	0	287	0		
Drainage (m)	23,680	4,480	6,400	0		
Pavement (m)	32,000	250 (up to sub-base)	9,000	0		
Stations (nos.)	19	1 (footbridge on going)	6	0		

2.4.8 Dhaka Elevated Expressway (DEE)

1) Objective

The purpose of the expressway is to increase traffic capacity within and around the city by improving connectivity between the northern part of Dhaka City with the central, south, and south-eastern parts. In addition to providing a much-needed increase in traffic capacity, the expressway will be designed to relieve existing overloaded roads. Access and distribution to the expressway will be designed to avoid adding congestion to existing facilities.

2) Project Scope

Design, construction, operation, and maintenance of the approximately 23-km elevated expressway including construction of culverts, toll plazas, underpass and overpass, lay byes, wayside amenities; installation of computerized toll collection system, providing adequate lights and development of service areas with all required facilities.

3) Main route

The route of the DEE shall commence at Shahjalal International Airport and go along the New Airport Road and the rail alignment through the Mohakhali, Tejgaon and Moghbazar to Kamalapur Rail Station. Then the expressway shall pass through Golapbag that is south of Kamalapur Stadium and east of Jatrabari, and then connect to Dhaka–Chittagong Highway near Kutubkhali. Elevated Link 1 is Manik Mia Avenue–Holy Cross College–Tejgaon Crossing. Elevated Link 2 is Palashi–Katabon–Hatirpul–Hotel Sonargaon (backside)–Moghbazar.

4) Progress of DEE PPP Project

A meeting was held on 8 June 2017 with the Project Director (PD) of the DEE Project to discuss progress of works and changing scenarios if any of the alignment works. The PD discussed about the general features of the project and progress of works by items in detail. He informed that the land acquisition is going smoothly for both public and private lands. Land acquisition was divided into three tranches and total land acquisition was completed. Only the removal of structures at tranches 2 and 3 remains. The investor is also making progress of physical works.

The following tables show the features of the project and progress of works up to April 2017.

Table 2.4.5 General Features of Dhaka Elevated Expressway (DEE) Project

Items	Descriptions
Executing Agency	Bangladesh Bridge Authority (BBA)
Investor Agency	Italian Thai Development Public Company Limited
Signing of Agreement	15 December, 2013
Project Route	Shahjalal International Airport – Kuril – Banani – Mohakhali – Tejgaon – Mogbazar – Kamlapur – Sayedabad – Jatrabari – Dhaka Chittagong Highway (Kutubkhali).
Length	Mainline: 19.73 km Phasing of the Project: 1st Phase – Chain 0+000 m to 7+450 m 2nd Phase – Chain 7+450 m to 13+300 m 3rd Phase – Chain 13+300 m to 19+730 m
Ramp	31 number, length 27 km
Total length	46.73 km
Construction Costs	BDT 8940.18 Crore
Support to Dhaka Elevated Project Expenditure	BDT 3216 Crore.
Viability Gap Funding (VGF)	BDT 2413.84 Crore.
Concession Period	25 years (including 3.5 years construction period)

Source: Bangladesh Bridge Authority (BBA), June 2017

Table 2.4.6 Progress of Works by Items of Dhaka Elevated Expressway (DEE) Project

Items	Description	Progress
Land (205 acre)	1st Tranche (69 acre)	Land acquisition completed. Removed structures from the land and transferred land to the Investor.
	2nd and 3rd Tranche	Land acquisition completed and removal of structures is going on.
Utility	Utility shifting/replacement	1st Phase completed. 2nd and 3rd Phase is going on.
Compensation of Affected People	1st Phase	Compensation given.
	2nd and 3rd Phase	Compensation is ongoing.
Resettlement Area	Land development	Land filling by sand in the state of running.
	Construction of building for affected People	Tender receipt on 29 March 2017 for appointment of Contractor. Evaluation is going on.
Early Works	Construction of Yard	Investor developed 15.95-acre area land where constructed site office, stock yard, and construction yard. In addition, Batching Plant installed in the same place.
Main Construction Works	Pile Driving Works is ongoing	Construction works is going on from August 2015: 647 number pile, 43 number pile caps, column 2 number (completed) and 8 number (partial) completed up to April 2017.
	Completion of Works	December 2020.
Viability Gap Funding (VGF)	BDT 405 Crore	VGF will due on May 2018.

Source: Bangladesh Bridge Authority (BBA), June 2017

3 Route Selection

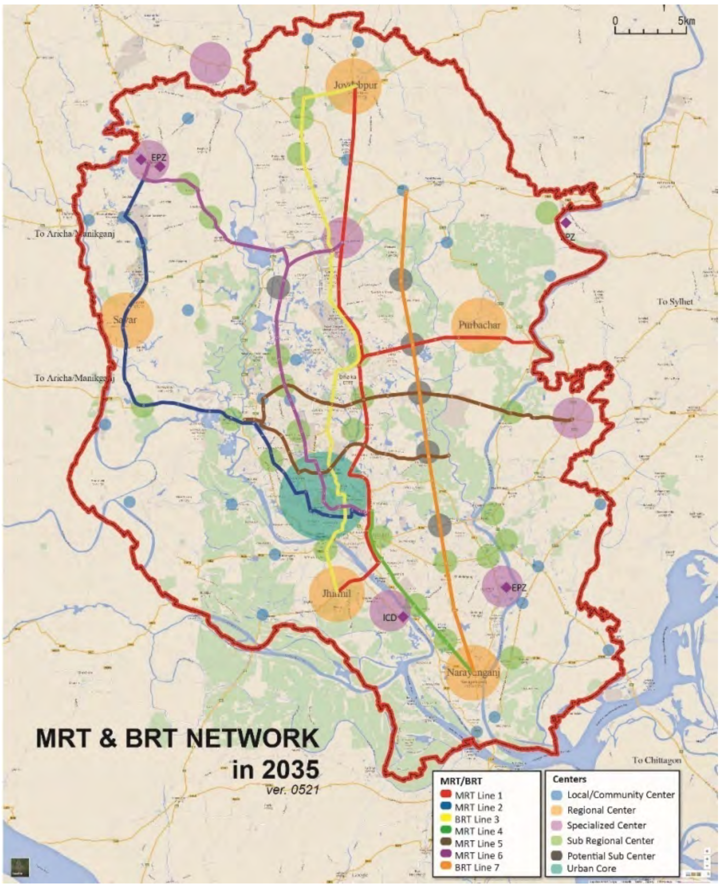
3.1 Review of Previous Studies

3.1.1 Revision and Update of Strategic Transport Plan (RSTP), JICA, 2015

Strategic Transport Plan (hereinafter: STP) for Dhaka Metropolitan Area (hereinafter: DMA) was formulated by Bangladesh government with World Bank (hereinafter: WB) finance in 2005. However, after formulation of STP, since population in DMA has rapidly increased, and many of the STP components were not implemented as par planned, further review of traffic plan and modifications of interventions became necessary. Therefore, Revision and Update of Strategic Transport Plan (hereinafter: RSTP) has implemented by Japan International Cooperation Agency (hereinafter: JICA) for revision and update of the transport plan based on the analysis of latest traffic study in 2015. RSTP was approved by the Government of Bangladesh (hereinafter: GOB) in 2016.

In the RSTP, it is planned to develop five MRT routes and two BRT routes as public transport network. The future public transport network is shown in following figure.

MRT Line5 is unique and only line aligned in east-west direction in the mass transportation network of Dhaka, and it is an important network connecting all MRT/BRT lines except MRT Line 4. By developing MRT Line5, it is expected that the function of the urban transport network will be further enhanced as well as will ensure a total network integration. This line will not only eliminate congestion along the corridor, but also it will reduce the congestion of the whole city by virtue of its network integration.



Source: RSTP Study Team

Figure 3.1.1 Public Transport Network (2035)

Outline of each MRT/BRT proposed by RSTP and future forecast of passengers is as follows.

For the estimated ridership in 2035 (Table 3.1.2), MRT Line 5 shows the third highest value (28,340 PHPDT) after MRT Line6 (between Uttara 3rd Phase and Motijheel) which is implemented at present and MRT Line 1 which connects airport with Kamalapur station.

Table 3.1.1 Outline of MRT/BRT

Project	Route	Final length (km)	Situation/ Open year
MRT Line 1	Gazipur - Airport – Kamalapur - Jhilmil Purbachal– Khilkhet	52	2025
MRT Line 2	Ashulia - Savar - Gabtoli - Dhaka Univ. – DSCC – Kamalapur	40	2035
BRT Line 3	Gazipur – International Airport – Jhilmil	42	On going
MRT Line 4	Kamalapur - Narayanganj	16	2035
MRT Line 5	Bulta - Badda – Mirpur Road – Mirpur 10 – Gabtoli Bus Terminal – Dhanmondi – Bashundhara City – Hatir Jheel Link Road	35	2035
MRT Line 6	Ashulia - Uttara Phase 3 – Pallabi – Tejigaon –Motijheel - Kamalapur	41.8	On going
BRT Line 7	Eastern Fringe Area	36	2035

Source: RSTP Study Team

Table 3.1.2 Future Estimated Ridership of MRT/BRT

Project	2025		2035	
	Ridership/Day	PHPDT	Ridership/Day	PHPDT
MRT Line 1	1,365,800	34,740	1,887,200	37,770
MRT Line 2	—	—	1,084,600	23,020
BRT Line 3	1,832,700	23,730	1,814,100	25,960
MRT Line 4	—	—	332,000	17,930
MRT Line 5	—	—	1,478,600	28,340
MRT Line 6	483,200	16,440	1,816,700	45,860
BRT Line 7	—	—	541,800	22,330
Total	3,681,700	—	8,955,000	—

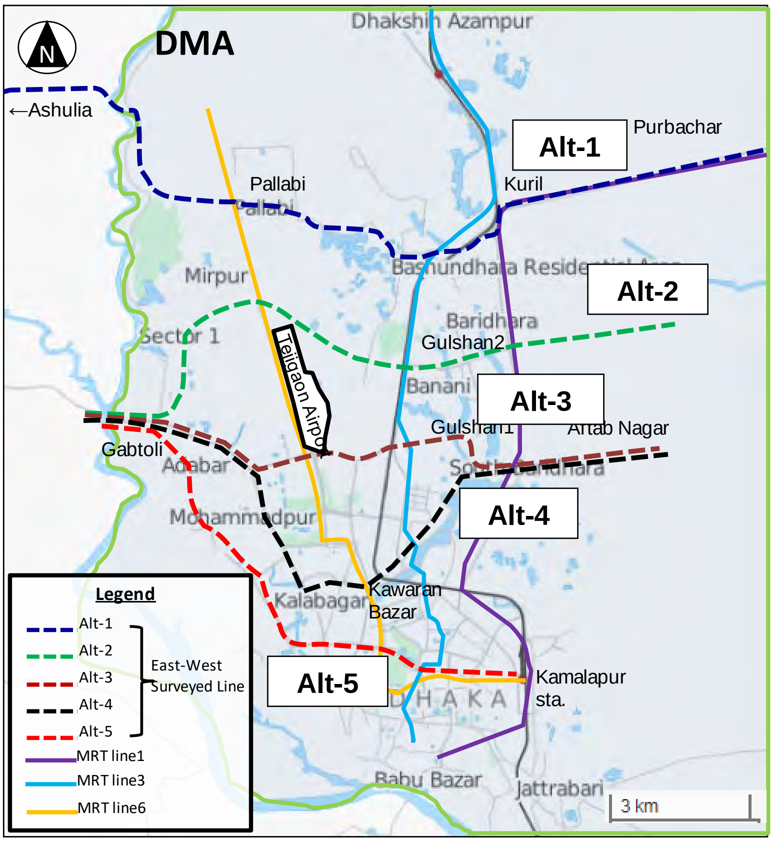
Source: RSTP Study Team

3.1.2 Study on Dhaka Mass Rapid Transit East-West Line Project, METI, 2015

Study on Dhaka Mass Rapid Transit East-West Line Project (hereinafter: METI-FS) is a feasibility study for MRT Line 5 funded by Ministry of Economy, Trade and Industry (hereinafter: METI) of Japan. It was conducted in 2015.

In this study, the optimum development section was selected within the proposed route by RSTP, and preliminary feasibility was studied from technical, environmental, social, financial and economic aspects.

The following five proposed alternative routes were considered, and the comparative study was carried out in consideration of traffic demand and construction feasibility.



Source: METI-FS Study Team

Figure 3.1.2 Alternative Route of MRT Line5

Table 3.1.3 Characteristics and Evaluations of Alternative Route

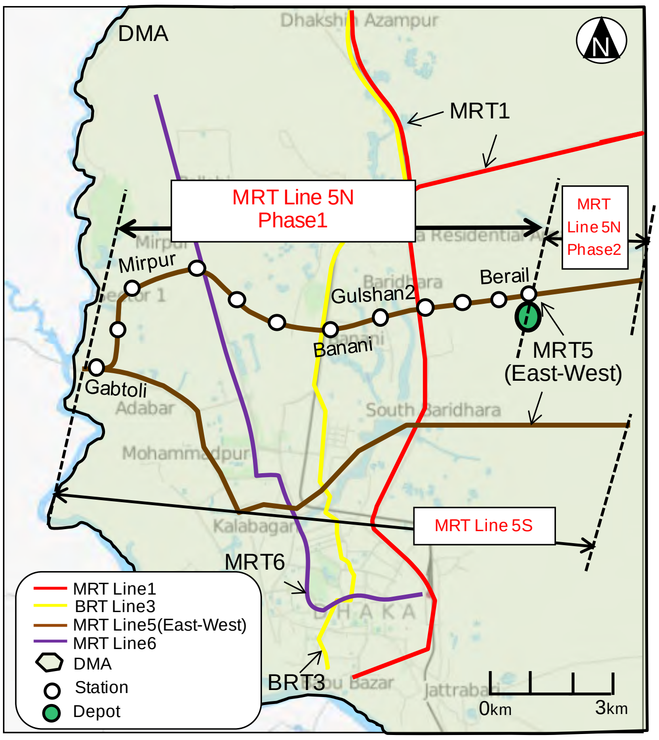
Alternative Route	Characteristics	Evaluation
Alt-1	・Passing through Purbachal with a planned population of 1 million (○) ・Duplicate route with the MRT Line 1 (×) ・Crossing the Kuril Flyover (△) ・Low demand between Ashulia and DMA (×)	×
Alt-2	・Passing through Gulshan 2, which is a central business district(○) ・Passing through Banani, which is a major commercial area (○) ・Passing through the Gabtoli Bus Terminal, which is a transportation Hub(○) ・Good location for station connectivity with MRT Line 6 and BRT Line 3 (○) ・Passing through Banani Cantonment (△)	○
Alt-3	・Passing through Gulshan 1, which is a central business district(○) ・Passing through the Tejigaon Airport (×)	×
Alt-4	・Passing through the Gabtoli Bus Terminal (○) ・Passing through the Kawaran Bazar, which is a commercial area (○) ・Passing through the Dhaka Expressway flyover and MRT Line 6 which are viaduct structures (△) ・Road is wide enough and comparatively easy execution (○)	○
Alt-5	・Passing through the Gabtoli Bus Terminal (○) ・Passing through the Kamarapur Station, which is a transportation Hub(○) ・Road is narrow and difficult to construction (△) ・There are low income residential areas, in which the residents may not use MRT (△) ・Duplicate with the MRT Line 6 (×)	×

Note: ○ = Positive evaluation, △ = Medium evaluation, × = negative evaluation

Source: METI-FS Study Team

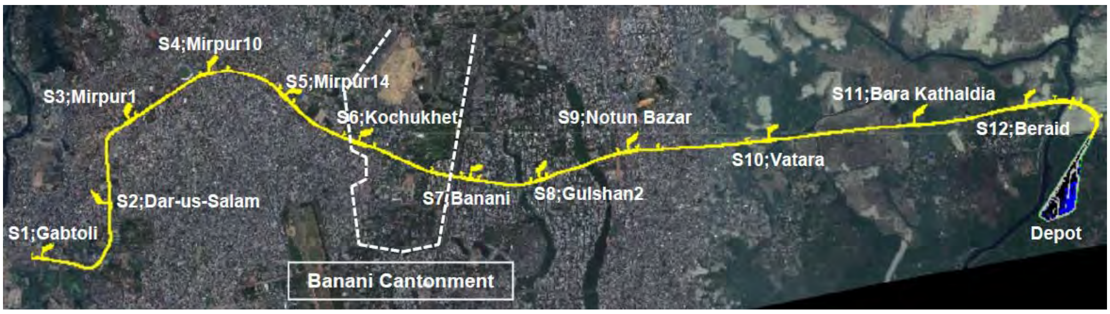
As a result of the above comparative study, Alt-2 and Alt-4 were selected as optimum routes. In METI-FS, Alt-2 is called as northern route, and Alt-4 is called as southern route. Based on the demand forecast of RSTP, Alt-2 northern route was selected as high priority route.

Within the selected northern route between Gabtoli and Bhulta, further analysis was conducted based on RSTP demand forecast, and it was concluded that phase 1 (priority portion) of the northern route is 17km section between Gabtoli and Beraid, while phase2 of the northern route is 6km section between Beraid and Bhulta. The current development situation between Beraid and Bulta is limited with one main road and some houses. However, urbanization has not been progressed yet. METI-FS proposed the depot location at Beraid as shown in Figure 3.1.4.



Source: METI-FS Study Team

Figure 3.1.3 Phasing of MRT Line5 as par METI Study



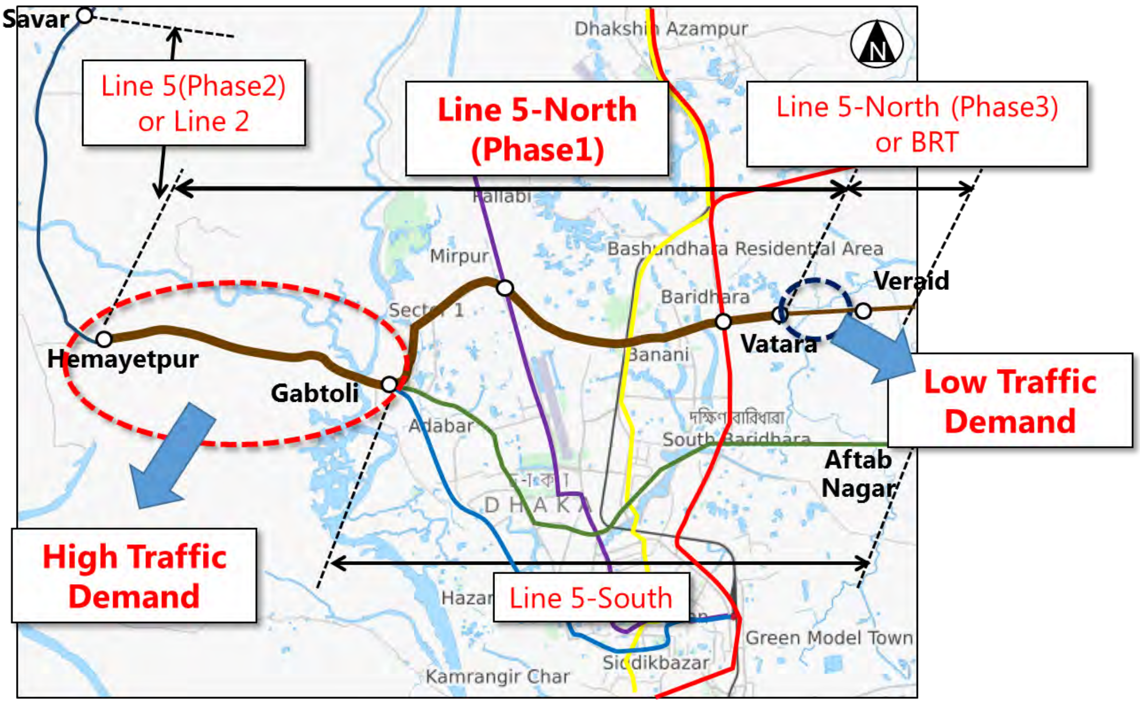
Source: METI Study Team

Figure 3.1.4 Plan of MRT Line5 as per METI-FS

3.1.3 RSTP Supplemental Study for Line 5, JICA, 2016

After METI-FS has finished, reconsideration of depot location is required, because candidate depot land near Beraid was already sold to many individuals by a private developer company. On the other hand, it was revealed that the section between Gabtoli and Hemayetpur will have a high potential according to demand forecast of RSTP. Therefore, reconsideration of the route in MRT Line5 was carried out within the RSTP study in 2016 as a supplemental study (hereinafter: RSTP Supplemental Study).

In the supplemental study, not only reconsideration of route, and selection of depot candidate site near Hemayetpur was studied but also relocation plan of Gabtoli bus terminal was studied, which is a proposal of RSTP.



Line 5(Phase2) or Line 2	: Savar – Hemayetpur
Line 5- North (Phase1)	: Hemayetpur – Gabtoli – Vatara
Line 5- North (Phase3) or BRT	: Vtara – Veraid
Line 5- South	: Gabtoli – Aftab Nagar

Source: RSTP Study Team

Figure 3.1.5 Reconsideration of MRT Line5 Route

3.2 Comparative Study of Alternatives

3.2.1 Horizontal Route

Horizontal route was studied in METI-FS and RSTP Supplemental Study. In METI-FS, five route plans including suggested routes by RSTP were examined from the viewpoint of demand forecast results, future transportation networks, and environmental and social considerations, and the two current routes were selected as the optimum routes, and northern route was selected for Phase 1 development. Further, in the RSTP Supplemental Study, the horizontal extent of Phase 1 was studied and finalized.

Since the time has not passed since the route was selected and the circumstances around the railway line are not changed so much, the study team believes that the proposed development plan in the METI-FS and RSTP supplementary survey are optimum route at present as well. Thus, the scope of this F/S is same as the RSTP Supplemental Study, as shown below.

Source: JICA Study Team

Figure 3.2.1 Horizontal Route of MRT Line5, Northern route, Phase 1 Development

3.2.2 Study for Structure Type of Main Line

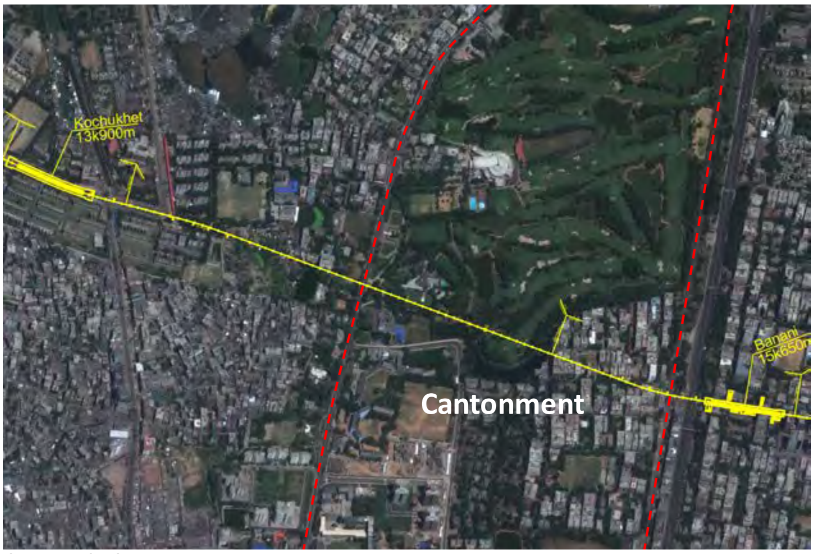
Structural type of urban railway is divided into three as (1) At grade (embankment), (2) Elevated (viaduct), (3) Underground (tunnel). Since MRT Line 5 is a railway operating in a densely populated area of Dhaka, the embankment type, in which urban facilities are divided by railway construction, is not suitable.

Therefore, study team has examined the suitability of the elevated structure or underground structure along the route. Control points for the structural type selection are described as follows.

1) Cantonment Area

Between Kochukhet station and Banani station, there is a military residential area within the Cantonment area. The horizontal and vertical route study for the Cantonment area was carried out in METI-FS, and a plan to pass the area with the tunnel structure was proposed. The cantonment area is a densely populated residential area, and it is difficult to adopt an elevated structure, thus underground structure is the most suitable structure as proposed by METI-FS.

The depth of the underground structure (shield tunnel) is described in detail in "4.1 Route Plan" later.



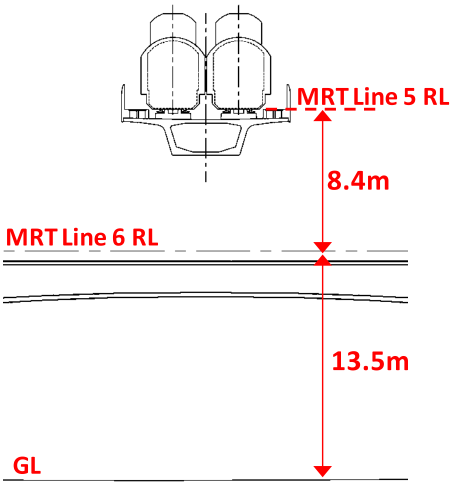
Source: JICA Study Team

Figure 3.2.2 Proposed route in Cantonment Area

2) Crossing the MRT Line 6

MRT Line 6, which is now under construction as first MRT in Dhaka, is an elevated structure for the entire route. MRT Line 5 is planned to cross MRT Line 6 at Mirpur intersection near Mirpur 10 station. RL of MRT Line 6 at the intersection is 21.800 m, and height is 13.5 m from GL. In case the MRT Line 5 is elevated structure, MRT Line 5 needs to cross over MRT Line 6. Therefore, RL of MRT Line 5 will be approx. 22 m height from GL considering structure gauge and girder thickness.

On the other hand, in the case of the underground structure, since the bridge span at the intersection of the MRT Line 6 is 70 m, even if the single track shield pass in parallel, sufficient separation (approx. 19 m) is secured from the foundation structure of MRT Line 6. For that reason, there is no influence such as displacement and settlement due to the construction of MRT Line 5. Thus, it is better to have underground section for MRT Line 5 near Mirpur 10 intersection.



Source: JICA Study Team

Figure 3.2.3 Cross Over MRT Line 6 by the Elevated Structure

3) Structure Type of Gabtoli Station

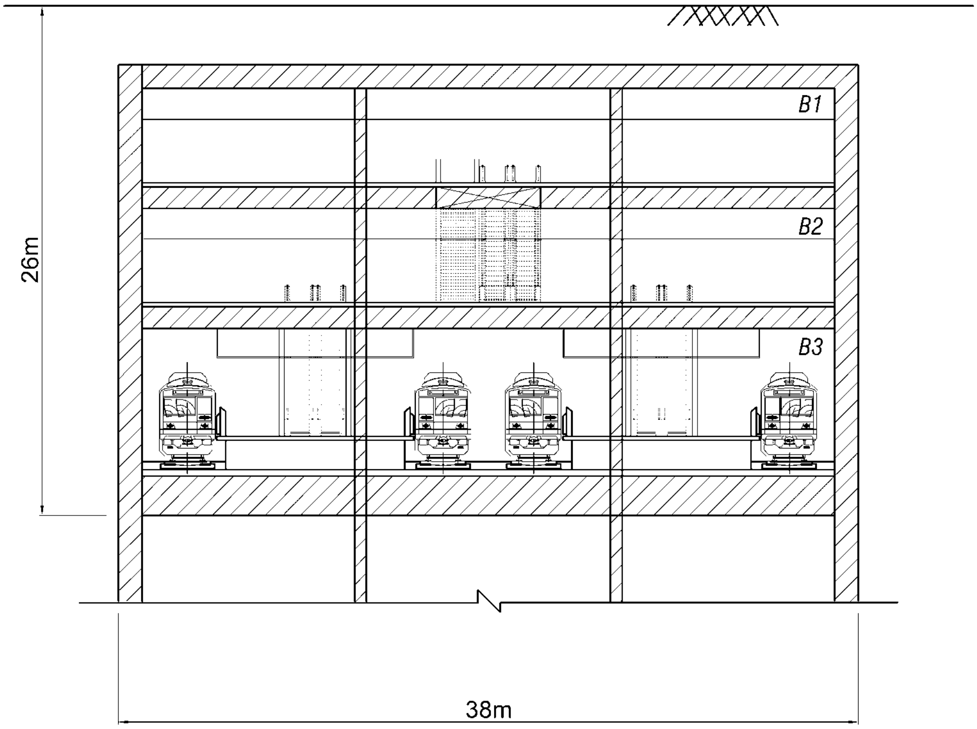
The Gabtoli station is a big terminal station which is scheduled to connect with MRT Line2, in addition to the north and south routes of MRT Line5 in the future. The width of the station for MRT Line 5 is about 38 m and it is impossible to place it within the current road since road width is only about 34 m near Gabtoli station. Therefore, Gabtoli station is be planned in Gabtoli bus terminal site.

Decision for structure type of Gabtoli station is depends on workability, economy, and functionality as transport hub in future. Regarding the structure type of Gabtoli station, features of the elevated and underground stations are shown below.

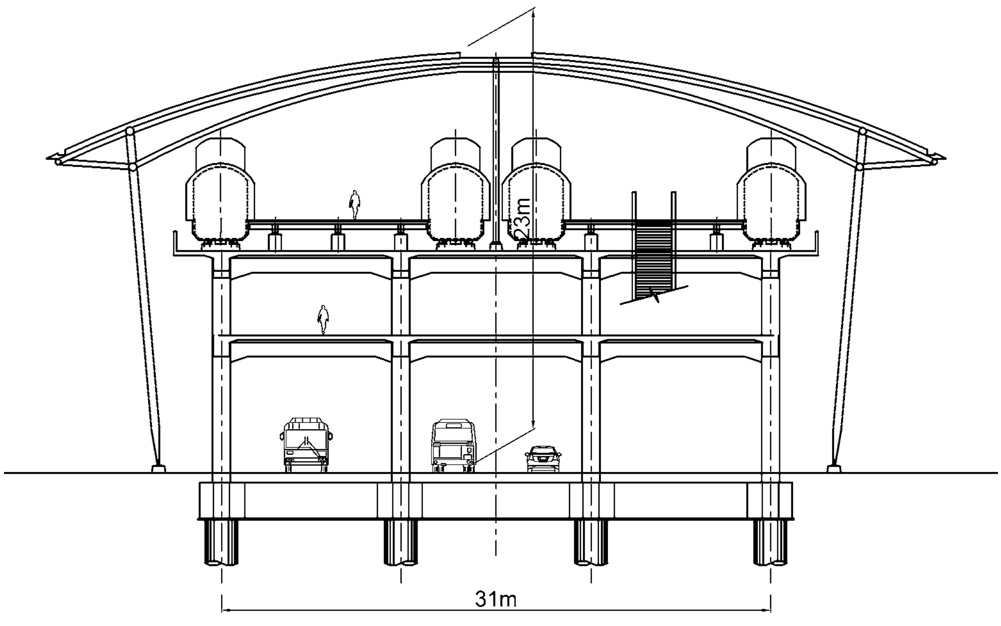
Table 3.2.1 Comparision of Structure Types of Gabtoli Station

Item	Elevated Station	Underground
Outline	✓ Station width is about 37m and height is about 23m. ✓ The ground floor part of the station can be used as part of the bus terminal, but other commercial facilities are difficult to construct without increasing station floor.	✓ Station width is about 38m and station layer is three. ✓ Because the ground portion of the station can be used freely, it is possible to install bus terminals and commercial facilities.
Workability	△: Since a work space for construction of elevated station is required, a temporary relocation of the bus terminal will be occurred.	△: Since a huge excavation work is required, a temporary relocation of the bus terminal will be occurred.
Impact on traffic during construction	△:Since construction work for viaduct on the existing road will be occurred at the end side of Gabtoli station, there is concern that traffic congestion will be worse.	◎: Since there is no construction on the existing road, there is no impact on traffic during construction.
Construction cost (Station civil work)	1.3 billion Yen	14.0 billion Yen
Land acquisition	△: In addition to the station building section, Land acquisition will be required in viaduct section after the station.	○:It is necessary to acquire land only for excavation area of station. However, it is possible to use the ground space after completion of the station.
Landscape	△: Since station height is about 20 m from the ground to the top of the station building, there is a concern about the influence on the landscape.	◎:There is no influence on the landscape because it is an underground station.
Future station development	△: Since the ground part is occupied by the station building, freedom of station development is limited.	◎:Since the station is underground, the ground can be effectively utilized by developing the bus terminal and commercial facilities together with the station facilities.

Source: JICA Study Team



(Underground Station Option)

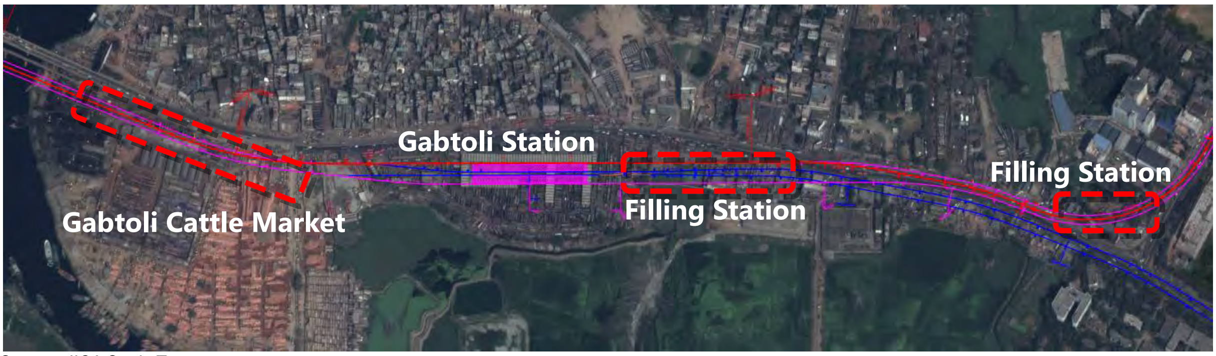


(Elevated Station Option)

Source: JICA Study Team

Figure 3.2.4 Cross Section of Gabtoli Station for Elevated and Underground Constructions

In case of elevated station, there are following three places where land acquisition near Gabtoli station will be occurred.



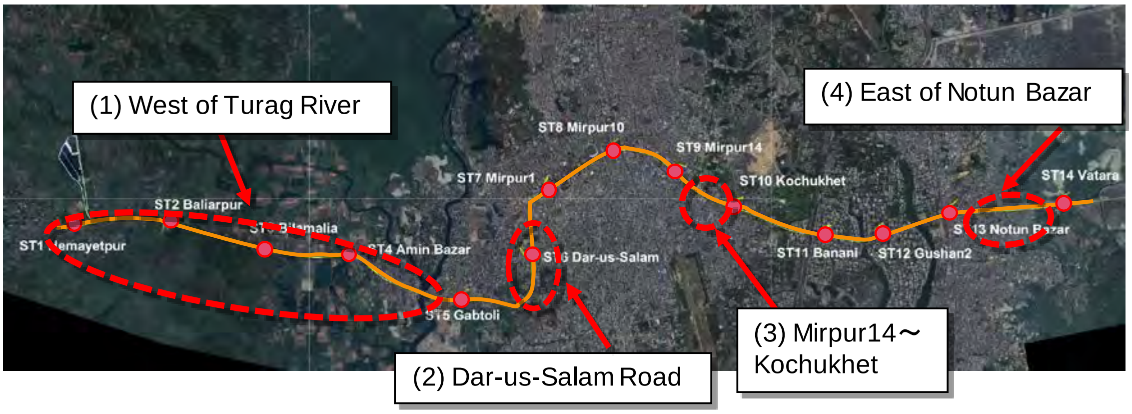
Source: JICA Study Team

Figure 3.2.5 Estimated Place for Land Acquisition in Elevated Option

4) Transition Section

As mentioned in "1) Cantonment Area", section of the cantonment district must be selected for the underground structure, but other sections have the possibility to build the elevated structure. At the boundary between the underground section and the elevated section, it is necessary to provide a transition section as shown below. The transition section will permanently occupy the site for approx. 10 m width and approx. 500 m long. For this reason, possible installable places are limited where the current road width is wide.

As a result of site survey, the study team has confirmed that the following four places are possible to have the transition section.



Source: JICA Study Team

Figure 3.2.6 Candidate Places of Transition Section

Among these candidate places of transition section, only (4) East of Notun Bazar between Notun Bazar and Vatara is located on the eastern side of the Cantonment area, so the transition section on the eastside has to be provided there.

The situation of each candidate places of transition section is described below.

(1) West of Turag River

For the west side from Turag River, the ROW of Roads & Highway Department (hereinafter: RHD) is secured 200 to 300 feet (60 m to 90 m), and the railway structure is planned to be built within it. There is a plan for Gabtoli-Savar-Nabinagar Access Control

Toll Road in the same ROW. But since the occupation width is about 40 m, it is possible to provide a transition structure in the remaining ROW of RHD.

Width of Road Crest 36.6 m				
Service Rd	2 Lanse	Devider	2 Lane	Service Rd
5.5 m	(7.3 + 3) m	(1.5 + 2 + 1.5) m	(7.3 + 3) m	5.5 m

Source: Based on the Presentation document of RHD, edited by JICA Study Team

Figure 3.2.7 Planed Cross Section of Gabtoli-Savar-Nabinagar Access Control Toll Road

(2) Dar-us-Salam Road

Dar-us-Salam Road is connecting south of Mirpur street and Mazar Road to the north and south, and the road width is secured about 15 m on one side. Traffic volume is relatively less, and heavy traffic jams do not occur so much.

Even if the width of the transition structure is 10 m in the middle of the road, the remaining road width is approx. 10 m on one side, so three lanes can be secured.

Source: JICA Study Team

Figure 3.2.8 Current Condition of Dar-us-Salam Road

Source: JICA Study Team

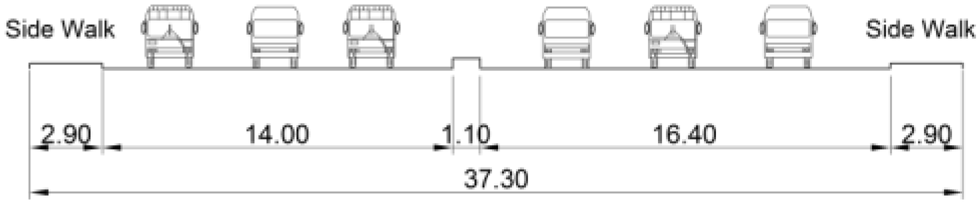
Figure 3.2.9 Cross Section of Dar-us-Salam Road

(3) Between Mirpur14 and Kochukhet

On Mirpur Road from Mirpur 1 station to the Kochukhet station, the road width is secured 14 m or more on one side between Mirpur14 station and Kochukhet station. Especially near Kochukhet Station, road width on one side is ensured at 16m at present. Regarding this section, even if a transition structure is constructed in the center of the road, it is possible to secure three lanes after the construction.

Source: JICA Study Team

Figure 3.2.10 Current Condition of between Mirpur14 and Kochukhet



Source: JICA Study Team

Figure 3.2.11 Cross Section of Kochukhet Station

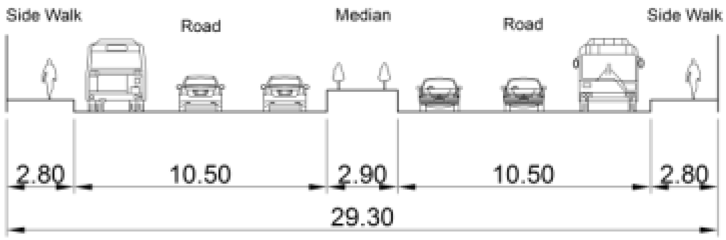
(4) East of Notun Bazar (Madani Avenue)

Transition section can be constructed on the east side of Notun Bazar station. The road width is approx. 10.5 m at present, and when the transition structure is constructed at the center of the road, the remaining road width is approx. 7 m (2 lanes road).

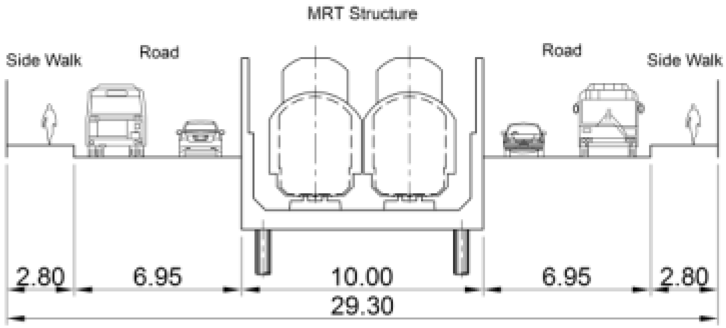
Source: JICA Study Team

Figure 3.2.12 Current Condition of East of Notun Bazar

(Current Road)



(After Construction)



Source: JICA Study Team

Figure 3.2.13 Cross Section of Road

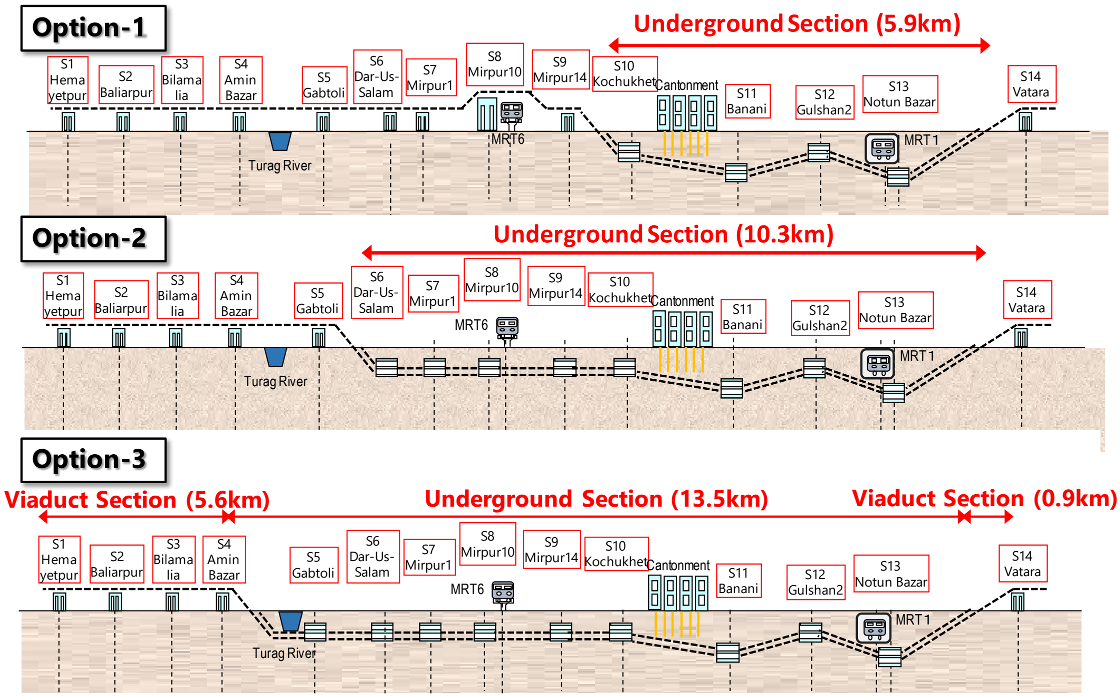
5) Study on the Structure Type

Comparison of the underground section considering the control points and the transition section site is shown below.

Option-1 is a proposal that a western transition section is constructed between Mirpur 14 and Kochukhet and the underground section is between Kochukhet and Notun Bazar.

Option-2 is a proposal that a western transition section is constructed between Dar-us-Salam and Gabtoli and the underground section is between Dar-us-Salam and Notun Bazar.

Option-3 is a proposal that a western transition section is constructed between Gabtoli and Amin Bazar and the underground section is between Gabtoli and Notun Bazar.



Source: JICA Study Team

Figure 3.2.14 Comparison of Structure Type

Table 3.2.2 Comparison Table of Structure Type

	Option-1	Option-2	Option-3
Construction			
Construction Length	20.0 km (Elevated:14.1 km, Underground: 5.9 km)	20.0 km (Elevated:9.7 km, Underground:10.3 km)	20.0 km (Elevated:5.9 km, Underground:13.5 km)
Station Number	14(Elevated:10, Underground:4)	14(Elevated:6, Underground:8)	14(Elevated:5, Underground:9)
Social Environment			
Land Acquisition and Resettlement	△: There is a possibility that land acquisition and resettlement of relocation may occur for the construction site and the entry and exit construction in the underground station building part, but it does not occur in the tunnel section. At the center of Dhaka, the negative influence is big because there is a possibility that it is necessary to obtain land for entry and exit of the station building and bridge piers.	○:There is a possibility that land acquisition and resettlement of relocation may occur for the construction site and the entry and exit construction in the underground station building part, but it does not occur in the tunnel section. Since the elevated section is constructed within ROW of RHD, land acquisition is easy. For the tunnel section, influence on the ground right must be considered. Land acquisition will be occurred in elevated section near Gabtoli station.	◎ : There is a possibility that the land acquisition and resettlement of relocation may occur for the construction site and the entry and exit construction in the underground station building part, but it does not occur in the tunnel section. Since the elevated section is constructed within ROW of RHD, land acquisition is easy. For the tunnel section, influence on the ground right must be considered.
Affected Households	△801	○771	◎721
Regional Division	◎ : Because of the underground and elevated structure, there are no regional divisions by structures.	◎ : Because of the underground and elevated structure, there are no regional divisions by structures.	◎ : Because of the underground and elevated structure, there are no regional divisions by structures.
Natural Environment			
Preservation Area	○ : The alignment does not run in preservation areas.	○ : The alignment does not run in preservation areas.	○ : The alignment does not run in preservation areas.
Biodiversity (Wetland)	○ : On the west viaduct section, the structure is constructed in ROW. Therefore negative impacts to wetland is less. On the east viaduct section, the structure is constructed in the center of an existing road. Therefore no negative impacts to wetland is expected.	○ : On the west viaduct section, the structure is constructed in ROW. Therefore negative impacts to wetland is less. On the east viaduct section, the structure is constructed in the center of an existing road. Therefore no negative impacts to wetland is expected.	○ : On the west viaduct section, the structure is constructed in ROW. Therefore negative impacts to wetland is less. On the east viaduct section, the structure is constructed in the center of an existing road. Therefore no negative impacts to wetland is expected.
Damage to the project by inundation	◎: No inundation on viaduct structures expected. Because there is a possibility of inundation from an entrance and exit, appropriate measures are required. This option has	○:No inundation on viaduct structures expected. Because there is a possibility of inundation from an entrance and exit, appropriate measures	○:No inundation on viaduct structures expected. Because there is a possibility of inundation from an entrance and exit, appropriate measures

	Option-1	Option-2	Option-3
	least negative impacts comparing the other options.	are required.	are required.
Landscape	△: Negative impacts to landscape is most among the options because viaducts are installed on density areas.	○: There is no impact to landscape because structure in the centre of Dhaka is underground. In case that Gabtoli station takes viaduct structure, large structure of the station may affect the landscape.	◎: There is no impact to landscape because structure in the centre of Dhaka is underground. Although viaduct sections may affect landscape, it will be insignificant because the areas are not density areas.
Ecologically Critical Area (ECA)	△: Construction of viaduct may affect water quality of Trug river which is designated as ECA.	△: Construction of viaduct may affect water quality of Trug river which is designated as ECA.	◎: Underground tunnel will not affect may affect water quality of Trug river which is designated as ECA.
Pollution Control			
Noise and Vibration	△: Construction noise of stations and viaducts is expected. Negative impacts are wider than the other options. Railway operation causes noise along viaduct sections.	○: Although construction noise of stations and viaducts is expected, negative impacts are small. Although railway operation causes noise along viaduct sections, negative impacts are limited.	○: Although construction noise of stations and viaducts is expected, negative impacts are small. Although railway operation causes noise along viaduct sections, negative impacts are limited.
Air Pollution	△: Negative impacts to air pollution is most among three options because construction area is very wide.	◎: Negative impacts to air pollution is less than (1) because viaducts are constructed on suburb.	◎: Negative impacts to air pollution is less than (1) because viaducts are constructed on suburb.
Water Quality (Groundwater)	○: Negative impacts to underground water are expected. However it is expected that negative impacts are small because the length of underground section is shorter than the other options.	△: Negative impacts to underground water are most among three options because the length of underground sections is long.	△: Negative impacts to underground water are significant because the length of underground sections is long.
Waste	◎: Volume of excavation soil is least.	△: Volume of excavation soil is large.	△: Volume of excavation soil is most.
Engineering			
Outline Construction Cost	280 Billion YEN	330 Billion YEN	360 Billion YEN
Structural Characteristics	△: The intersection with MRT Line 6 is at the high pier with height of 20 m or more.	○: All of the Dhaka center except Gabtoli is the tunnel structure and out of the Dhaka center is the elevated structure.	◎ : :All of the Dhaka center is the tunnel structure and out of the center Dhaka is the elevated structure.

	Option-1	Option-2	Option-3
Workability	△: Only the station area needs a work area in the underground section. Since length of the elevated structure is long, it is necessary to secure a lot of work area.	○: Only the station area needs a work area in the underground section. Since the traffic volume is heavy in Gabtoli area, it is difficult to construct the elevated structure.	◎: Only the station area needs a work area in the underground section. Since the elevated structure is constructed at the side of road, a work space can be secured within ROW.
Traffic	△: The range of lane regulation due to the construction of viaduct is long, and the influence on the surrounding traffic during the construction is the largest.	○: In Gabtoli, lane regulation is necessary due to the construction of viaduct, so there is a risk of deteriorating the traffic congestion.	◎ : Although lane regulation is necessary due to the construction of viaduct, influence is small because it is not center of Dhaka area.
Liquefaction by Earthquake	△: There is little damage to liquefaction for underground structures. As for the elevated structure, since the extension is longer than other options, it is assumed that adverse effects on the foundation due to liquefaction are relatively higher.	○: There is little damage to liquefaction for underground structures. For the elevated structure, it is assumed that the adverse effect on the foundation by liquefaction is limited.	○: There is little damage to liquefaction for underground structures. For the elevated structure, it is assumed that the adverse effect on the foundation by liquefaction is limited.
Safety	○: Railway level crossing is unnecessary, so traffic accident is not assumed. There is a concern about the elevated structure of earthquake damage and safety against fire at underground station.	○: Railway level crossing is unnecessary, so traffic accident is not assumed. There is a concern about the elevated structure of earthquake damage and safety against fire at underground station.	○: Railway crossing is unnecessary, so traffic accident is not assumed. There is a concern about the elevated structure of earthquake damage and safety against fire at underground station.
Evaluation			
Evaluation	△: Construction cost is the lowest, influence in flood occurrence area is small, but in urban areas resettlement of residents and environmental impact are great. There are concerns about the traffic congestion during the construction and safety against earthquakes. It may influence Turag River ECA.	○: It is evaluated next to Option-3, but there are concerns about impact on the landscape, influence the traffic congestion and land acquisition accompanying the elevated construction around Gabtoli. It may influence Turag River ECA.	◎ : It is the most suitable for this project because it can maximize benefits by constructing the underground structure in Dhaka central area and the elevated structure in suburbs. It has no influence with Tugag River.

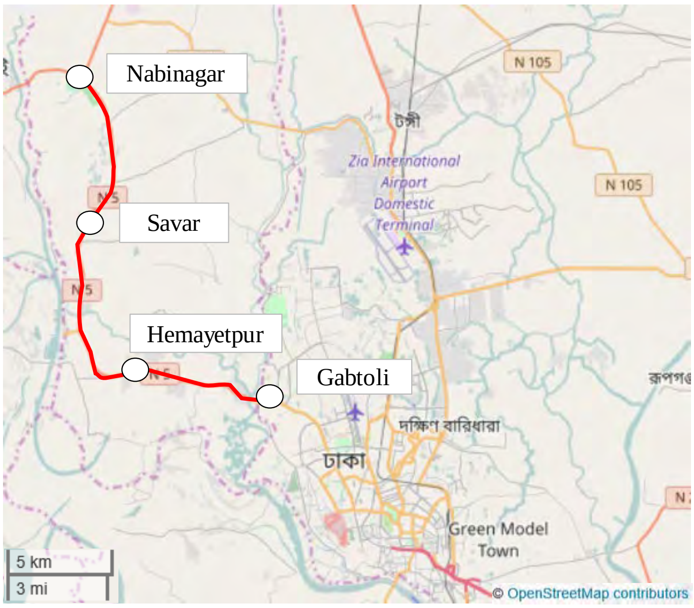
Note: ◎ = Very good, ○ = Good, △ = Medium,

From the results in the table above, the underground section is <u>between Gabtoli and Notun Bazar</u> is recommended.

3.3 Related Development Plan

3.3.1 Highway Plan

The related highway plan for MRT Line 5 is “Gabtoli-Savar-Nabinagar Access Control Toll Road”. Total length is 22 km from Nabinagar located at north-west area of Dhaka central area to Gabtoli via Savar-Hemayetpur. This highway is planned to pass parallel with the future extension plan of MRT Line 5 or MRT line 2 alignment.



Source：JICA Study Team

Figure 3.3.1 Location Map of Gabtoli-Savar-Nabinagar Access Control Toll Road

The current four lanes are planned to be improved for toll road operation and a local road is planned to be developed at both side of the toll road (see Figure 3.3.2).This plan is prepared by RHD. Although PPP scheme is planned, private company is not found until today.

Source：Presentation document by RHD

Figure 3.3.2 Completion Drawing of Gabtoli-Savar-Nabinagar Access Control Toll Road

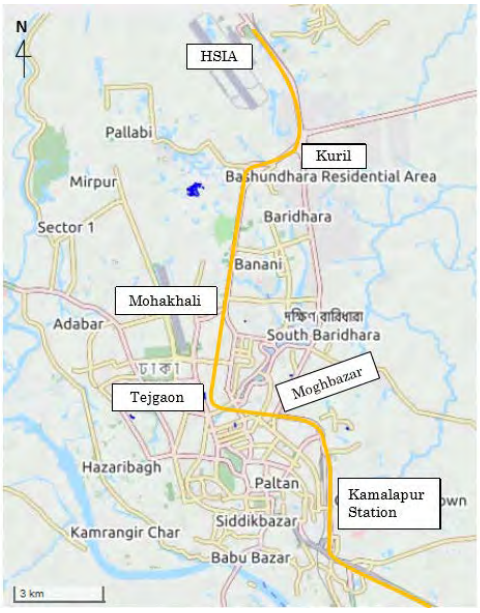
According to the RHD, ROW of RHD road is 200 ft.～300 ft. (Approx. 60 m～90 m). This toll road project is planned to occupied approx. 40 m, therefore it is possible to build MRT Line 5 within remaining ROW.

3.3.2 Urban Road Plan (DEE)

Dhaka Elevated Expressway (hereinafter: DEE) Project is currently under construction as a 19.7 km long elevated expressway along the alignment of Hazrat Shahjalal International Airport (hereinafter: HSIA)– Kuril – Mohakhali – Tejigaon – Moghbazar – Kamalapur.

The Italian Thai Development Public Company Limited of Thailand was selected as the developer for the project and signed the concession agreement on 19 January 2011 with the GoB as the guarantor of the DEE Project, covering a 25-year concession period from the construction commencement date.

DEE is the elevated structure at Banani station and MRT Line 5 is the underground structure, thus there is no interference between each other.



Source：JICA Study Team

Figure 3.3.3 Location Map of DEE

3.3.3 Public Transport Plan

Five MRT lines and two BRT lines were proposed by RSTP. Existing public transport which will connect with MRT is Bangladesh Railway (hereinafter: BR) and crossed at Banani station. In addition, MRT Line 1, MRT Line 2, BRT Line 3 and MRT Line 6 are planned to develop and connected with MRT Line 5 in the future.

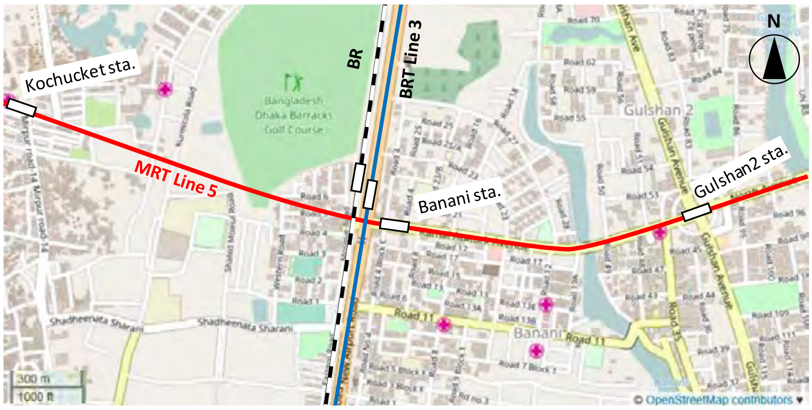
1) BR

BR is the existing at grade railway operated in whole Bangladesh country and crossed at Banani station with MRT Line 5. There is no interference between each other because MRT Line 5 is underground. Underpass is planned to be constructed between them with a length of approx. 200 m to connect each other.

2) BRT Line 3

BRT Line 3 is dedicated bus lane proposed by RSTP. Total length is 42 km and it connects Gazipur – HSIA – Jhilmil. North section from Gazipur is now under construction funded by Asian Development Bank (hereinafter: ADB) while south section from HSIA completed the detail design funded by WB.

Although project implementation of south section of BRT Line 3 is not clear, connection with MRT Line 5 and BRT Line 3 will be considered in the study.



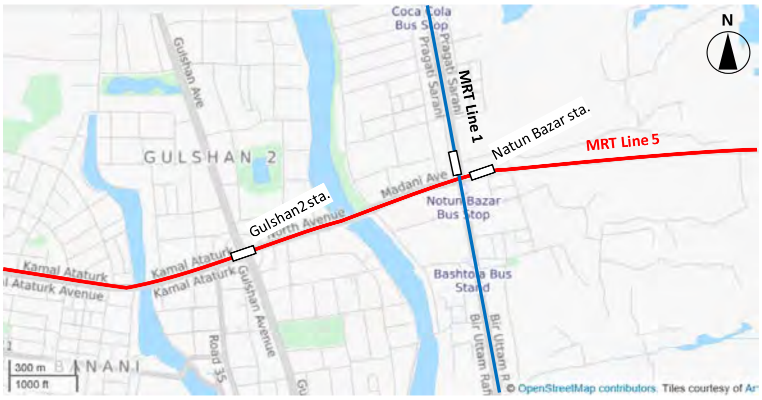
Source：JICA Study Team

Figure 3.3.4 Route Map of BR, BRT Line 3 and MRT Line 5

3) MRT Line 1

MRT Line 1 is underground railway proposed by RTSP. Total length is 52 km and it connects Gazipur and Purbachal to Jhilmil via Kamalapur. Natun Bazar station is the junction station with Line 5 and both stations are planned to be built at underground. Alignment of MRT Line 5 is deeper than MRT Line 1.

MRT Line 1 is under Feasibility Study. The priority corridor is HSIA – Purbachal – Kamalapur in 26.6 km long. As the loan agreement with JICA has been signed for engineering service in June 2017, expected start of detail design is mid. 2018. Planned operation year is 2025. Connection with each other is planned by 200 m long underpass.

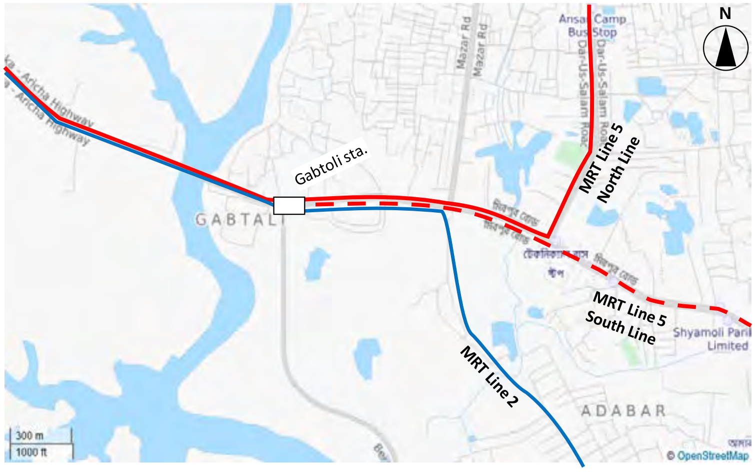


Source：JICA Study Team

Figure 3.3.5 Route Map of MRT Line 1 and MRT Line 5

4) MRT Line 2

MRT Line 2 is proposed by RSTP and it connects Ashulia – Gabtoli – Dhaka University – Kamalapur by 40 km long stretch. Route is overlapped with MRT Line 5 between Hemayetpur and Gabtoli. More discussion is necessary to determine if west wide extension from Hemayetpur should be part of Line 2 or extension of Line 5. Planned operation year is 2035.



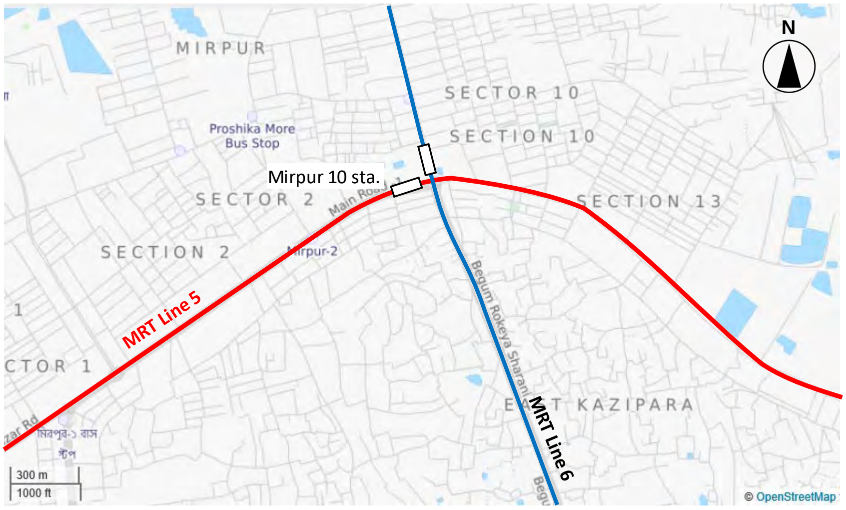
Source：JICA Study Team

Figure 3.3.6 Route Map of MRT Line 2 and MRT Line 5 (North line and South Line)

5) MRT Line 6

MRT Line 6 is a route proposed by RSTP. Total length is 35 km and it connects Ashulia – Uttara – Tejigaon – Kamalapur. And 20 km long priority section between Uttara North and Motijheel is now under construction by JICA fund. Expected operation year is 2022.

Mirpur 10 station is the junction station with each other. MRT Line 6 has the elevated station and MRT Line 5 will have the underground station. Pedestrian bridge will be constructed to connect each other and it can detour the passengers from the at grade busy intersection.



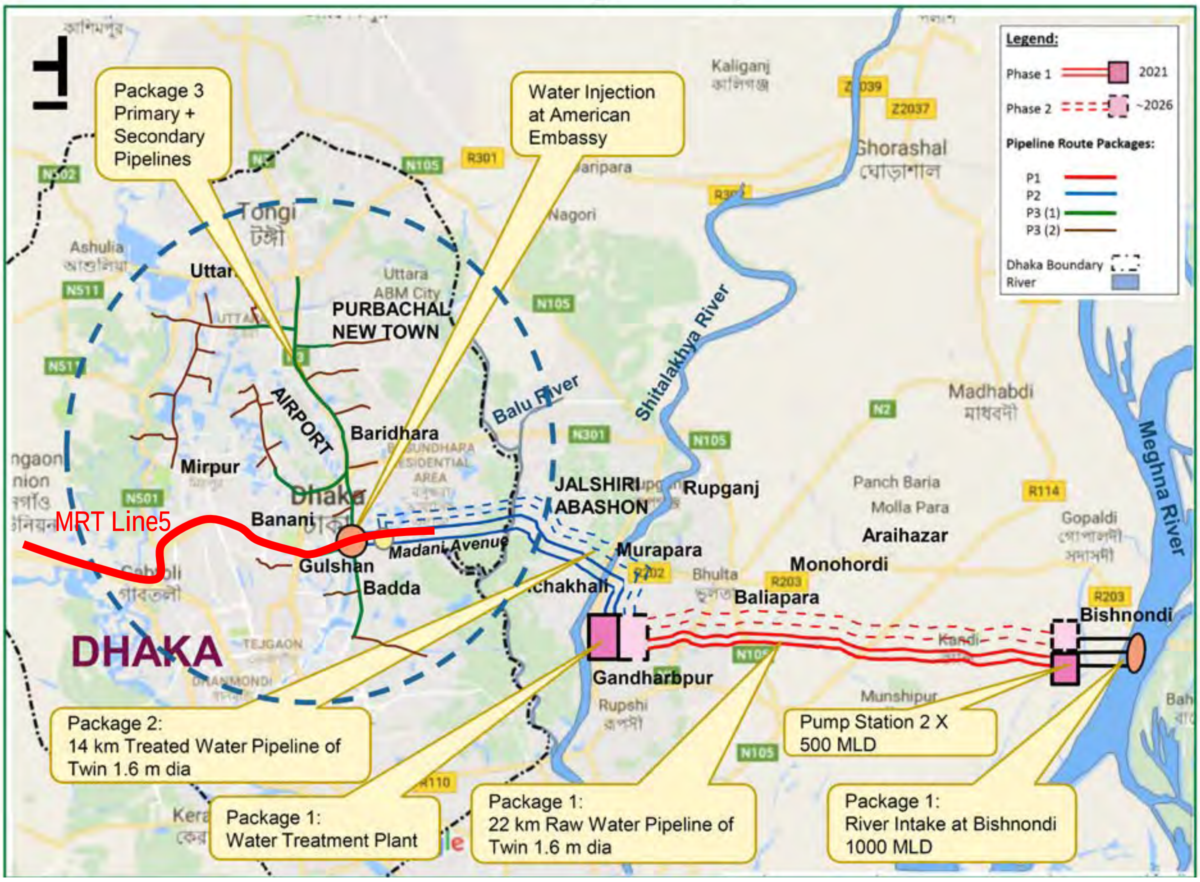
Source：JICA Study Team

Figure 3.3.7 Route Map of MRT Line 6 and MRT Line 5

3.3.4 Dhaka Environmentally Sustainable Water Supply Project (DESWSP)

Currently, 85% of water supply in Dhaka city is supplied by the pumping up of ground water. However, problem of subsidence of ground has occurred in recent years, and plans to purify water of Meghna River and supply it to Dhaka city are progressing as a solution.

Outline of project is shown below.



Source：DESWSP Study Team

Figure 3.3.8 Project Layout of DESWSP

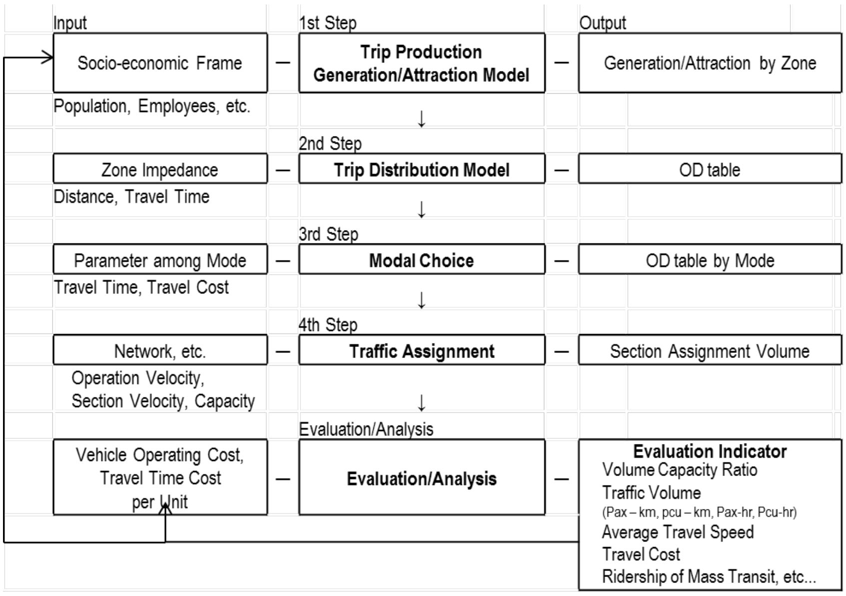
MRT Line 5 is planned along Madani Avenue as well as a water supply route to the city of Dhaka and water pipe will be interfered with construction work for Notun Bazar station.

Details of positional relationship of both structures are mentioned in Chapter 4.2.3 Underground Section.

3.4 Passenger Demand Forecast for MRT Line5

3.4.1 Framework of Demand Forecast

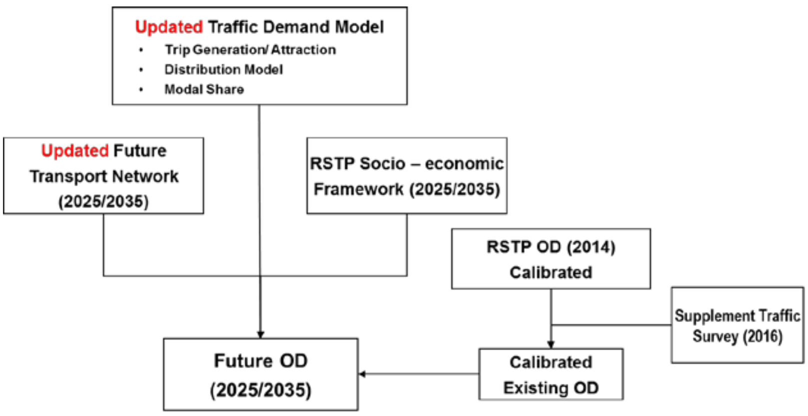
Demand forecast was carried out by 4 step models as shown in **Figure 3.4.1**. Database used in the study was based on RSTP which is the basis of target MRT routes of the Study.



Source: JICA Study Team

Figure 3.4.1 Flowchart of 4 Step Traffic Demand Forecast Model

Updating OD tables was carried out by the method as shown in Figure 3.4.2. The OD table developed in RSTP was updated through supplemental traffic survey along MRT corridors. The outline of the supplemental traffic survey is described in following section.



Source: Study Team

Figure 3.4.2 Flowchart of Updating OD Table

3.4.2 Update of RSTP Traffic Demand

1) Supplemental Traffic Survey

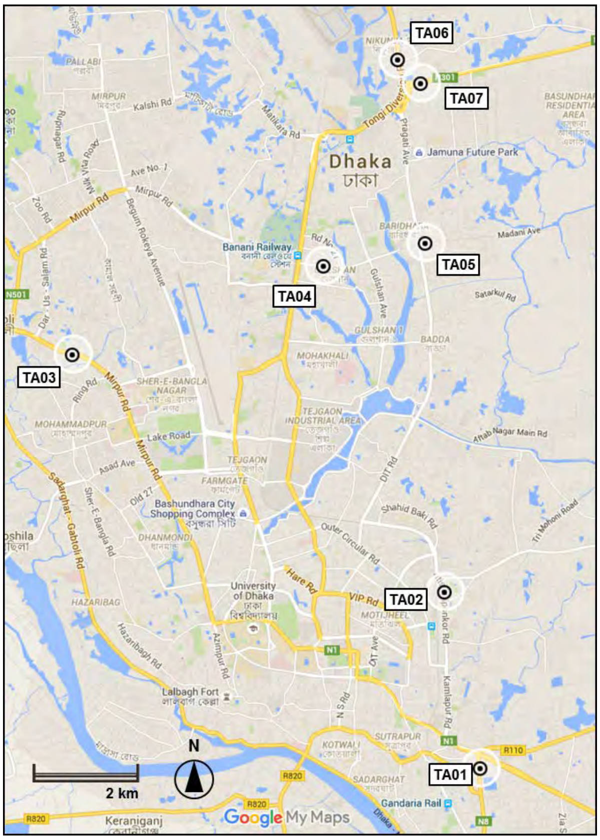
Supplemental Traffic Survey is to provide vehicular traffic and passenger information to update the current distributed traffic volume along the planned UMRT corridors. The survey location is shown in Table 3.4.1 and Figure 3.4.3.

Table 3.4.1 Traffic Count Survey Stations

Code	Survey Station	Survey Period (no. of hours) 1)		Survey Date
		Vehicle Count	Vehicle Occupancy	
TA 01	Dhaka–Mawa Highway	24	16	11 May 2016 (Wed)
TA 02	Kamlapur Road	16	16	16 May 2016 (Mon)
TA 03	Mirpur Road	16	16	17 May 2016 (Tue)
TA 04	Kemal Ataturk Avenue	16	16	18 May 2016 (Wed)
TA 05	Madani Avenue	24	16	10 May 2016 (Tue)
TA 06	Dhaka–Mymensingh Highway	24	16	23 May 2016 (Mon)
TA 07	Purbachal Express Highway	16	16	04 May 2016 (Wed)

1) 24: conducted for 24 hours from 6 a.m. to 6 a.m of the following day. 16: conducted for 16 hours from 6 a.m. to 10.p.m. of the same day.

Source: JICA Study Team



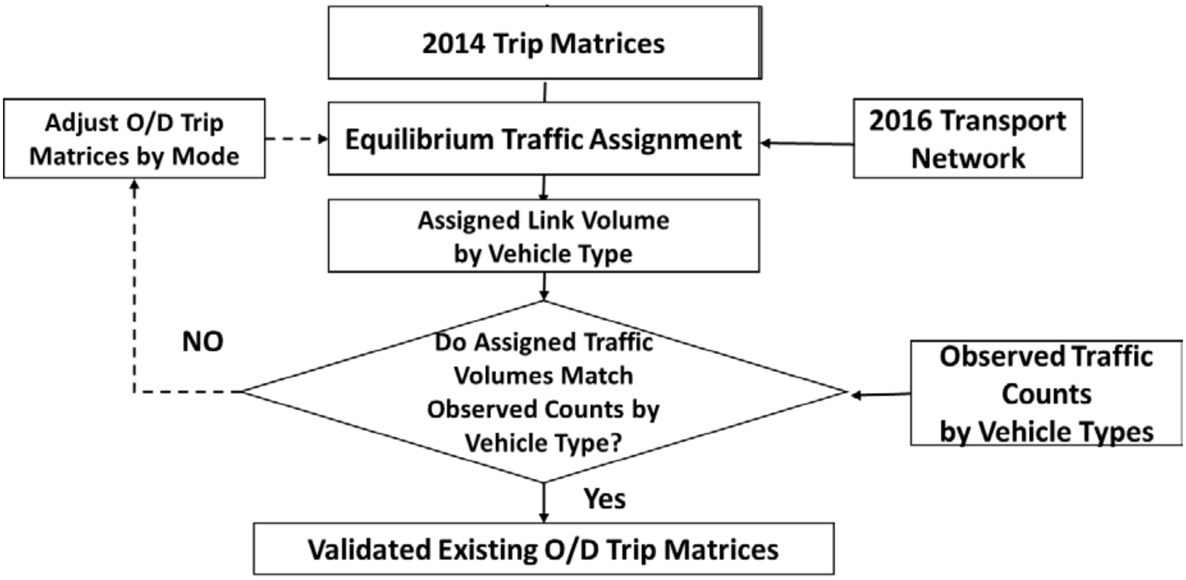
Source: Worked out by JICA Study Team, based on Google

Figure 3.4.3 Location of Supplemental Traffic Survey

2) Carburation of O-D Table

The base year model validation was carried out by comparing the assigned traffic volume against the result of supplemental traffic survey. The initial OD trip tables for each mode were assigned to the updated network using the traffic assignment model. The modelled results, i.e., the assigned traffic volumes were compared with the observed traffic counts across the survey location.

The OD table adjustment and traffic assignment were repeated until the assigned traffic volumes were within +/- 10% of the observed counts, at which stage the model was then considered valid. The final iteration of the OD trip matrices was deemed as the validated 2016 travel demand. This process is illustrated in **Figure 3.4.4**.



Source: Worked out by JICA Study Team, based on Google

Figure 3.4.4 Update of Current O/D Table

Based on the validated current O/D table, the future O/D table also will be updated. The socio-economic indicators such as population, employment and student by traffic analysis zone is of RSTP study. MRT Line 5 is planned to open in 2028 and OD table in 2028 has not been created, therefore the OD table in 2028 is estimated by interpolating between 2025 and 2035 and assigned on 2025 transport network. Passenger demand in 2058 is also necessary because the economic project life of MRT Line 5 is 30 years. Therefore, it is assumed that annual growth rate is 1 % from 2035 to 2058.

3) Hourly Passenger Demand Forecast

(1) Policy of Data Utilization

Hourly demand forecast is required to formulate the train operation during peak time and off-peak time. There is no current MRT in operation. In addition, BR is functioned as an intercity railway, so it is not suitable to refer the BR operation statistics for MRT hourly demand forecast. Thus, hourly trip ratio of current bus operation is applied for MRT hourly demand forecast because bus passengers' behaviour is similar to MRT passenger even though bus is the road transport.

The latest traffic count survey was conducted by RSTP supplement study in May 2016 at 7 sites. There are three count sites along the MRT Line 5 as shown in **Figure 3.4.5** and cross section traffic of east-west direction was observed at all three sites. Although T03 is not along the actual MRT Line 5 north section alignment, it's almost same traffic pattern with other sites since T03 is close to the MRT Line 5 route and lies on the same road of the corridor.

Source：Edited by JICA Study Team based on RSTP Supplement Study

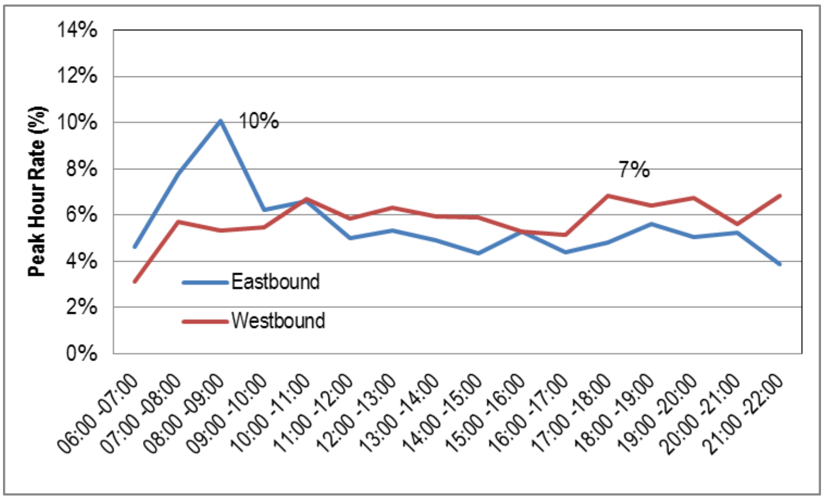
Figure 3.4.5 Location Map of Traffic Count Survey by RSTP Supplement Study

(2) Calculation Method and Its Result

Calculation method is as follows;

- Target transport modes are "Micro Bus/ Mini Bus", "Standard Bus" and "Large Bus".
- The hourly number of person trips for each direction.
- T03 and T04 were conducted over 16 hours only, so 24 hours' traffic is estimated as same as the RSTP study method

Hourly trip ratio is shown in Figure 3.4.6 as calculated by above procedure. Peak ratio is 10 % at 8:00-9:00 for eastbound. After this peak time, there is no clear peak or off-peak and it looks similar pattern between eastbound and westbound. Peak time for westbound is 7 % at 17:00 – 18:00.



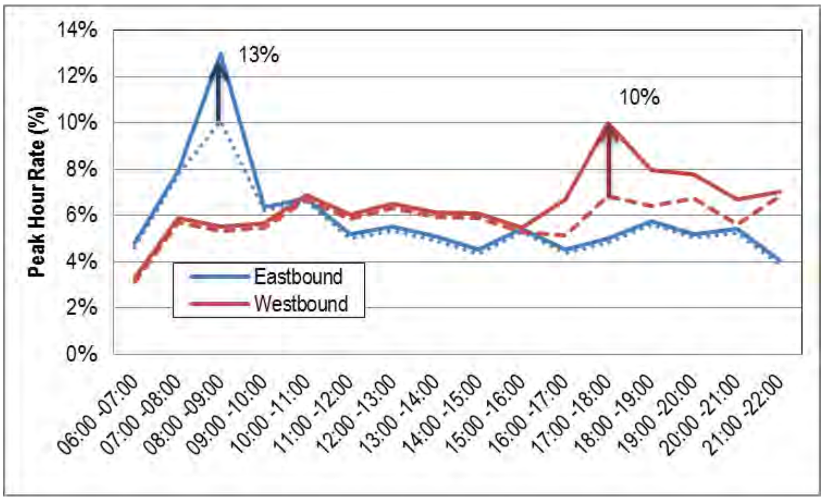
Source： JICA Study Team

Figure 3.4.6 Hourly Trip Ratio (Present)

(3) Hourly Trip Ratio for Train Operation Plan

Current trip ratio as shown in **Figure 3.4.6** is applied because MRT will start to operate from 2028. After 2035, several MRTs will be operated. In general, peak ratio increases with the development of urban railway. The peak ratio of MRT Line 6 is set as 13%, therefore the future peak ratio of MRT Line 5 in 2028 and 2035 is assumed as 13% coordinated with MRT Line 6.

Other time of passenger ratio is distributed by increased 2.5 % to peak time equally. Regarding westbound, although clear peak time and off-peak time are not shown, symmetry pattern will be seen between eastbound and westbound normally. Peak time is 7.2% between 17:00 and 18:00 at present, so this time, it is assumed to be 10%. **Figure 3.4.7** shows the adjusted hourly trip ratio.



Source：JICA Study Team

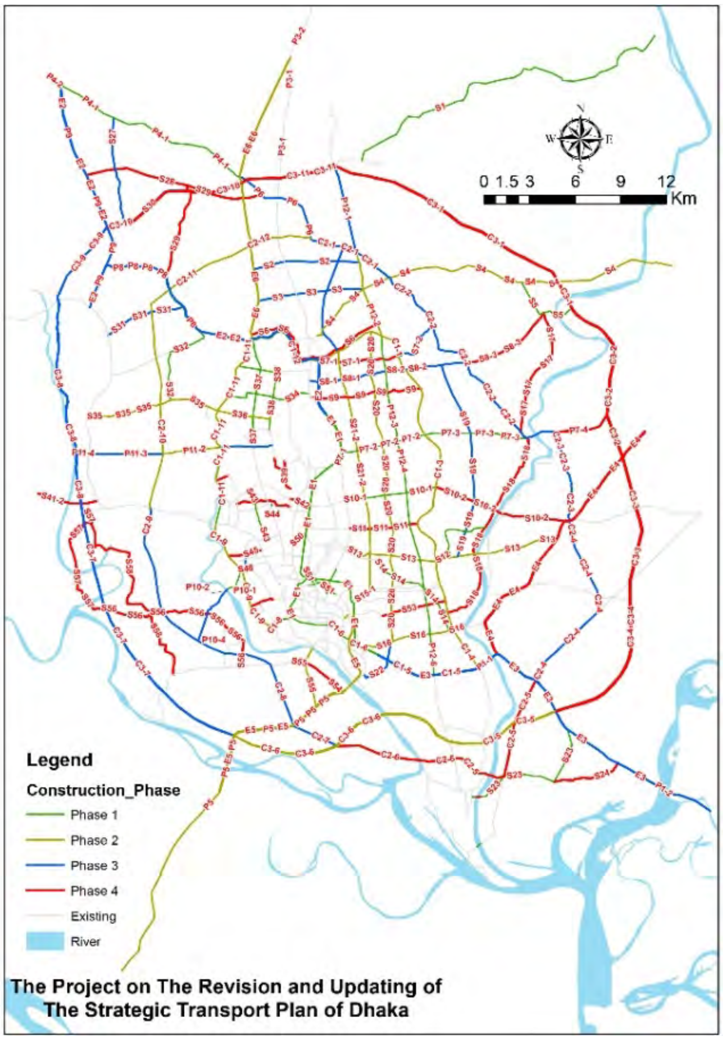
Figure 3.4.7 Hourly Trip Ratio (After 2035)

3.4.3 Network Setting

1) Updating Transport Network

(1) Road Network

In demand forecast, the road network is based on the road development plan proposed in RSTP study. The proposed road network by phase is shown in Figure 3.4.8.



1) Phase 1:2016 – 2020, Phase 2: 2021-2025, Phase 3: 2026-2030, Phase 4: 2031-2035

Source: RSTP Study (2016)

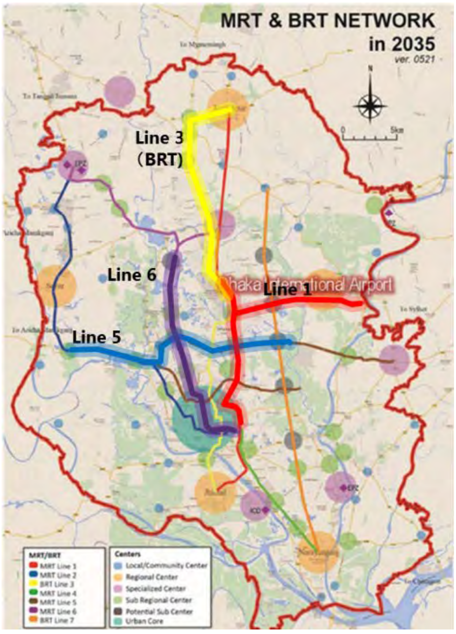
Figure 3.4.8 Road Development by Phase Proposed in RSTP

(2) MRT/BRT Network

Although the mass transit network assumed in the study is consistent with RSTP study, the development roadmap was updated from RSTP. The parts of Route 2 and Route 5 are proposed to be integrated into route 5 and proactively developed as east – west urban transit backbone. The mass transit network proposed in the study is shown in Table 3.4.2 and Figure 3.4.9.

Table 3.4.2 List of Prioritized Route / Section

Route	Section	Length (km)
MRT Line 1	Kamalapur – Bashundhara (Main Line) Future Park - Purbachal Terminal (Purbachal Line)	28.2
MRT Line 5	Hemayetpur- Vatara	22.4
MRT Line 6	Kamalapur – Uttara	20.4
BRT Line 3	Airport - Joydebpur	20.4



Source: Study Team

Figure 3.4.9 Prioritized Route / Section

2) LOS and Fare Setting of Mass Transit

LOS and fare setting assumed in this demand forecast model is shown in Table 3.4.3.

Table 3.4.3 List and Fare Setting of Mass Transit

<table>
<tr><th>Mode</th><th></th><th>2025/2028</th><th>2035</th></tr>
<tr><td rowspan="4">MRT</td><td>Headway (min)</td><td colspan="2">3.5</td></tr>
<tr><td>Capacity (000 pax/day/ direction)</td><td colspan="2">200</td></tr>
<tr><td>Speed (km/h)</td><td colspan="2">35</td></tr>
<tr><td>Fare (Tk)</td><td>22.6+2.8 /km</td><td>30.6+3.8 /km</td></tr>
<tr><td rowspan="4">BRT</td><td>Headway (min)</td><td colspan="2">3.0</td></tr>
<tr><td>Capacity (000 pax/day/ direction)</td><td colspan="2">64</td></tr>
<tr><td>Speed (km/h)</td><td colspan="2">23</td></tr>
<tr><td>Fare (Tk)</td><td>9.9+4.5/km</td><td>13.4+6.1 /km</td></tr>
<tr><td rowspan="4">BR</td><td>Headway (min)</td><td colspan="2">60</td></tr>
<tr><td>Capacity (000 pax/day/ direction)</td><td colspan="2">64</td></tr>
<tr><td>Speed (km/h)</td><td colspan="2">15</td></tr>
<tr><td>Fare (Tk)</td><td>0.7 / km</td><td>1.0 / km</td></tr>
</table>

Source: Study Team

3.4.4 Daily Passenger Demand Result

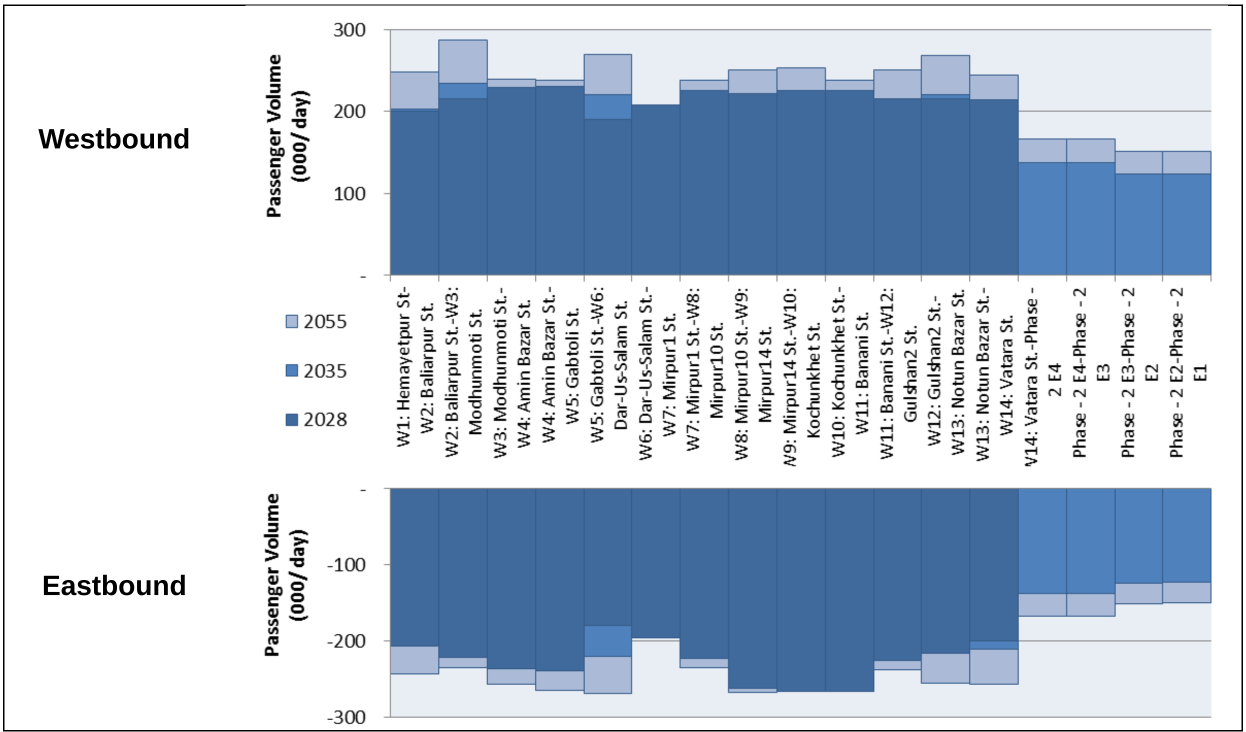
Table 3.4.4 shows the estimated railway performance indicators of MRT Line 5. PPHPD (Passenger Per Hour Per Direction) will be 26,600 pax in 2028 of the opening year, 28,600 in 2035 and 35,100 in 2055. As well as Line 1, this line is desirably handled by Mass Transit.

Table 3.4.4 Estimated Performance Indicators of MRT Line 5

	Route Length (km)	Ridership (000)	PPHPD 1)	Pax-Kms (000)	Pax/km (000)	Pax-kms /km (000)
2028	22.4	1,230	26,600	9,775	54,960	437
2035	51.0	2,404	28,600	17,502	47,109	343
2055	51.0	3,106	35,100	22,792	60,840	446

1) Peak Hour Rate is assumed to be 10 % in 2025 and 13 % in 2035 & 2055. Based on the estimation in Train Operation Plan

Traffic demand by section of MRT Line 5 is indicated in Figure 3.4.10 and Table 3.4.5. The passenger volume is high at whole phase 1 section and will carry more than 400,000 pax /day in 2025. The demand in extended section from Vatara Station to eastern area is relatively low. **Figure 3.4.10** shows the line volume by section and direction.



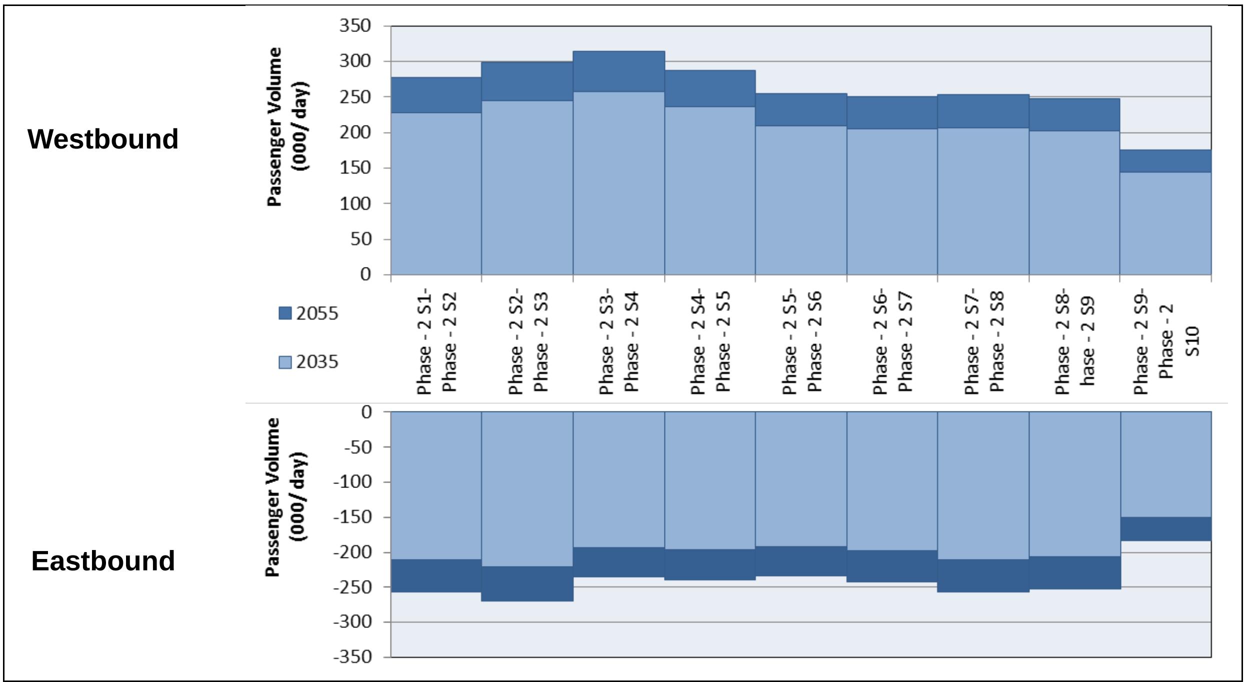
Source: Study Team

Figure 3.4.10 Line Volume by Section of MRT Line 5 (Phase 1/ Phase 2 East Section)

Table 3.4.5 Line Volume by Section of MRT Line 5 (Phase 1 Line) (000/day)

Section	By Station	2028		2035		2055	
		West Bound	East Bound	West Bound	East Bound	West Bound	East Bound
Line 5 Phase 1 Section	W1: Hemayetpur St	-	206	0	199	0	243
	W2: Baliarpur St.	201	221	203	193	248	235
	W3: Modhunmoti St.	216	236	235	210	287	256
	W4: Amin Bazar St.	230	239	196	216	239	264
	W5: Gabtoli St.	231	180	195	220	238	268
	W6: Dar-Us-Salam St.	191	195	221	125	270	153
	W7: Mirpur1 St.	208	222	136	193	166	235
	W8: Mirpur10 St.	226	262	195	219	238	267
	W9: Mirpur14 St.	222	266	206	218	251	266
	W10: Kochunkhet St.	226	266	207	193	253	235
	W11: Banani St.	226	226	195	194	238	237
	W12: Gulshan2 St.	216	216	206	209	251	255
	W13: Notun Bazar St.	215	199	220	211	268	257
	W14: Vatara St.	214	-	201	137	245	167
Line 5 Extension 1	Phase - 2 E4	-	-	137	137	167	167
	Phase - 2 E3	-	-	137	124	167	151
	Phase - 2 E2	-	-	124	123	151	150
	Phase - 2 E1	-	-	124	-	151	-

Source: Study Team



Source: Study Team

Figure 3.4.11 Line Volume by Section of MRT Line 5 (Phase 2 South Section)

Table 3.4.6 Line Volume by Section of MRT Line 5(Phase 2 Line)(000/day)

Section	By Station	2035		2055	
		West Bound	East Bound	West Bound	East Bound
Line 5 Extension 2	Phase - 2 S1	-	211	-	257
	Phase - 2 S2	228	221	278	270
	Phase - 2 S3	245	193	299	235
	Phase - 2 S4	258	196	315	239
	Phase - 2 S5	236	192	288	234
	Phase - 2 S6	209	198	255	242
	Phase - 2 S7	205	211	250	257
	Phase - 2 S8	207	207	253	253
	Phase - 2 S9	203	150	248	183
	Phase - 2 S10	144	-	176	-

Source: Study Team

4 Project Plan

4.1 Route Plan

4.1.1 Route Overview

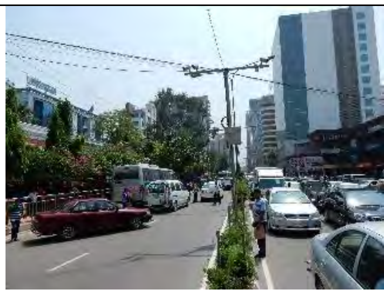
Phase 1 North route MRT Line 5 is a 20 km long east-west corridor from Hemayetpur to Vatara via Dar-us-Salaam road, Mirpur road, Banani cantonment and Madani avenue, which is selected as the scope of this Feasibility Study as well as for the immediate implementation. Underground section is planned in the central area of Dhaka for 13.5 km long and viaduct structure is planned at suburban area for 6.5 km. Route overview of MRT Line 5 along with brief descriptions of its surroundings are summarized in Table 4.1.1.

Table 4.1.1 Route Overview of MRT Line 5

<table>
<tr><td colspan="2">Photo Location

</td></tr>
<tr><td></td><td></td></tr>
<tr><td>1. Entrance of Depot
There is a vacant space but brick is stacked as of April 2017.</td><td>2. Around Hemayetpur station
Two lanes road at each side. There is approx. 15 m space from road berm to buildings.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>3. Around Baliarpur station
Embankment road with two lanes at each side. Southern side is wet land.</td><td>4. Bilamalia station～Amin Bazar station
There is an electric power substation at the south side of the route.</td></tr>
</table>

	
5. Around Amin Bazar station Two lanes road at each side. There are buildings at both south and north sides and street shops are located in 5 m space between road berm and buildings.	6. Turag river River width is approx. 100 m, river is located between Amin Bazar station and Gabtoli stations.
	
7. Around Gabtoli station Three lanes road at each side. Some buses are stopping on the road.	8. Around Dar-us-Salam station Three lanes road at each side. Sidewalk width is 3 m, road width is 15 m and median is 0.8 m.
	
9. Mirpur1 station ～ Dar-us-Salam station Building located at the curve section is 7 story high.	10. Around Mirpur1 station Three lanes road at each side. Sidewalk width is 5 m, road width is 12 m and median is 1.2 m.
	
11. Around Mirpur10 station Three lanes road at each side. Sidewalk width is 6 m, road width is 11 m and median is 1.2 m. There is a cricket stadium located at north side.	12. Around Mirpur14 station Three lanes road at each side. Sidewalk width is 3 m, road width is 14 m and median is 1.1 m.

	
13. Around Kochukhet station Three lanes road at each side. Sidewalk width is 3 m, road width is 15 m and median is 1.1 m.	14. Around Banani station Two lanes road at each side. Sidewalk width is 2 m, road width is 10 m and median is 0.65 m. There is a private building and its parking at south side of the road. Width of the parking is 12.5 m.
	
15. Access road to Banani station of BR Sidewalk width is approx. 3 m and there are ticket booths near bus stops.	16. Around Gulshan2 station A large intersection. There are heavy traffic and many hotels and shopping buildings.
	
17. Notun Bazar station Two lanes road at each side. Sidewalk width is 3 m, road width is 11 m and median is 2.9 m. There are Saudi Arabia embassy annex and fire station at north side and police station at south side.	18. Notun Bazar station ~ Vatara station (proposed location of Launching Shaft) Three lanes road at each side. Sidewalk width is 3 m, road width is 11 m and median is 2.9 m.
	
19. Vatara station One lane road at each side. Sidewalk width is 11 m, road width is 7.2 m and no median.	

Source: JICA Study Team

4.1.2 Design Criteria

The design standard for the alignment follows the "Technical Standards for the Metrorail in Bangladesh", and the main values are shown in the following Table 4.1.2

Table 4.1.2 Design Standard for Alignment

Item		Standard	Remarks
Maximum Operation Speed		100 km/h	
Maximum Design Speed		110 km/h	
Minimum Curve Radius	Main Line	200 m	Desirable 400m or more
	Along Platform	600 m	
	Siding	200 m	including Depot alignment
Maximum Gradient		35 ‰	
Minimum Gradient	Elevated section	0 ‰	
	Underground section	2 ‰	0‰ in station yard
Platform Length		170 m	for 8 cars

Source : JICA Study Team

4.1.3 Horizontal Alignment

1) Control Points

The control points for the horizontal alignment are shown in the following Figure 4.1.1.

Source : JICA Study Team

Figure 4.1.1 Control Points for Horizontal Alignment

(1) Access Control Toll Road Plan

There is a RHD plan to construct an Access Control Toll Road by PPP between Hemayetpur station and Gabtoli station. Although the railway alignment is determined while taking consistency with this road plan, according to the Road and Highway Department (RHD), the detailed road alignment has not been decided yet. Therefore, in this Study, the railway alignment and the planned road alignment are arranged based on the existing road alignment. Regarding the railway alignment of this section, it is necessary to finalize it coordinating with the Access Control Toll Road in the future.

(2) The 8-Story Building at the Intersection of Dar-us-Salam Road and Mazar Road

There is an 8-story building at the intersection of Dar-us-Salam Road and Mazar Road. It is expected that there is pile foundation in this building, and the MRT Line5 should avoid the pile foundation.

Source： JICA Study Team

Figure 4.1.2 Eight Story Building at the Intersection of Dar-us-Salam Road and Mazar Road

2) Horizontal Alignment Plan

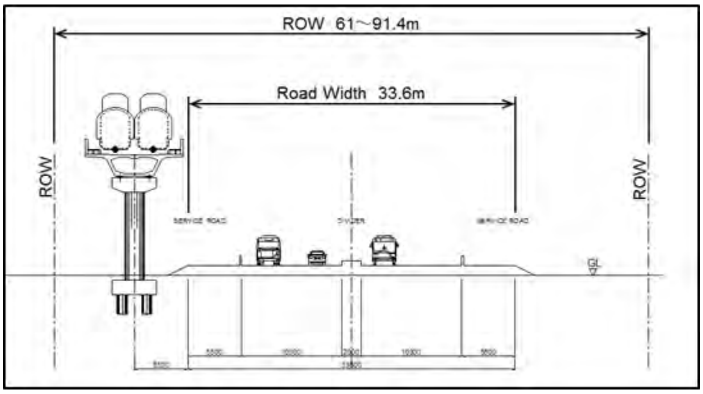
In the elevated section, land acquisition and house relocation are minimized by arranging the railway within the road right of way.

In the underground section, in case of passing the railway under the buildings, it is necessary to deepen the vertical alignment in order to avoid obstacles of the pile foundation. Deepening the vertical alignment leads to deepening the station section, and it is a factor of construction cost increase. Therefore, even in the underground section, the horizontal alignment should be arranged as much as possible within the road right of way.

The outline of the horizontal alignment plan is described below.

(1) Between Hemayetpur station and Turag River

There is a plan of Access Control Toll Road by PPP in this section as mentioned earlier. In the original plan, the road width is 120 feet (36.6m) with a median of 5.0m width and the width of RHD ROW is 200 - 300 feet (about 61 - 91.4m). In this section, MRT Line 5 is planned as the elevated railway, and the railway elevated facility will be placed in the ROW of RHD in parallel with the planned road. Regarding the total width of the planned road, the median width is proposed to reduce to 2.0m and the total width is changed to 33.6m.



Source： JICA Study Team

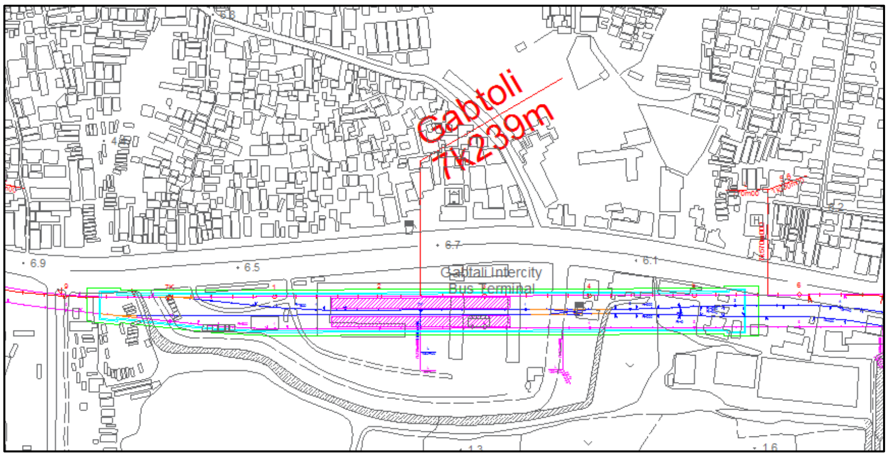
Figure 4.1.3 Typical Cross Section of the Alignment Parallel to Road

(2) Between Hemayetpur station and Baliarpur station

The branch line to the depot is arranged between Hemayetpur station and Baliarpur station. In the planned Access Control Toll Road section, MRT Line 5 basically runs in parallel at the south side of the road, but in order to shorten the length of the depot access line, the route of this section is located on the north side of the Access Control Toll Road. As a result, MRT Line 5 crosses over the Access Control Toll Road between Hemayetpur station and Baliarpur station.

(3) Gabtoli station

Gabtoli station is the junction station of the North Route and South Route of MRT Line 5, which is the underground station with 2 island platforms serving 4 tracks. In future, this underground station will also cater MRT Line 2. The size of this underground station is 616m in length and 38m in width. Construction of the station structure will be by the cut and cover method and in order to reduce the impact on the road traffic during construction, Gabtoli station is placed within the site of the Gabtoli bus terminal instead of under the road.



Source : JICA Study Team

Figure 4.1.4 Location of Gabtoli Station

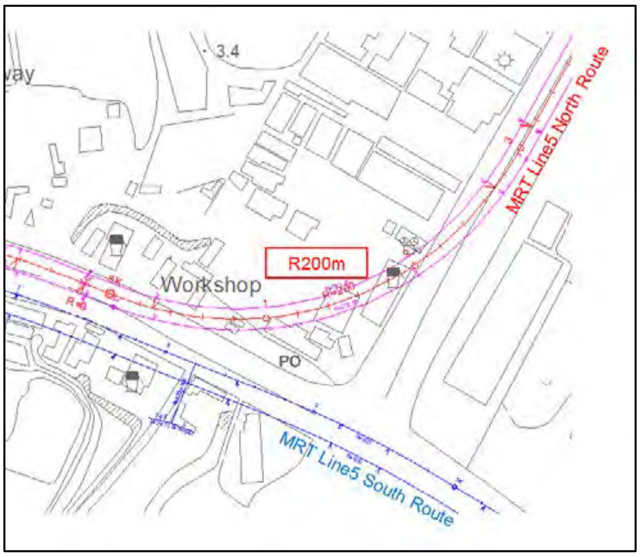
(4) Between Gabtoli station and Vatara station

Between Gabtoli station and Notun Bazar station is the underground section, and between Notun Bazar station and Vatara station is the elevated section. This section passes within the road ROW along the road alignment except for Banani Cantonment area.

As for the 3 places, namely at around 8k150m, around 8k600m, and around 10k000m, the minimum curve radius of R200 m must be used for the following reasons.

<At Around 8k150m>

Although the route of this section passes under the gas station, the buildings are built adjacent to the gas station. It is assumed that there is pile foundation in this building, and the minimum curve radius of R200 m is used to avoid this pile foundation.

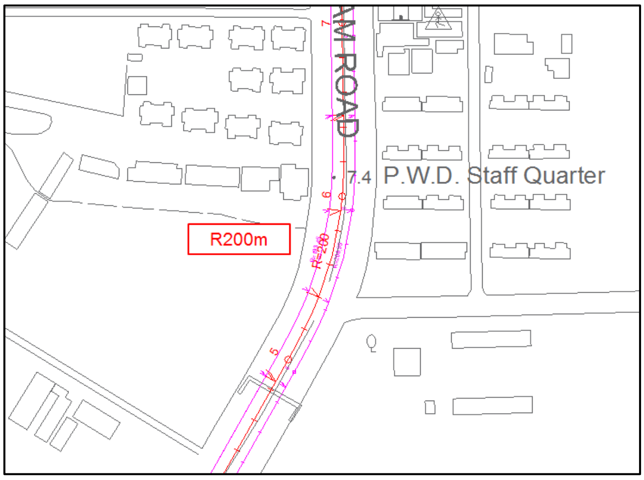


Source： JICA Study Team

Figure 4.1.5 R200 m Curve around 8k150m

<At Around 8k600m, between Gabtoli station and Dar-us-Salam station>

In this section, since the road alignment is the R200 m curve, the MRT Line 5 alignment is also R200 m curve along the road.

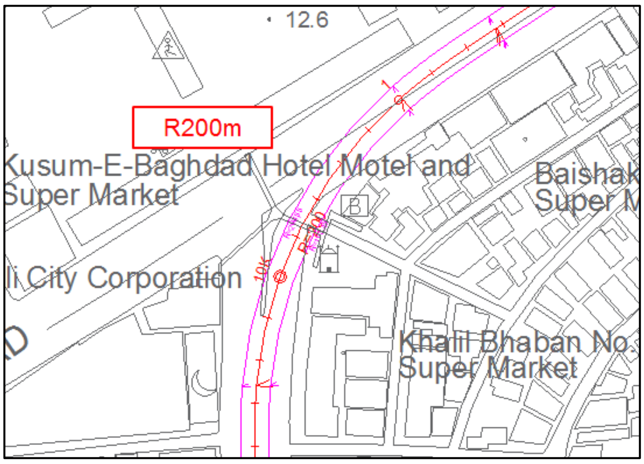


Source： JICA Study Team

Figure 4.1.6 R200 m Curve around 8k600m

<At Around 10k000m, between Dar-us-Salam and Mirpur 1>

In order to avoid the 8-story building at the intersection of Dar-us-Salam Road and Mazar Road, the R200 m curve must be used.



Source： JICA Study Team

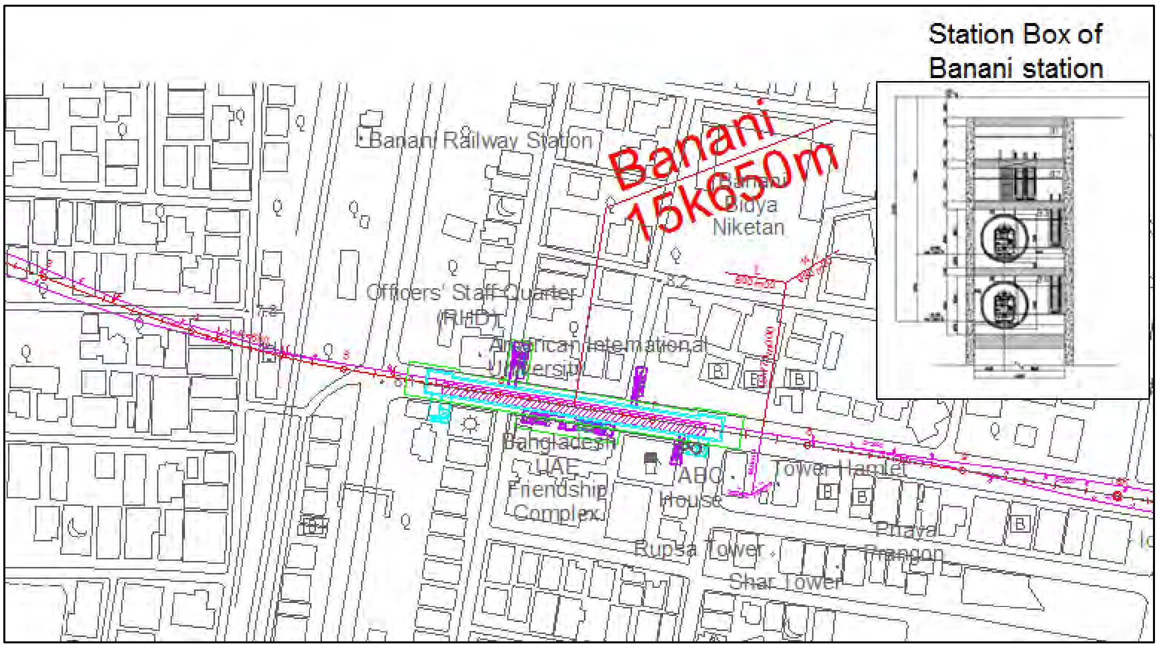
Figure 4.1.7　R200 m Curve around 10k000m

(5) Banani Cantonment area

Although the horizontal alignment basically passes under the existing road, the east-west direction road is blocked by Banani Cantonment in this area. Therefore, the horizontal alignment of this area connecting Kochukhet station and Banani station is the shortest.

(6) Banani station

The Kemal Ataturk Ave., where Banani station is located, is a narrow road with a width of approx. 20 m and high buildings are built along the roadside. Therefore, Banani station has a station structure in which the up line and the down line are vertically arranged, so that the station structure can fit within the existing road width by narrowing the width of the station box. At Banani station, the horizontal alignment of the up line and the down line overlaps into each other.



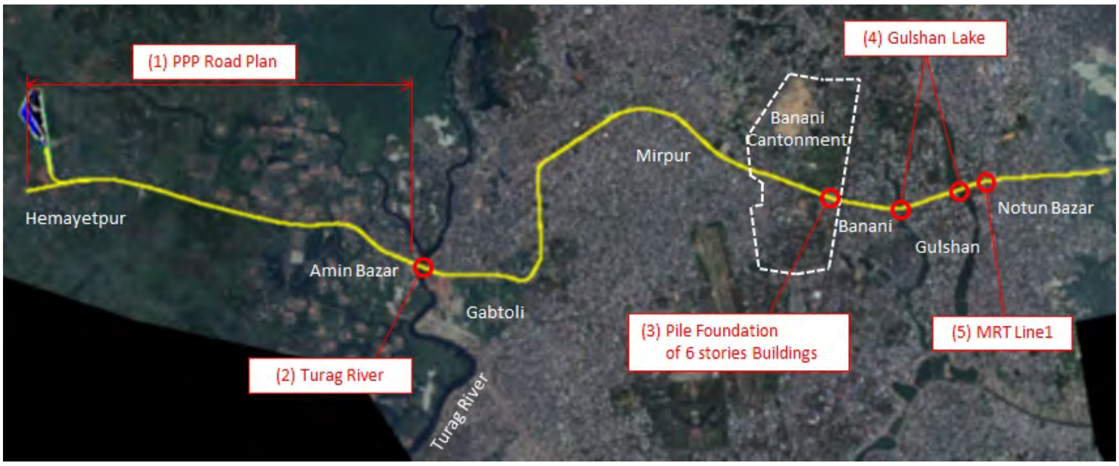
Source： JICA Study Team

Figure 4.1.8　Horizontal Alignment before and after Banani Station

4.1.4 Vertical Alignment

1) Control Points

The control points for the vertical alignment are shown in the following Figure 4.1.9.



Source： JICA Study Team

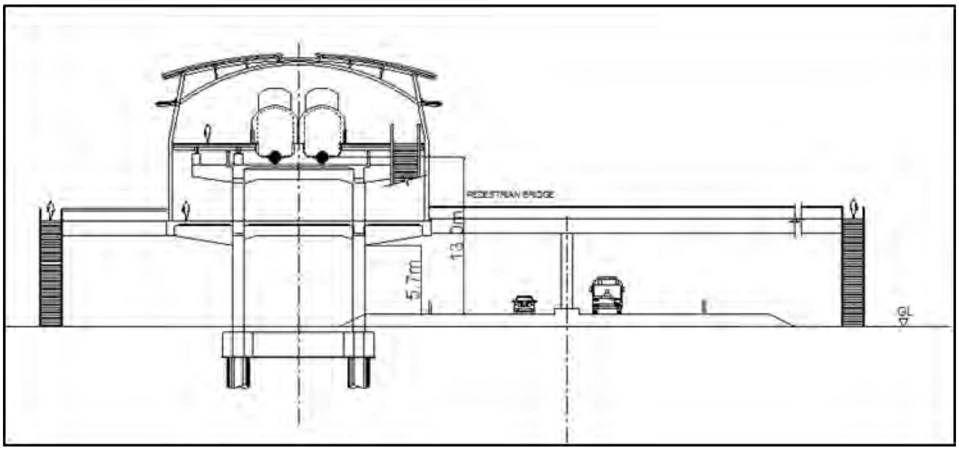
Figure 4.1.9 Control Points for Vertical Alignment

(1) Access Control Toll Road Plan

In the parallel section with the Access Control Toll Road, although the railway structure is arranged within the ROW of RHD, the station section cannot be fit within the MRT ROW. In the station section, in order to accommodate the railway structure as much as possible within the ROW, a part of the station structure overhangs the road as shown below.

Therefore, the height of the PPP road surface is the control point for vertical alignment plan at the station. Road construction gauge and concourse floor clearance are secured from road surface height, and at least 13.0 m from road surface height to Rail Level (hereinafter: RL) is required.

Since the planned road height of the Access Control Toll Road has not been decided yet, in this Study, the road surface height of the existing road is set as the Access Control Toll Road surface height.



Source： JICA Study Team

Figure 4.1.10 Control Point in Parallel Section with Access Control Toll Road

Source： JICA Study Team

Figure 4.1.11 ROW of RHD

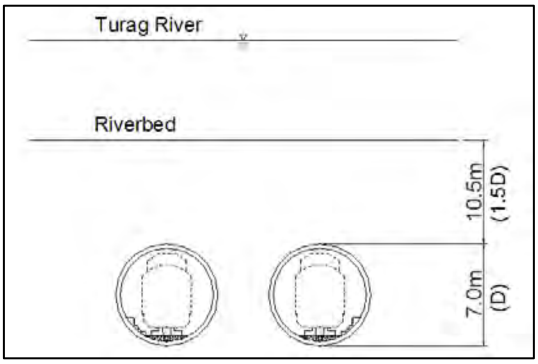
Table 4.1.3 Required RL at each Station

Station	Road Surface Height (altitude)	RL (altitude)
Hemayetpur	8.5 m	21.5 m
Baliarpur	9.2 m	22.2 m
Bilamalia	7.8 m	20.8 m
Amin Bazar	10.0 m	23.0 m

Source：JICA Study Team

(2) Intersection with Turag River

The distance from the riverbed to the upper end of the tunnel shall be more than 1.5 D (D: tunnel outer diameter) ※1, so that 16.35 m or more will be secured from the riverbed to the RL. The level of the riverbed at the deepest part of Turag River is measured as -6.34 m in altitude, so the RL at the intersection with Turag River should be less than -22.69 m in altitude.



Source： JICA Study Team

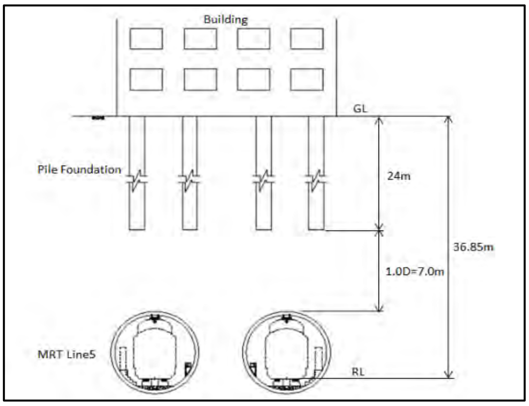
Figure 4.1.12 Control Point at Intersection with Turag River

※1 1.5D is prescribed as the arrangement minimum depth of the overburden at the bottom of river by Cabinet order concerning Structural Standards for River Management Facilities (Japan River Association).

(3) 6 stories apartment buildings of Banani Cantonment

In Banani DOHS Cantonment area, there are many buildings of 6 stories, and MRT Line 5 passes under these buildings.

According to information from DTCA/ Cantonment authority, the maximum length of the pile foundations of the apartments is about 80 feet (approx. 24 m). In order not to affect the apartments, the distance of the tunnel outer diameter 1.0D (7.0 m) ※2 from the tip of the pile foundation to the upper end of the tunnel is secured.



Source： JICA Study Team

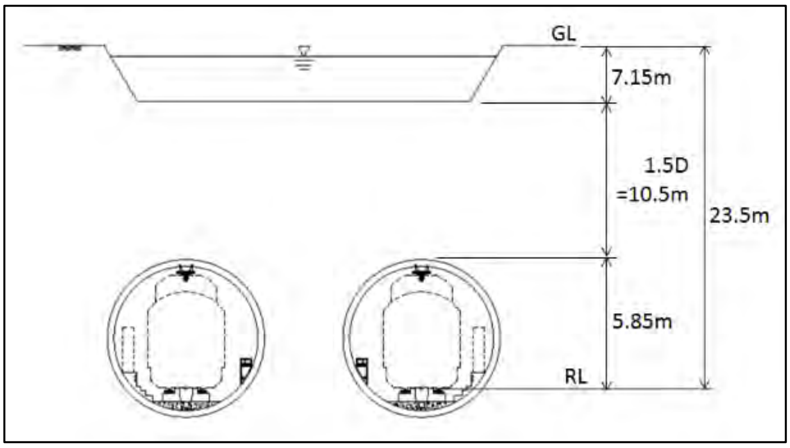
Figure 4.1.13 Control Point at 6-Story Apartment Buildings

※2 In order to prevent acting the concentrated load from the tip of pile to the tunnel, it is assumed that 1D is secured from the pile tip to the tunnel for the distribution width of the load becomes lager than the tunnel diameter.

(4) Gulshan Lake

The tunnel of MRT Line 5 passes under the Gulshan Lake. The overburden of tunnel (from the bottom of the lake to the upper end of the tunnel) is the 1.5D (10.5 m).

The depth of Gulshan Lake is 7.15 m at the deepest place according to the topographic survey.



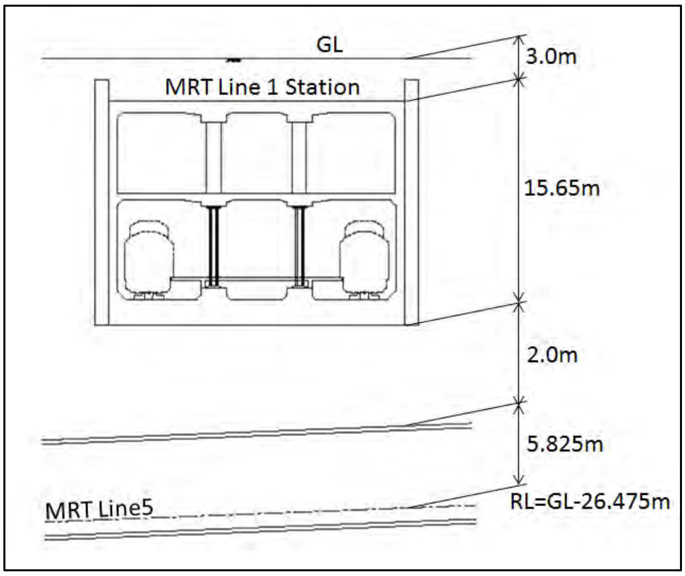
Source： JICA Study Team

Figure 4.1.14 Control Point at Gulshan Lake

(5) Intersection with MRT Line 1

At the chainage of 17k900m of MRT Line 5, MRT Line 5 crosses MRT Line 1. In this section, MRT Line 1 is the underground railway, and MRT Line 5 passes under MRT Line 1.

Regarding the height, MRT Line 1 has the station section at the intersection, and the distance of 2.0 m is secured from the lower end of the station structure to the upper end of the tunnel. As a result, the RL of MRT Line 5 is GL-26.475 m.



Source： JICA Study Team

Figure 4.1.15 Control Point at Intersection with MRT Line 1

2) Vertical Alignment Plan

After the height of the station section is decided, the vertical alignment connects the stations while considering the control points. The gradient is kept as gentle as possible. In addition, the gradient at the station section is level.

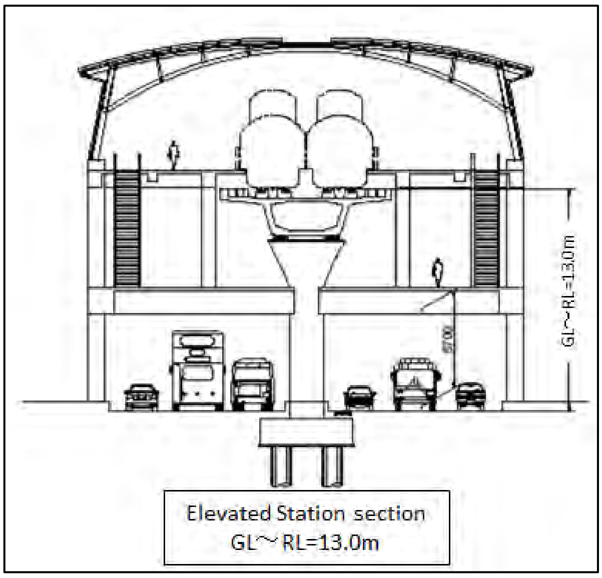
In the underground section, sag point is not provided between the stations, and the minimum gradient is set to 2‰. Thus, basically the tunnel leakage collecting point is set at the station. However, as for the intersection with Turag River and the intersection with the up line and south route after Gabtoli station, the sag is unavoidably provided between the stations. And tunnel leakage will be discharged by lift up pump which is installed in tunnel sag point.

The required height at the station section is shown in the following figure, and the height from GL to RL is 13.0 m or more for the elevated stations. As for underground stations, the height from GL to RL for the 2-layer underground station is 16.87 m or more, and the height from GL to RL for 3-layer underground station is 22.97 m or more.

Table 4.1.4 Structural Form of Underground Stations

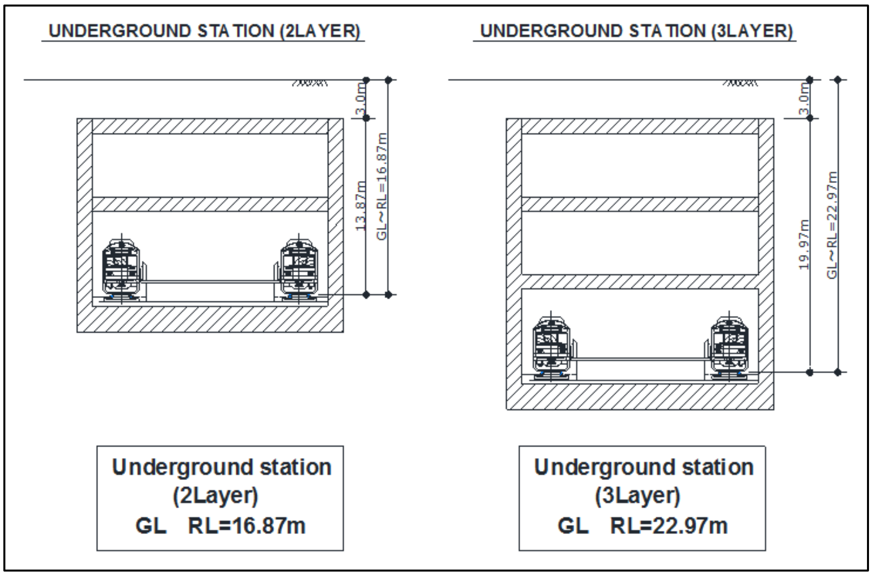
Station	Structural form	Remarks
Gabtoli	3 layer	
Dar-us-Salam	2 layer	
Mirpur1	2 layer	
Mirpur10	3 layer	
Mirpur14	2 layer	
Kochukhet	2 layer	
Banani	4 layer	Vertical parallel station with up and down lines
Gulshan2	3 layer	
Notun Bazar	3 layer	

Source : JICA Study Team



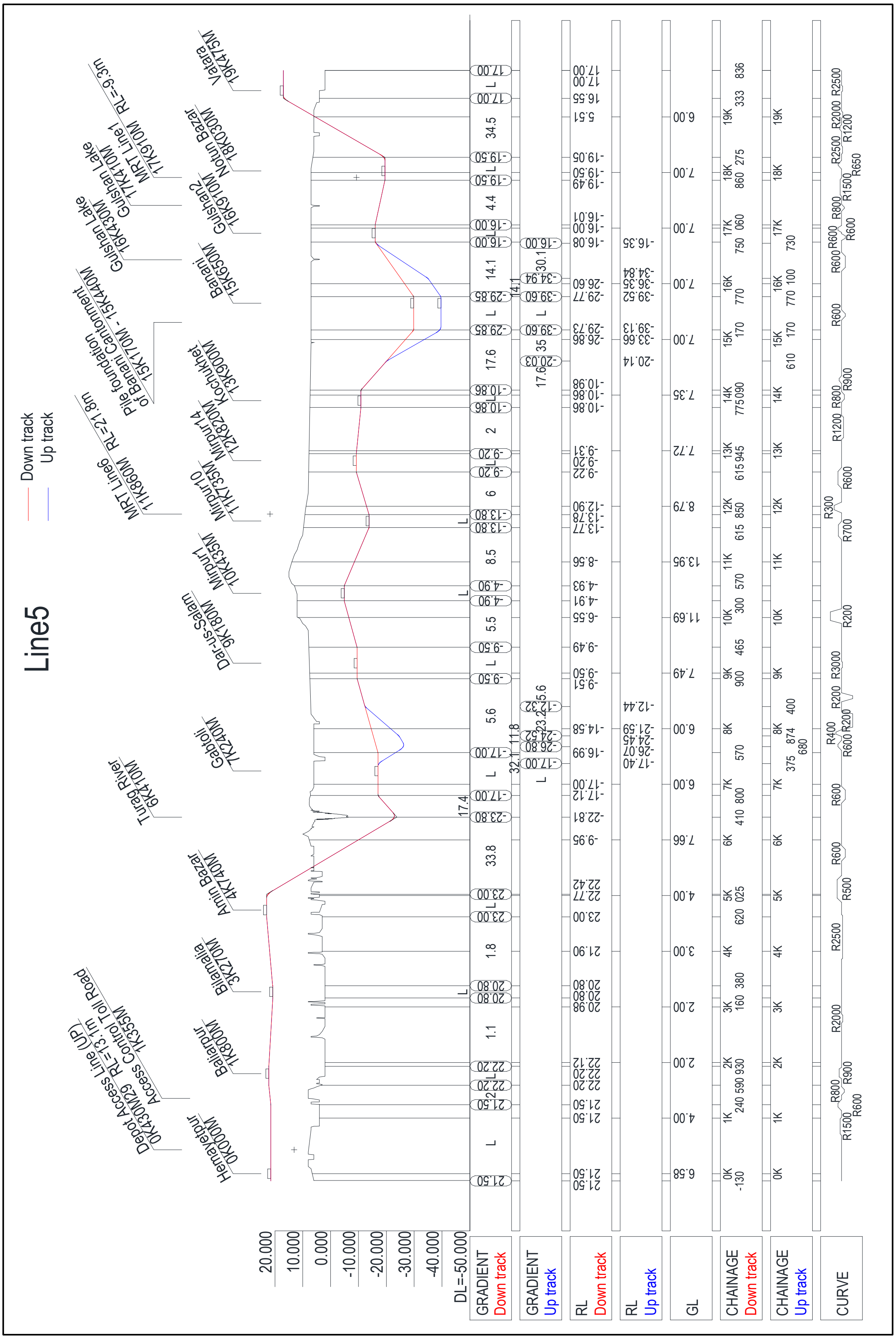
Source : JICA Study Team

Figure 4.1.16 Required Height at Elevated Station



Source : JICA Study Team

Figure 4.1.17 Required Height at Underground Station



Source： JICA Study Team

Figure 4.1.18 Plan and Profile

4.1.5 Station Location

The station should be placed at approximately every 1km, in general. In consideration of horizontal alignment, vertical alignment, demand center, and connection with other lines, the station location positions are shown in the table below.

Table 4.1.5 Station Location

	No.	Station	Location	Distance	Remarks
Elevated	1	Hemayetpur	0k000m		Station in straight section as close as possible to urban area in west side
				1.8km	
Elevated	2	Baliarpur	1k800m		Intersection with PPP road before station, station location as far as possible on the west side considering vertical alignment at intersection
				1.47km	
Elevated	3	Bilamalia	3k270m		Near the center between Baliarpur station and Amin Bazar station
				1.47km	
Elevated	4	Amin Bazar	4k740m		Transition section after station, station location is determined by the position of transition section.
				2.5km	
Underground	5	Gabtoli	7k240m		Located at the current Gabtoli bus terminal position
				1.94km	
Underground	6	Dar-Us-Salam	9k180m		Near the center between Gabtoli station and Mirpur1 station
				1.255km	
Underground	7	Mirpur1	10k435m		Location to avoid monument in roundabout
				1.3km	
Underground	8	Mirpur10	11k735m		Station location as close as possible to MRT Line6, considering the connection with MRT Line6. Curve of R300m to the east side of Line6, station installation is impossible.
				1.085km	
Underground	9	Mirpur14	12k820m		Near the center between Mirpur10 station and Kochukhet station
				1.08km	
Underground	10	Kochukhet	13k900m		Box culvert after station, station location as far as possible to east side, avoiding box culvert. Station arrangement within Banani Cantonment is not allowed.
				1.75km	
Underground	11	Banani	15k650m		Bangladesh Railway and Plan of BRT Line3 before station. Station location shall be the position considering the connection with these. Station arrangement within Banani Cantonment is not allowed.
				1.26km	
Underground	12	Gulshan2	16k910m		Considering the accesibility to commercial buildings in Gulshan2 Circle, station is located in the center of the circle.
				1.12km	
Underground	13	Notun Bazar	18k030m		Station location as close as possible to MRT Line1, considering the connection with MRT Line1. East side of MRT Line1, considering the accesibility to market.
				1.445km	
Elevated	14	Vatara	19k475m		Transition section before station, station location is determined by the position of transition section.

Source： JICA Study Team

Table 4.1.6 Station Location Map

ST1: Hemayetpur

ST2: Baliarpur

ST3: Bilamalia

ST4: Amin Bazar

ST5: Gabtoli

ST6: Dar-us-Salam

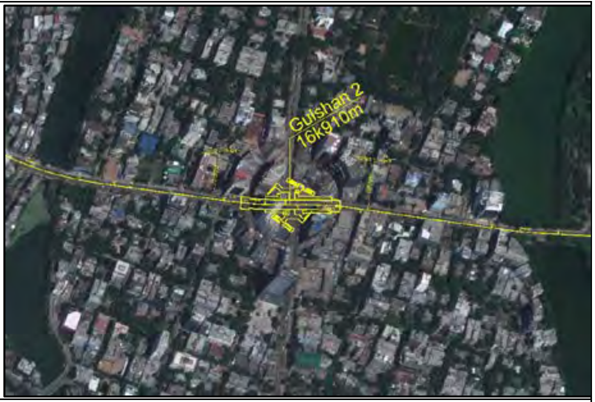
ST7: Mirpur1

ST8: Mirpur10

ST9: Mirpur14

ST10: Kochukhet

ST11: Banani



ST12: Gulshan2

ST13: Notun Bazar

ST14: Vatara

Source： JICA Study Team

4.1.6 Schematic Proposed Alignment (Plan, Longitudinal) and Track Layout

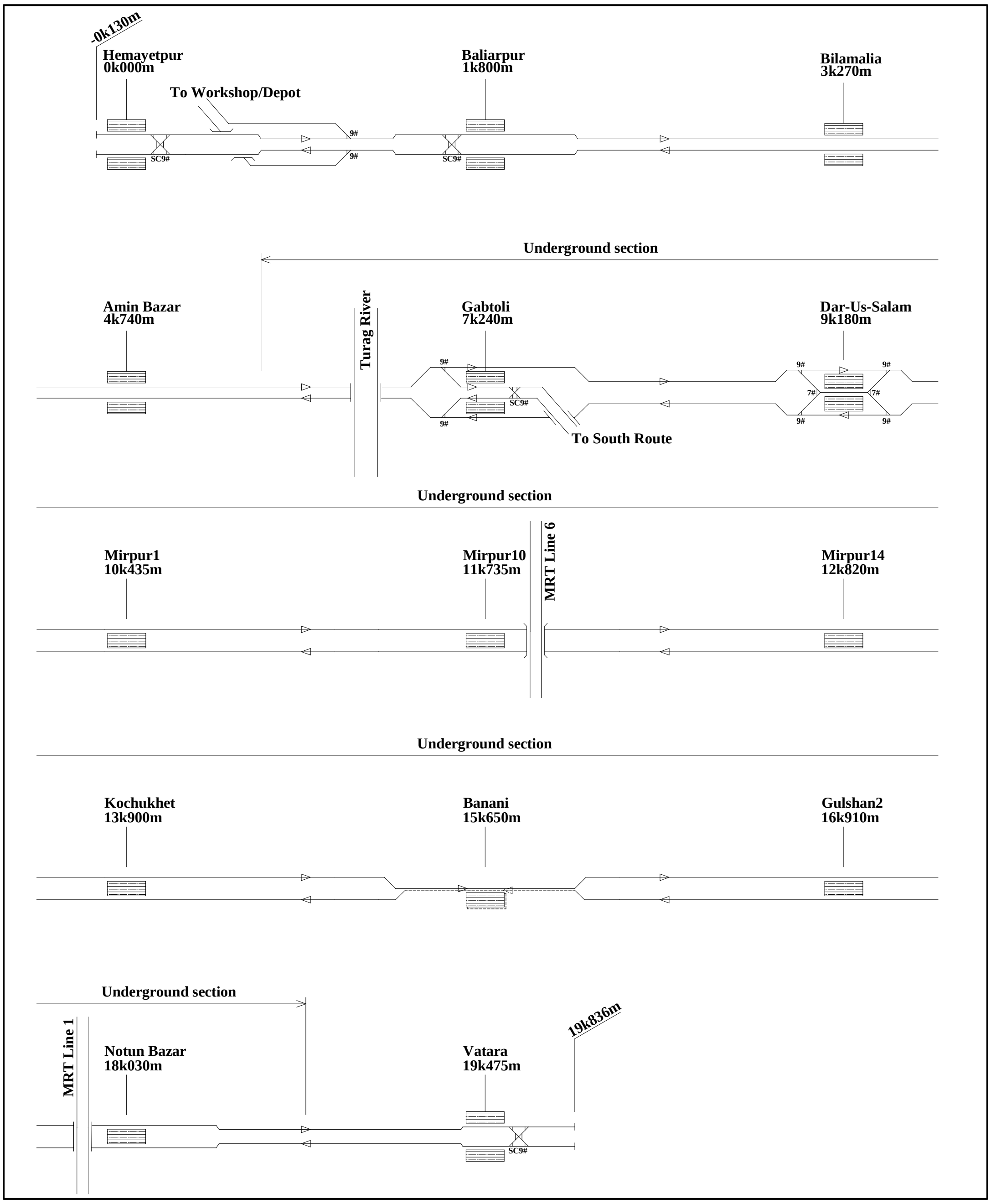
Basically, the station layout is 2 separate platforms serving 2 tracks for the elevated station, and 1 island platform serving 2 tracks for the underground station. However, the following stations will have some exceptions.

- Gabtoli station is a junction station of North Route and South Route of MRT Line 5 and it is an underground station of 2 island platforms serving 4 tracks. Station layout is “same direction operation on one platform” considering the transfer convenience of passengers. Therefore, the north route of up line and the south route are grade separated after the station.
- Because Dar-us-Salam station is located near the center of the route of MRT Line 5 and the road width is wide, the track layout of 2 island platforms serving 3 tracks underground station with common passing siding is selected. By providing common passing siding, it is possible to perform turn-back operation in emergency such as stabling of broken car or accident.
- Since the road width is narrow at Banani station, the track layout is 1 platform serving 1 track, vertically arranged parallel up and down line, in order to reduce the width of the station structure.

Also, at the terminal stations of Hemayetpur Station and Vatara Station, the scissors crossing for turn-back operation is installed. Hemayetpur station has a future plan for westbound extension, and at the time of extension, the turn-back operation at this station disappears and the scissors crossing is removed. And, in order to locate the station as far as possible to the west side, scissors crossing is set in front of station. Although there is an extension plan at Vatara station in near future, turn-back operation can be carried out at Vatara station considering the passenger convenience in Phase1. Therefore, considering passenger convenience, scissors crossing is inserted behind the station, and the turn-back track for 1 train length is set behind the station.

In addition, the scissors crossing is inserted into the south route of Gabtoli station assuming turn-back operation.

The branch line to the depot will be set between Hemayetpur station and Baliarpur station. Considering the operation from Hemayetpur station to depot via Baliarpur station, scissors crossing for turn-back operation is inserted before Baliarpur station.



Source： JICA Study Team

Figure 4.1.19 Track Layout

4.1.7 Connection with other MRT Line

1) Link line between MRT Line1 and MRT Line5

Link line is a railway facility that connects with MRT Line 1 and MRT Line 5 at Notun Bazar (MRT Line 1: Notun Bazar) station. The plan of link line should consider the following points.

- The depot and workshop of both MRT Line 1 and MRT Line 5 have plans to install the stabling lines, inspection line and inspection functions. For this reason, depot and workshop facilities do not need to be planned for mutual use by both the lines.
- Both depots of MRT Line 1 and MRT Line 5 are located approximately 20 km from Notun Bazar station. Thus, long time is required to stable the rolling stocks at either depot. So, link line is not required to be used regularly.

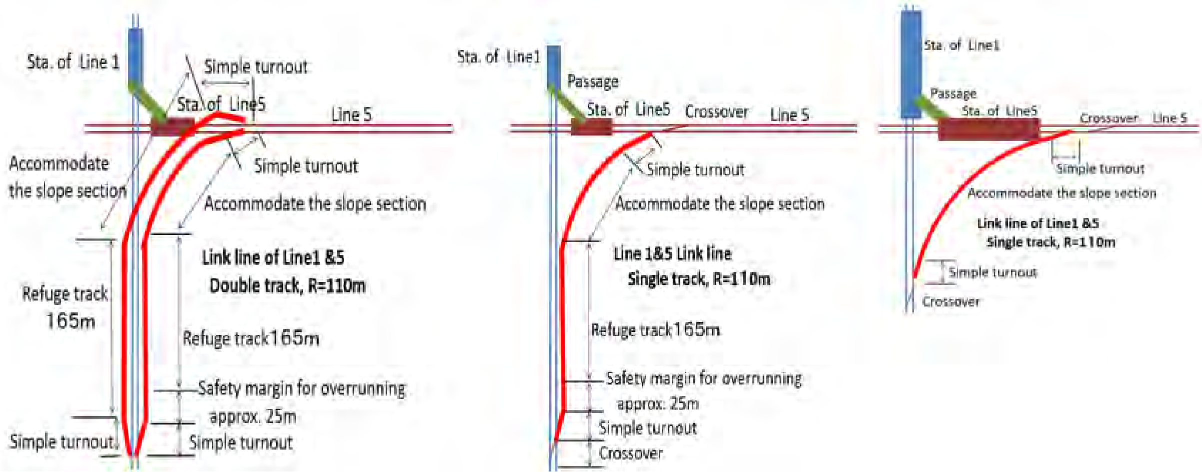
The following table shows the functions and required facilities for 4 types of proposed Link line, namely, Double track plan, and Single track plan -1, 2 and 3. The layout of each type is shown in Figure 4.1.20.

Table 4.1.7 Functions and Required Facilities for Link Line

Item	Functions of Link line	Required facilities for Link line	Specifications of Rolling stocks
Double track plan	It does not interfere with normal operation, and can deadheads the Rolling stocks of MRT Line 1 and MRT Line 5 each other.	It should install the turnout at the upper and lower tracks of both main line of MRT Line 1 and MRT Line 5, and install Refuge track* at Link line. (Figure 4.1.20 Left)	the common specifications of Rolling stocks for MRT Line 1 and MRT Line 5 should be applied.
Single track plan-1	It can deadhead Rolling stocks of MRT Line 1 and MRT Line 5 each other at off-peak hour.	It should install the turnout at both main line of MRT Line 1 and MRT Line 5, and install Refuge track* at Link line. (Figure 4.1.20 Center)	Ditto
Single track plan-2	It can deadheads Rolling stocks of MRT Line 1 and MRT Line 5 each other after the close of operation hour.	It should install the turnout at both main line of MRT Line 1 and MRT Line 5. (Figure 4.1.20 Right)	Ditto
Single track plan-3	It can deadheads the maintenance cars (Track inspection car, Electric inspection car or Rail grinding machine etc.) of MRT Line 1 and MRT Line 5 each other after the close of operation hour.	Ditto	The common specifications of Rolling stocks for MRT Line 1 and RT Line 5 need not to be applied.

Note * : Refuge track should be installed in order to avoid the delay of trains for other Line.

Source: JICA Study Team



(Double Track Plan) (Single Track Plan-1) (Single Track Plan-2 and 3)

Source: JICA Study Team

Figure 4.1.20 Link Line Plan

Based on the above discussion, it can be concluded that as follows;

- Double track plan and Single track plan-1 needs long cut and cover tunnel construction, thus the construction cost will be expensive than others.
- Single track plan-2 is a case that the common specifications of rolling stocks are applied, and the Link line can deadhead Rolling stocks of MRT Line 1 and MRT Line 5 each other.
- Single track plan-3 is a case that the common specifications of rolling stocks are not applied, and the functions of Link line will be restricted to deadhead the maintenance cars.

For these reasons, Single track plan-2 or plan-3 are appropriate for Link line.

2) Connection between MRT Line 2 and MRT Line 5

The connection between MRT Line 2 and MRT Line 5 is studied in METI Study, and it is concluded that MRT Line 2 and MRT Line 5 are connected at Gabtoli station. However, in that report Gabtoli station has been considered as an elevated station, which is different from the current situation. In this survey, on the premise that Gabtoli station is an underground station, the connection between MRT Line 2 and MRT Line 5 is examined.

(1) Preconditions for Study

Gabtoli station is an underground station with 2 island platforms serving 4 tracks. The size of the underground station structure is 616 m in length and 38m in width, and the structure is constructed by cut and cover method. Although it is conceivable to change the track layout and location of Gabtoli station in considering the connection with MRT Line 2, in that case, the Gabtoli station cannot fit within the site of the existing bus terminal and many obstacles of buildings occur. Detailed study including track layout and location should be conducted by another study, and in this study, connection plan is proposed without changing the track layout and location of Gabtoli station.

In addition, in case of connecting in the underground section, it is necessary to make the branch section by the cut and cover method or use the special section shield method. Since new building obstacles occur and the difficulty of construction increases, the connection in the underground section is not adopted in this study.

It is considered that, Gabtoli station of MRT Line 2 is an underground station and it is located on the south side of Gabtoli station of MRT Line 5.

Though it is possible to construct the MRT Line 2 Gabtoli station without any rolling stock connection, but in that case, MRT Line 5 depot can never be used by MRT Line 2 rolling stocks. Considering difficulty in obtaining depot site for MRT Line 2, rolling stock connectivity is considered.

As the underground connectivity is quite difficult, connection after Gabtoli station is not considered. Thus, connection is proposed at overground near Amin Bazar Station. The three possible options are shown below.

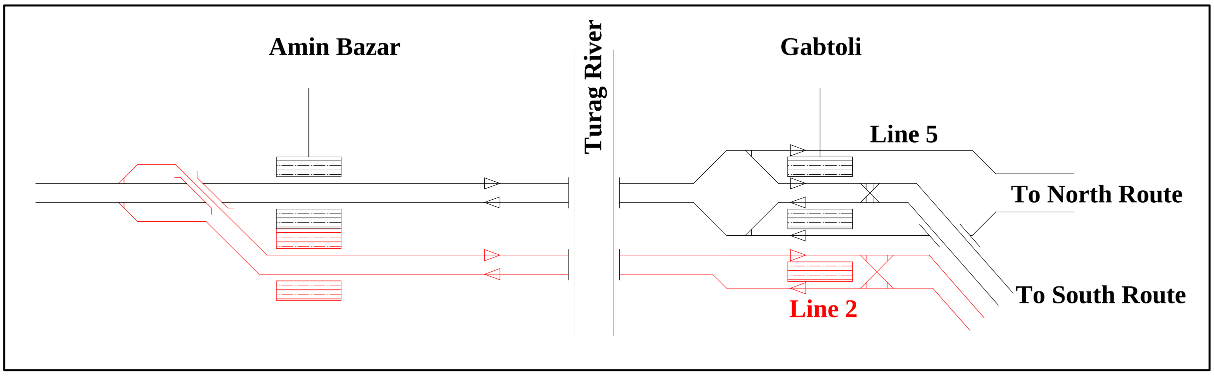
(2) Connection Plan

【Alt.1】

Amin Bazar station of MRT Line 2 is located on the south side of Amin Bazar station of MRT Line5, and between Amin Bazar station and Gabtoli station, MRT Line 5 and MRT Line 2 run in parallel. MRT Line 5 and MRT Line 2 are connected in grade separation before Amin Bazar station.

Although there is no need to move the location of Amin Bazar station and there is no need to change the track layout of MRT Line 5, the construction cost increases due to an elevated facility for the grade separation and Amin Bazar elevated station of MRT Line 2.

Since MRT Line 5 and MRT Line 2 are connected in grade separation, through operation of MRT Line 2 to MRT Line 5 is possible.



Source : JICA Study Team

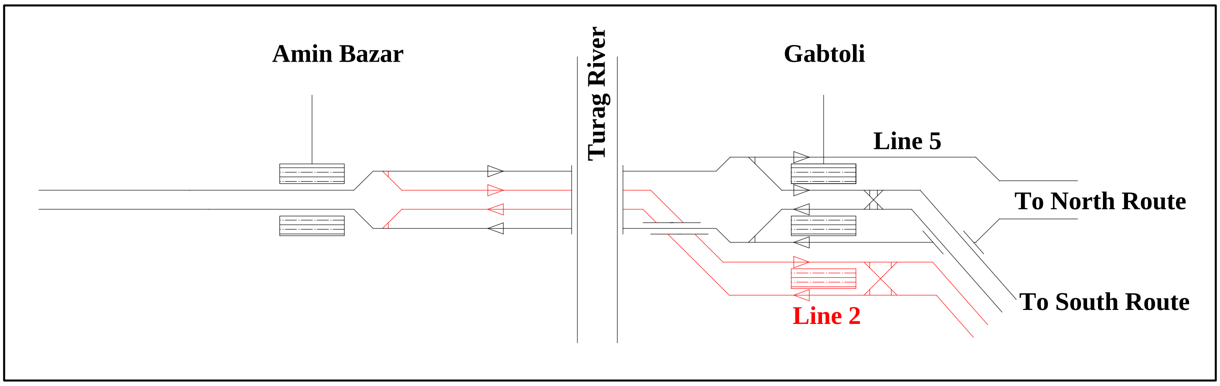
Figure 4.1.21 Connection between MRT Line 2 and MRT Line 5 (Alt.1)

【Alt.2】

Between Amin Bazar station and Gabtoli station, the distance between the up line and the down line of MRT Line 5 is expanded, and MRT Line 2 is placed between the both lines. Grade separation of MRT Line 5 and MRT Line 2 is built before Gabtoli station. The connection point with MRT Line 5 is after Amin Bazar station.

In the case of Alt.2, it is necessary to expand the distance between the up line and the down lines of MRT Line5 in advance, as for Amin Bazar station, a level section for inserting turnouts is required, and it is necessary to move the station toward Bilamalia station. Due to moving Amin Bazar station toward Bilamalia station, the distance between Amin Bazar station and Gabtoli station will be even longer.

Since MRT Line 5 and MRT Line 2 are connected in grade separation, through operation of MRT Line 2 to MRT Line 5 is possible.



Source : JICA Study Team

Figure 4.1.22 Connection between MRT Line 2 and MRT Line 5 (Alt.2)

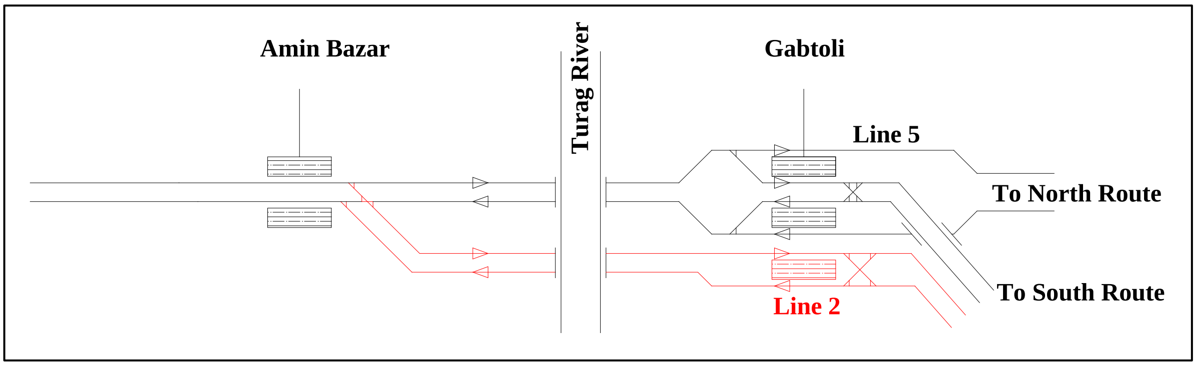
【Alt.3】

Between Amin Bazar station and Gabtoli station, MRT Line 5 and MRT Line 2 run in parallel. MRT Line 5 and MRT Line 2 are connected in level crossing after Amin Bazar station.

As for Amin Bazar station, a level section for inserting turnouts is required, and it is necessary to move the station toward Bilamalia station. Due to moving Amin Bazar station toward Bilamalia station, the distance between Amin Bazar station and Gabtoli station will be even longer.

Since MRT Line 2 and MRT Line 5 are connected in level crossing, there is no need for a large elevated facility compared to Alt.1, and construction costs can be kept lower. However, there is restriction for through operation of MRT Line 2 to MRT Line 5. In the case of Alt.3, the operation of MRT Line 2 is basically turn back operation at Gabtoli station, and the connection with MRT Line 5 is for sharing the depot of MRT Line 5.

This issue will be discussed in detail design stage with DMTC and Line2 design consultant.



Source : JICA Study Team

Figure 4.1.23 Connection between MRT Line 2 and MRT Line 5 (Alt.3)

4.2 Civil Structure

4.2.1 Overall

1) Major Structure Types of MRT Line 5

Structure types of MRT Line 5 are classified into three based on the circumstances along the railway route.

(1) Type 1 (Hemayetpur station to Amin Bazar station)

Railway structures are planned to locate within the ROW of RHD along the current road. ROW of RHD has a width of at least 200 feet, and there is a plan to construct an access control highway between Gabtoli and Nabinagor within the RHD ROW.

Because railway structures have to be constructed within the ROW of RHD along with the access control highway, viaduct structure with column type pier is applied in this section.

(2) Type 2 (Amin Bazar station to Notun Bazar station)

Based on route comparison study mentioned in earlier chapter, shield tunnel is applied in this section.

(3) Type 3 (Notun Bazar station to Vatara station)

Viaduct structure with column type pier is applied in this section, and it is to be constructed on road divider median.

(4) Type 4 (On the road near Baliapur)

Three continuous bridge is applied since alignment is crossing on the existing road (Dhaka Aricha Highway).

2) Applicable Technical Standards

Technical standard for Dhaka MRT to be applied is “Technical Standards for the Metrorail in Bangladesh” which was formulated under the study named “Preparation of Rules and Regulations under Urban Mass Rapid Transit Act” in 2015 by JICA. For other technical standards required during detail design in addition to above standard, the following standards shall be applied.

- Design Standards for Railways Structures and Commentary “Concrete Structures”, published in 1999 ~ edited by Railway Technical Research Institute, Japan
- Design Standards for Railways Structures and Commentary “Foundation Structures”, published in 2000 ~ edited by Railway Technical Research Institute, Japan
- Design Standards for Railways Structures and Commentary “Shield Tunnel”, published in 2002 ~ edited by Railway Technical Research Institute, Japan
- Design Standards for Railways Structures and Commentary “Cut and Cover Tunnel”, published in 2001 ~ edited by Railway Technical Research Institute, Japan
- AASHTO LRFD Bridge Design Specifications (2007), American Association of State Highway and Transportation Officials, USA
- Eurocode 1: Action on structures- Part2: Traffic load on bridges (2003), European Committee for Standardisation
- Bangladesh National Building Code (2013), Housing and Building Research Institute,

Bangladesh

In addition to above standards, Japanese railway design standards and international standards shall be applied as necessary.

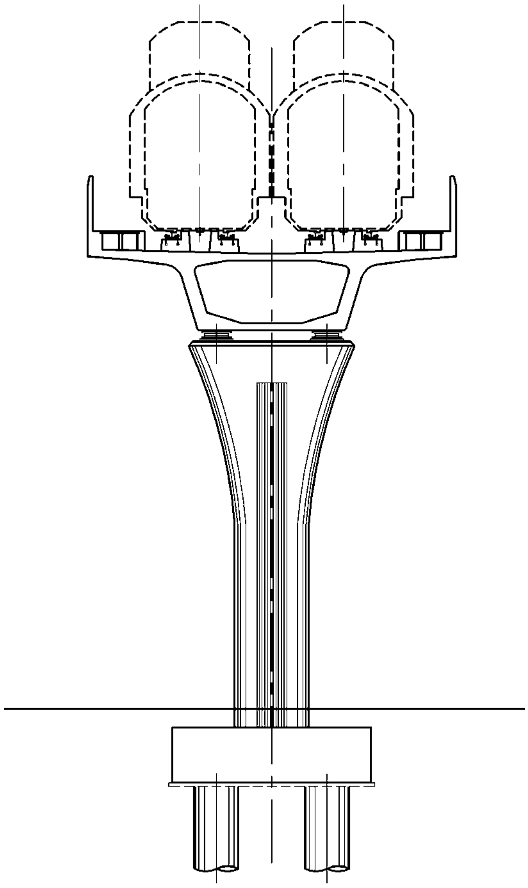
4.2.2 Elevated Section Structures

1) Selection of Substructure

Substructure type is selected as RC pier with single column as following figure. The main reasons are as follows;

- The occupation width of the bridge pier can be minimized, and the space under girder can be effectively utilized.
- The appearance of the structure is slender, and there is no feeling of pressure by the elevated structure.
- Since work space for substructure construction work is minimized, it is possible to reduce the influence on the road traffic during construction.

Based on the geotechnical survey, pile foundation is the most suitable considering that bearing layer is located at 40 m depth from the existing ground level. And pile diameter is applied as 1.2 m to 1.5 m, and the number of piles shall be as less as possible (that is, four numbers).



Source: JICA Study Team

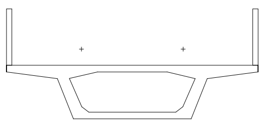
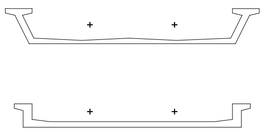
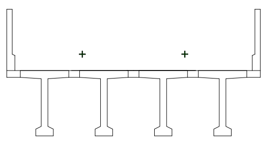
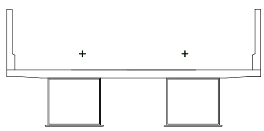
Figure 4.2.1 Standard Cross Section of Pier

2) Selection of Superstructure

Superstructure type is selected as PC Box girder considering structural performance, economy and workability. The standard span of superstructure is considered as 30 m, same as used in MRT Line 6. Other spans are also applied according to circumstances related to surrounding road and intersections. However, maximum span is 45 m considering workability. Comparison table for superstructure is shown in following.

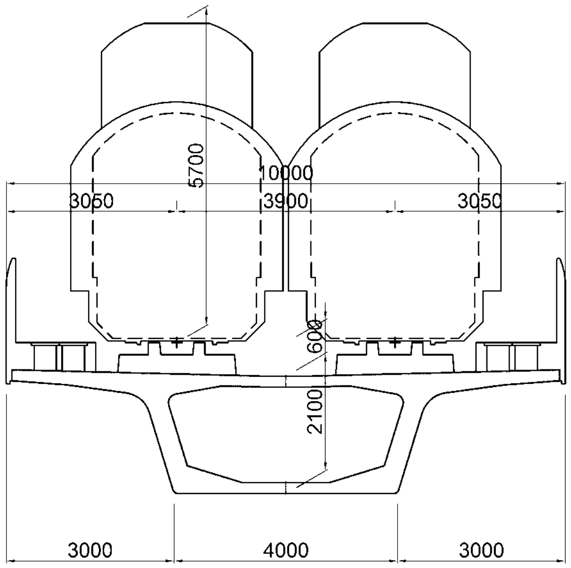
Superstructure is pre-cast segmental structure with erection girder method.

Table 4.2.1 Comparison Table for Superstructure

	Section	Structural	Economy	Workability	Characteristic
PC Box Girder		○	○	○	✓ Curve span can be applied ✓ Economical ✓ Road occupation during construction is minimized ✓ Construction duration is minimized ✓ Easy erection of precast blocks
PC U Girder		△	△	○	✓ Study for deflection of slab is necessary ✓ Not economical ✓ Road occupation during construction is minimized ✓ Construction duration is minimized ✓ Easy erection of precast blocks
PC I Girder		△	○	△	✓ Curve span cannot be applied ✓ Economical ✓ Work space under girder is required for erection by truck. ✓ Form work and concrete work are required for cross beam and slab
Steel Box Girder		△	×	△	✓ Concerning for corrosion ✓ Not economical ✓ Work space under girder is required for erection by truck. ✓ Form work and concrete work are required for cross beam and slab

Source: JICA Study Team

Cable duct (both sides), noise barrier wall, drainage (center of the girder) are installed on the girder surface of the superstructure in addition to the track structure. Formation width is 10 m for both curve span and straight span. Standard cross section of superstructure is shown in following.



Source: JICA Study Team

Figure 4.2.2 Standard Cross Section of PC Box Girder

Noise barrier wall of 1.5 m height from rail level is installed in both edge of girder. Noise barrier wall is made by precast concrete, and it is connected by anchor rebar with girder. By adopting the precast structure, it is easy to control the quality, and it is possible to unify the appearance, and construction period can be minimized.

Source: JICA Study Team

Figure 4.2.3 Precast Noise Barrier

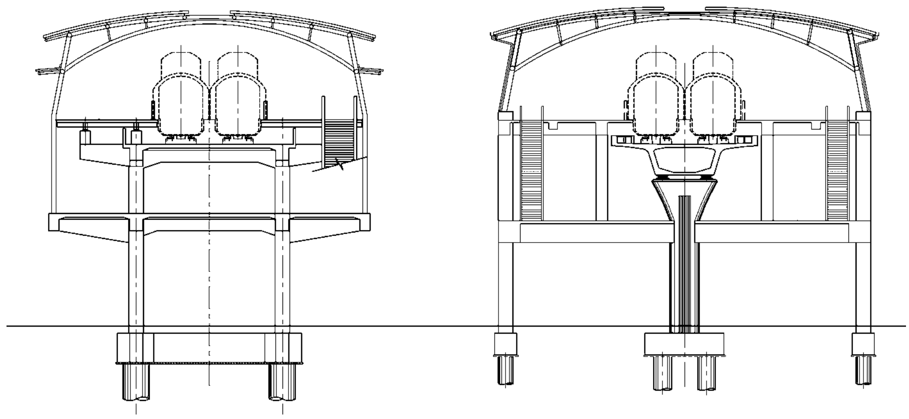
3) Selection of Elevated Station Structure

Generally, the elevated station structure type can be divided into a frame structure type and a girder structure type, but application is decided according to the situation under the station and construction conditions.

For the western section (Hemayetpur station – Amin Bazar station), the station is built at one side of the current road, and no road is located under the station. For that reason, frame structure is adopted since it is economical.

On the other hand, eastern section (Vatara station) is constructed at the center of road, similar to MRT Line 6. For this reason, main substructure is constructed on road divider, and adopted girder type structure which overhangs the concourse.

Frame Structure Type　　Girder Structure Type



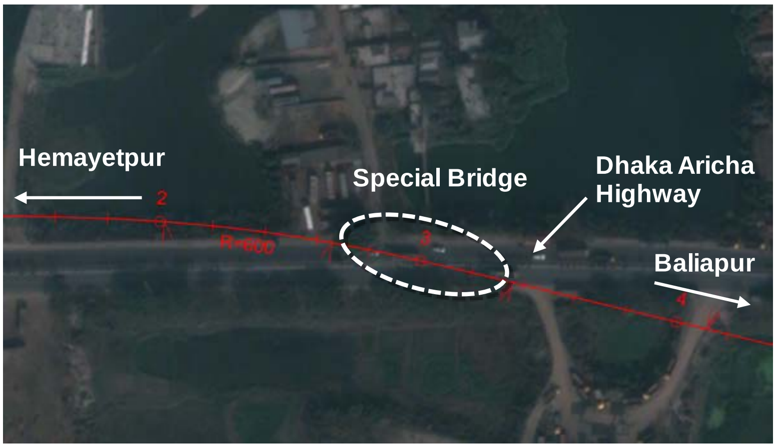
(Western Section: Hemayetpur station to Amin Bazar station)　(Eastern Section: Vatara station)

Source: JICA Study Team

Figure 4.2.4　Cross Section of Elevated Station

4)　Special Bridge

Since the route has to cross over the existing road for shifting alignment from south side to north side at a location between Hemayetpur and Baliarpur, the special bridge is planned on the existing road.

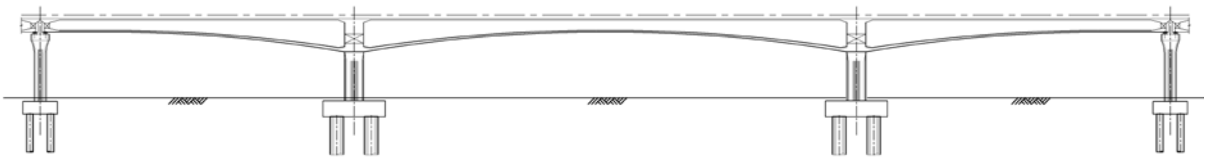


Source: JICA Study Team

Figure 4.2.5　Location of Special Bridge

At the road crossing area, there is plan to develop an access control toll road, but detailed plans such as routes and height are not decided at the moment. In the next stage of Line5, it is necessary to discuss with related organizations and study about detail structure plan.

The structure type of the proposed special bridge is assumed as a multi-span PC continuous bridge as shown below.



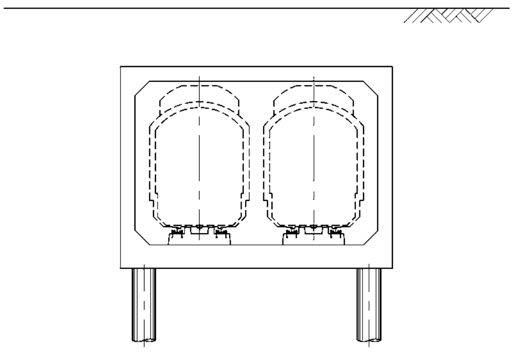
Source: JICA Study Team

Figure 4.2.6 Section of PC continuous bridge

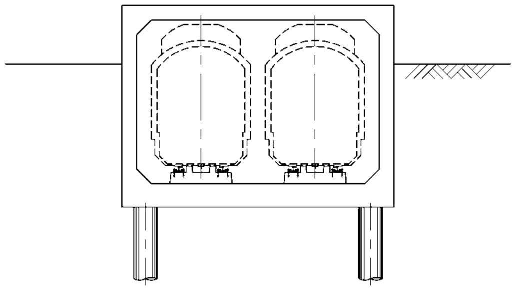
5) Transition Section Structure

The transitional section from the elevated section to the underground section is composed of a box culvert and a U-shaped retaining wall.

(1) Box Culvert (Cut and Cover) Section



(Underground Section)



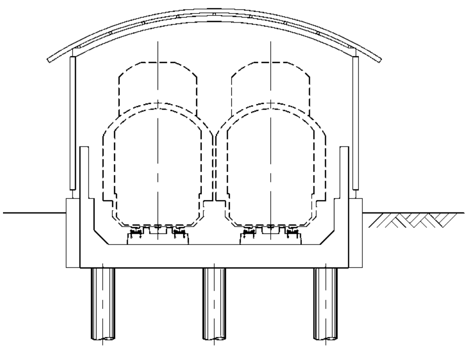
(Half Underground Section)

Source: JICA Study Team

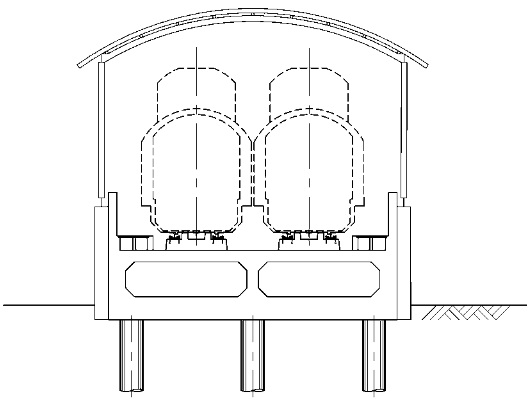
Figure 4.2.7 Cross Section of Box Culvert

Box culvert structure is adopted from end of shield tunnel. The box culvert section is applied until height of edge of the top slab is maximum flood level plus 300 mm (margin).

(2) U Shape Retaining Wall and Half Underground Retaining Wall Section



(U Shape Retaining Wall Section)



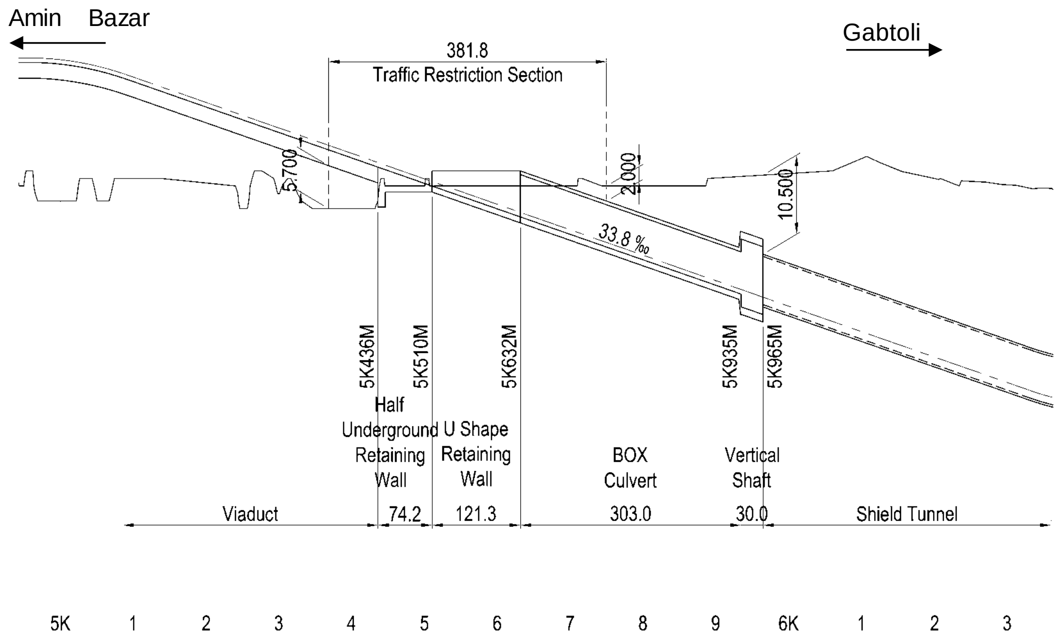
(Half Underground Retaining Wall Section)

Source: JICA Study Team

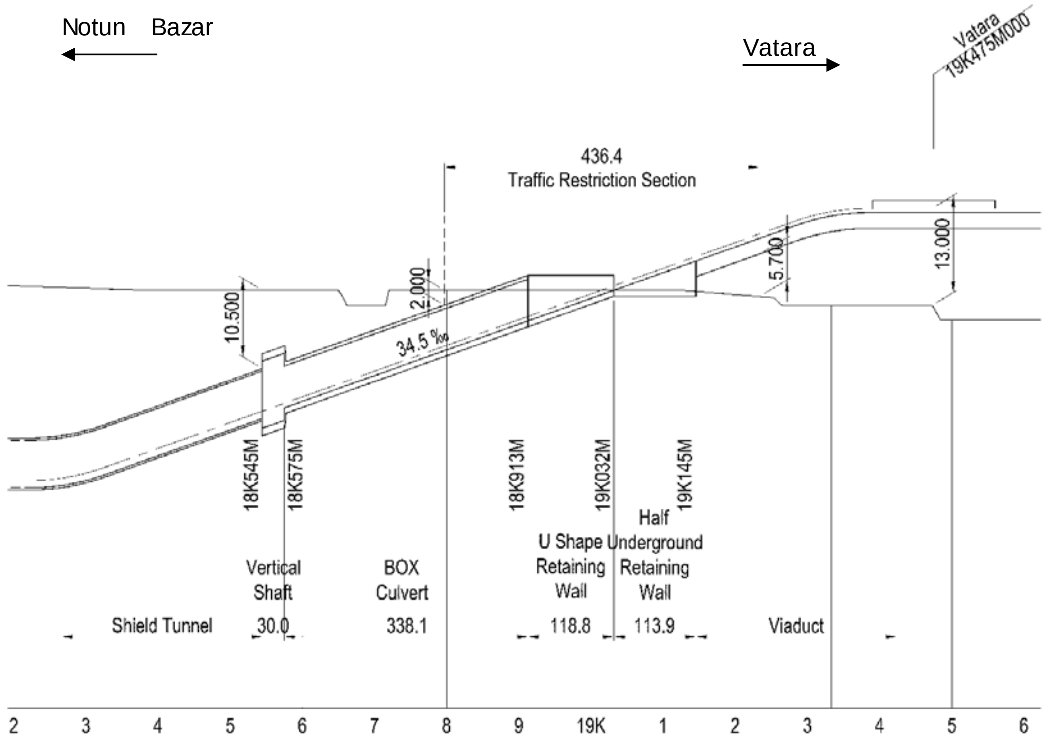
Figure 4.2.8 Cross Section of Retaining Wall

Since the top part of U shape retaining wall is opened, a roof is provided to prevent rainwater entering inside of tunnel. It is applied to section until distance is 4 m from rail level to ground level. After this section, normal viaduct section is adopted.

Detail of transition section in east section and west section is shown below.



(Between Amin Bazar and Gabtoli)



(Between Notun Bazar and Vatara)

Source: JICA Study Team

Figure 4.2.9 Detail Profile of Transition Section

(3) Flood Measures

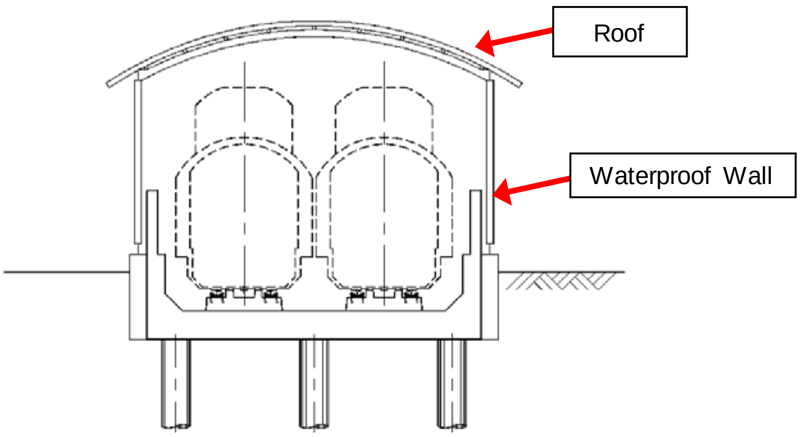
The transition section has a possibility to cause inundation damage to underground tunnels and underground stations. Therefore, it is necessary to take appropriate flood control measures during floods and torrential rains.

Countermeasures against flooding are the following items.

- Provision of waterproof wall considering the flood level against 100-year probability rainfall
- Provision of roof
- Provision of waterproof door at entrance of tunnel
- Provision of drain pump

(Waterproof Wall)

(Waterprrof Door at Entrance)



Source: JICA Study Team based on Tokyo Metro

Figure 4.2.10 Flood Measures in Transition Section

In addition to the hard measures mentioned above, it is also necessary to carry out evacuation guidance drills to minimize damage caused by flooding, as well as public relations activities to users of stations.

The training method for staff will be studied in detailed design by the general consultant in future. Also, the budget should be included in the project cost.

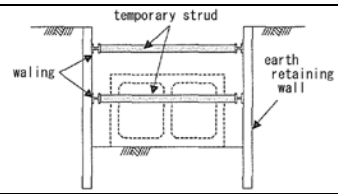
4.2.3 Underground Section

1) Tunnel Plan

(1) Tunneling Methods

Various methods can be applied for tunnel construction under roads in the urban area, namely, shield tunneling method, cut and cover method and mountain tunneling method. These methods are studied for this project. Table 4.2.2 shows the summary of each tunneling method and the applicability of the methods to Line 5.

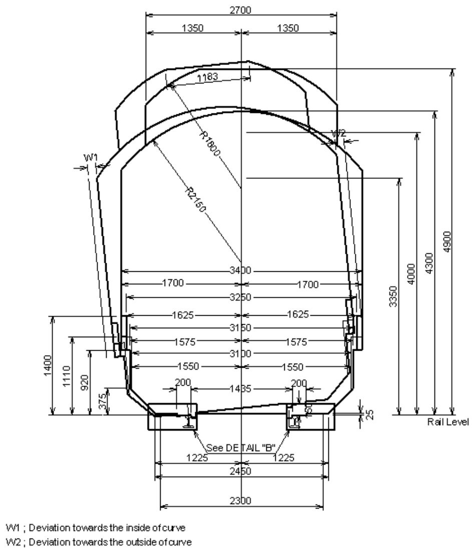
Table 4.2.2 Comparison of Tunneling Methods

	Shield Tunneling	Cut and Cover Method	Mountain Tunneling Method
Summary	Shield machine is driving while securing the stabilization of the face against earth and water pressure with muddy soil or slurry. Segments are assembled to retain the ground and the tunnel is constructed.	The ground is excavated from the surface to the predetermined depth and then the structures are constructed. The ground on top of the structures is backfilled to recover the surface.	The excavation is proceeded by effectively utilizing arch action of the ground around the excavation area while securing the stability of the ground with shotcrete, rock bolts, steel support and so on.
Schematic view			
Applicable Soil	Generally, this method can be applied to the soil conditions from very soft alluvium to diluvium and soft rock. It is relatively easy to adopt to the change of soil condition.	Earth retaining method and auxiliary method are adopted in accordance with specific soil condition.	Generally, this method is adopted for soft rock and hard rock.
Adaptability to Line 5	This method is suitable for the existing soil conditions and the impact on the current traffic can be minimized.	The planned route for construction is located under the heavy-trafficked roads, and if this method is adopted, then the impact on the current traffic is very large. It is not realistic to adopt this method.	This method can't be adapted since the soil is alluvium and the excavation ground cannot be stabilized.
Judgment	○ (good)	× (not good)	× (not good)

Source: JICA Study Team

(2) Construction Gauge for Vehicle

The inner diameter of the tunnel shall be determined based on the construction gauge shown below.



Source: JICA Study Team

Figure 4.2.11 Construction Gauge for Vehicle

(3) Type of Tunnels

Type of tunnels is categorized into single-track cross-section and double-track cross-section. In this project, single-track cross-section shall be applied considering the characteristics indicated below. The following section explains the shape of the single-track and double-track tunnel and the reasons for the selecting single-track as the type of the tunnel.

(a) Shape of Tunnel Cross-section

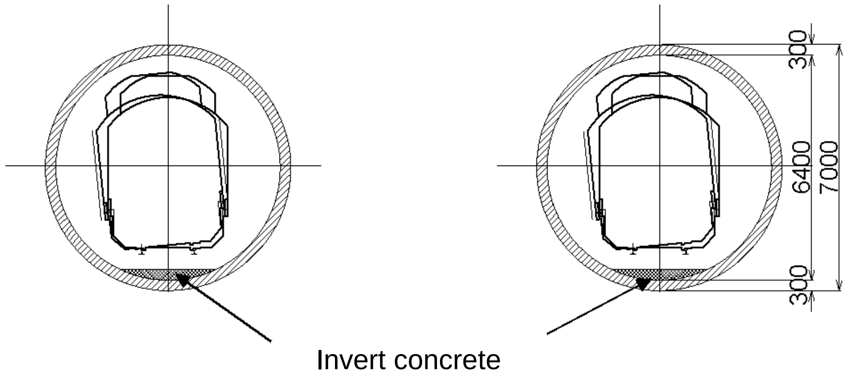
Since single-track cross-section only consists of one track in one tunnel in one direction, two tunnels are necessary for a double track railway. On the other hand, double-track cross-section consists of two tracks in one tunnel. Therefore, one tunnel with large inner diameter is necessary.

Table 4.2.3 shows the quantitative comparison between single-track and double-track. The volume of excavated soil (the amount of surplus soil) and the volume of segment are mostly equal. However, the necessary volume of invert concrete for double-track is 13.5 times more than that for single-track, thus single-track is favorable considering the construction cost.

Table 4.2.3 Comparison of Tunnel Cross Section

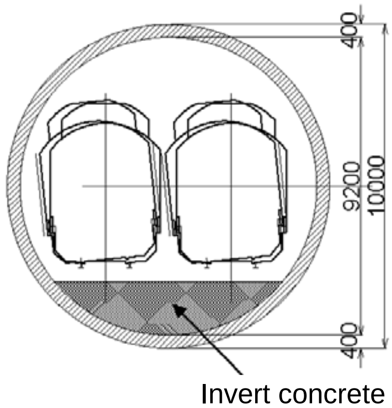
	Single-track tunnel	Double-track tunnel	Evaluation
Cross-section area for excavation	77 m^2	79 m^2 (+2.6%)	Mostly equal
Cross-section area of segment	12.6 m^2	12.1 m^2 (-4.1%)	Mostly equal
Cross-section area of invert concrete	0.6 m^2	8.1 m^2 (13.5 times more)	Cross-section for double-track is extremely large

Source: JICA Study Team



Source: JICA Study Team

Figure 4.2.12 Single-track Cross Section



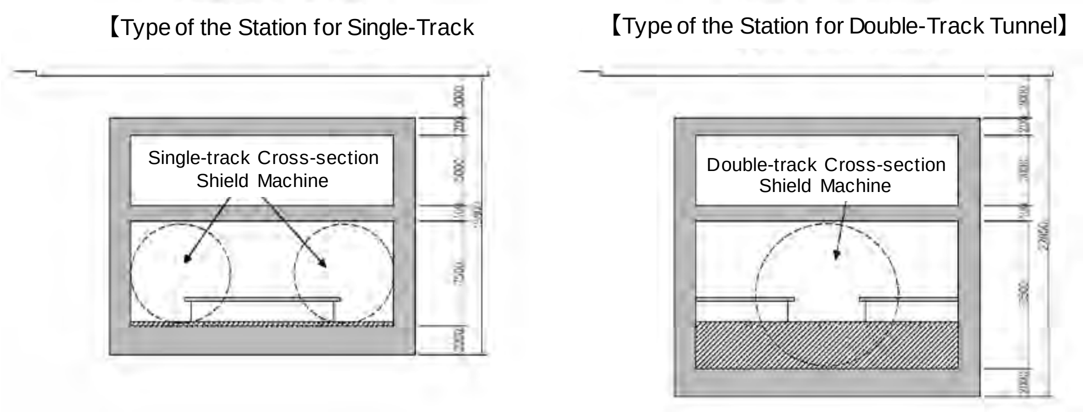
Source: JICA Study Team

Figure 4.2.13 Double-Track Cross Section

(b) Shape of the stations

The tunnel is constructed by reaching the shield machine at the station after the construction of the station framework. The machine is transported to the other side of the station and the machine re-starts tunnel construction. As a result, the shape of the station is large in case of the double-track cross-section tunnel since the height of inner space through which the shield machine is transported must be secured on the platform floor. The type of the station for each cross-section is shown in Figure 4.2.14 If the double-track tunnel is applied, the following inconvenience are expected. Therefore, it is desirable to apply the single-track cross-section tunnel for the shape of the station.

- As the ceiling of the platform floor gets higher, the length of span in the vertical direction gets longer. Therefore, acting stress increases, and the reinforcement volume also increases.
- Since the size of the station gets larger, the volume of excavation and concrete work will increase. Therefore, the construction cost gets larger and the period of construction gets longer.
- Island platform is applied to single-track tunnel and the side platforms are applied to double-track tunnel. The latter requires stairs, escalators and elevators on each platform and the number of facilities will double.
- The station shape for double-track tunnel requires more invert concrete to adjust the height (Refer to Figure 4.2.14)

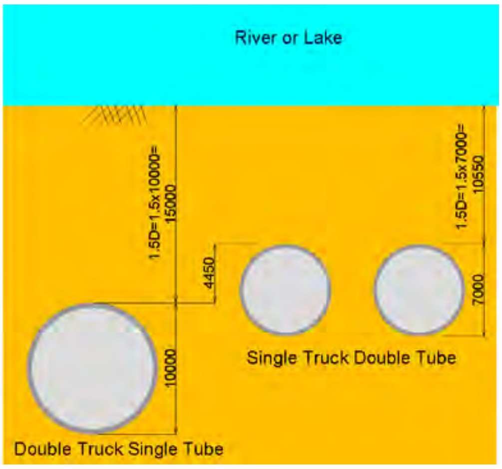


Source: JICA Study Team

Figure 4.2.14 Cross Section of Station Box for Single-track and Double-track Tunnels

(c) Overburden where the tunnel crosses the river or lake

The planned route runs under Turag River, Banani Lake and Gulshan lake. When crossing these, uplifting of the tunnel shall be of especial concern, and a depth of 1.5 D for the overburden load up to the river bed is secured considering the safety against the potential scouring. Therefore, the overburden to be secured in case of double-track cross-section with a large diameter will also be large. Setting sag points between 2 stations shall be avoided in the tunnel alignment to prevent water accumulation, and having a large overburden below the river bed is not favorable. Therefore, double-track cross-section with large tunnel diameter is not favorable.

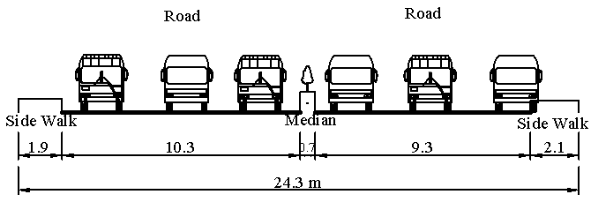


Source: JICA Study Team

Figure 4.2.15 Overburden Depth at the River or Lake

(d) Banani Station

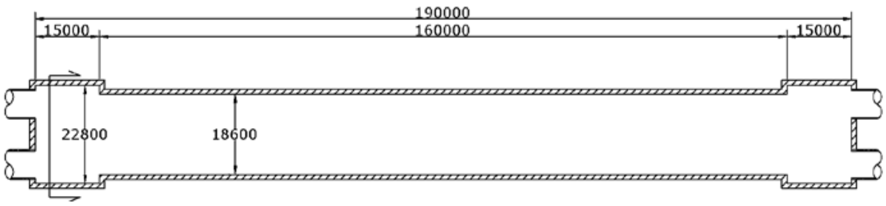
Kemal Ataturk Avenue, where Banani Station is planned to be constructed, is the narrowest road on the planned route and the width of the avenue is 24.3 m including sidewalks according to the site survey. Thus, underground station at Banani needs special considerations.



Source: JICA Study Team

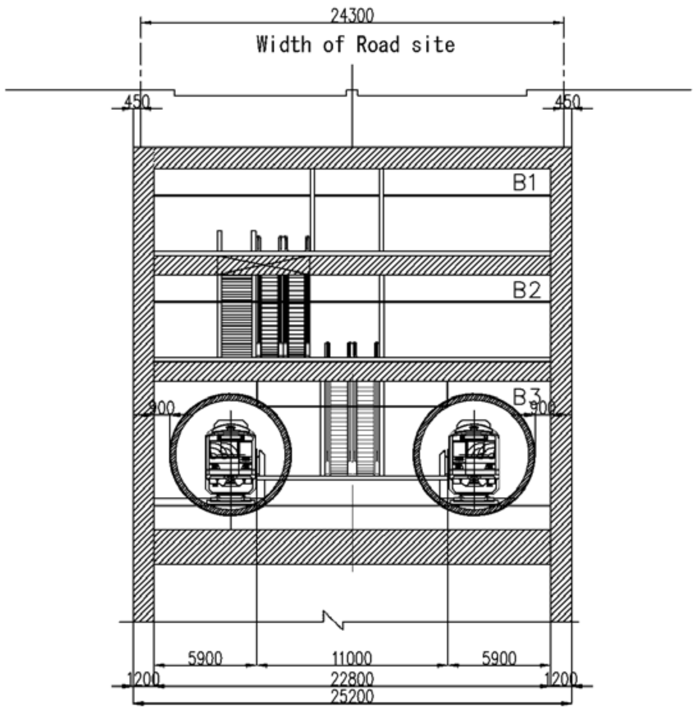
Figure 4.2.16 Current Cross Section of the Avenue

The private property will be acquired for exits/entrances of the station and ventilation towers, but the station itself must be constructed within the road width. As shown in the **Figure 4.2.17**, the width of a typical station is large on both side of the station to secure the space for launching and arrival of the shield machine. If this part including construction clearance can't be fit within the current road site, the station can't be constructed. **Figure 4.2.18** shows that, in case the Banani Station, the cross-section of the structure including launch and arrival part is 950 mm (475 mm each side) wider than the road site. Therefore, double track cross section cannot be applied at this station.



Source: JICA Study Team

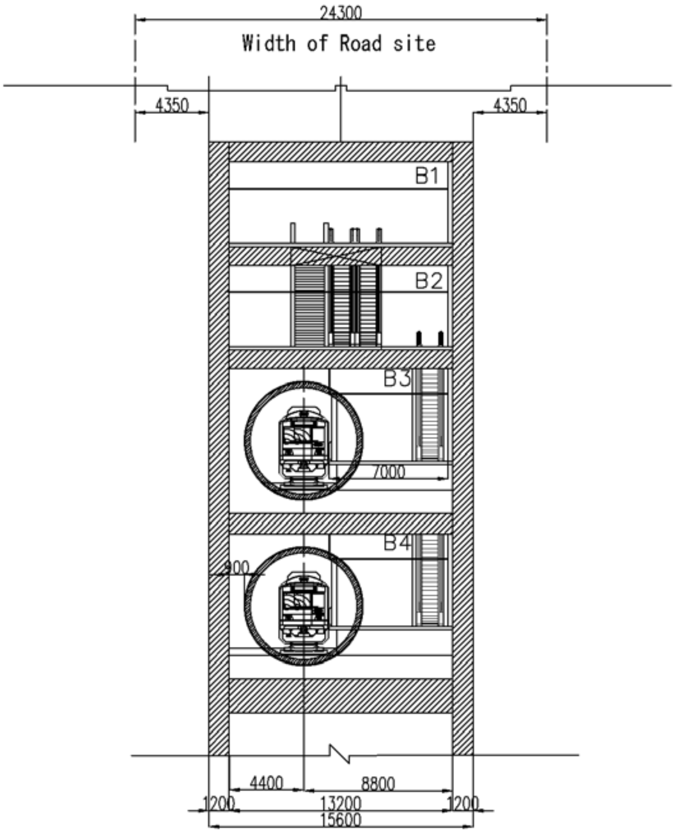
Figure 4.2.17 Plan Layout of a Typical Station



Source: JICA Study Team

Figure 4.2.18 Cross Section of a Typical Station

As a solution, the arrangement of the tunnels can be changed from horizontal parallel to vertical parallel and the platform floor is planned to be increased to two, upper floor and lower floor in order to construct the station within the road site. The shape of the station is shown in **Figure 4.2.19**. Because of this, double-track cross-section can't be applied to this station and single-track cross-section is needed to be applied at least before and after the Banani Station.



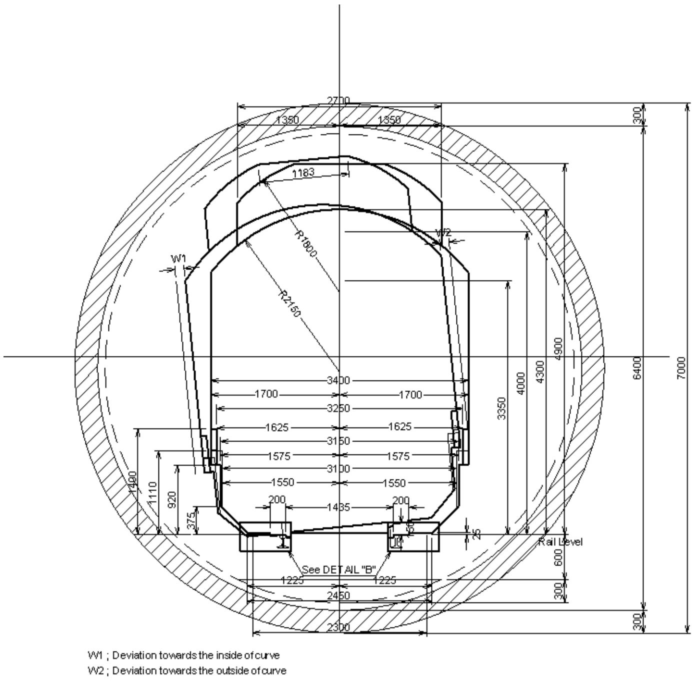
Source: JICA Study Team

Figure 4.2.19 Cross Section of Banani Station

(4) Tunnel Cross-section

(a) Inner Diameter Cross-section

Inner Diameter of the tunnel is determined by securing the construction gauge for vehicles and the space to install facilities including the space for maintenance corridor and by considering the construction errors. Since MRT Line 5 runs under a quiet residential area in Cantonment District, anti vibration track will be applied and 600 mm between RL and FL (Formation Level) and 300 mm from the FL to the bottom surface are secured. In addition, the inner diameter of the tunnel is φ6400 mm considering the construction gauge for vehicles and 100 mm of construction error. These numbers are not fixed yet as the location of facilities inside the tunnel not finalized in details at this point of the study. In the detailed design, the scale and the location of the facilities inside the tunnel as well as the tunnel cross-section shall be reviewed.



Source: JICA Study Team

Figure 4.2.20 Cross-section of Tunnel

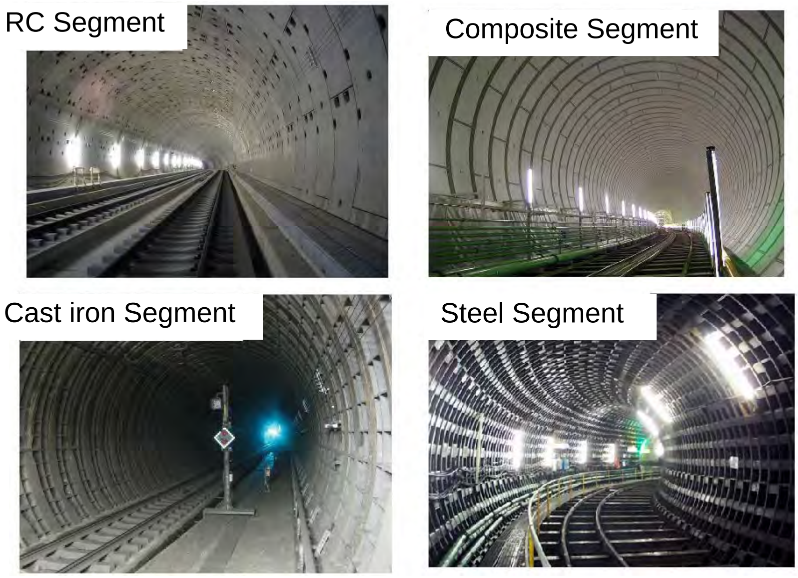
(b) Segments

Types of Segments are categorized into RC segment, Composite segment, Cast iron segment and Steel Segment and each segment has different characteristics. Since there are no special portions, such as heavily loaded portion or sharp curve portion, for the tunnel of MRT Line 5, RC segment will be applied, which is most economical.

Table 4.2.4 Comparison of Tunnel Segments by Type

Type	Characteristics
RC Segment	Highly Economical. Possible to handle various load conditions by adjusting the volume of reinforcing bars. Commonly adopted as the segment for the standard portions.
Composite Segment	Used partially at places where the thickness of the segment has limitation and the heavy load is expected; the type of segment is highly rigid and the thickness of the lining can be thinner.
Cast Iron Segment	Used partially at places where the strong bearing force is required, such as at heavily loaded part or sharp curve part, since the segment is highly rigid.
Steel Segment	Used at the sharp curve or at where the segment is cut open and the welding is required, since it is highly rigid and welding is possible.

Source: JICA Study Team



Source: JICA Study Team

Figure 4.2.21 Photos of Segments

(c) Thickness of the segment

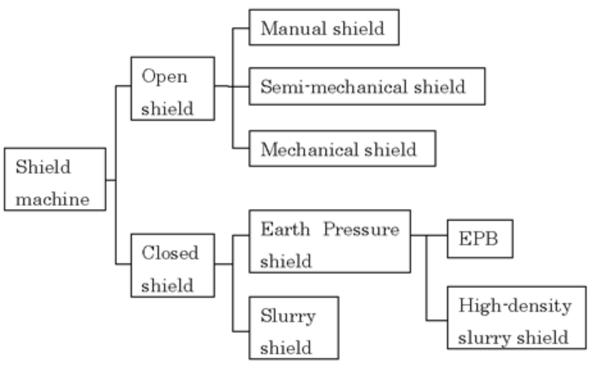
It is desired to make the thickness of RC segment larger than 4% of the tunnel outer diameter based on the performance proven in the past, and the thickness is determined based on this. Therefore,

$$t = (6400 + 2t) \times 0.04 \quad \Rightarrow \quad t = 280 \text{ mm}$$

The segment thickness is rounded up to 300 mm considering safety factor.

(5) Type and method of Shield Machine

There are two types of shield machines; one is closed type shield and the other is open type shield. The open type shield can be used in the condition where there is no water in the ground and the face can be independently stable. However, although there is no water in the ground, the soil for MRT Line 5 is relatively soft according to the results of Geotechnical Investigation (N value of 20~30) and it is difficult for the face to be independently stable. Therefore, in this study, closed type machines like Earth Pressure Balanced (hereinafter: EPB) shield machine and Slurry Shield machine are to be considered.



Source: JICA Study Team

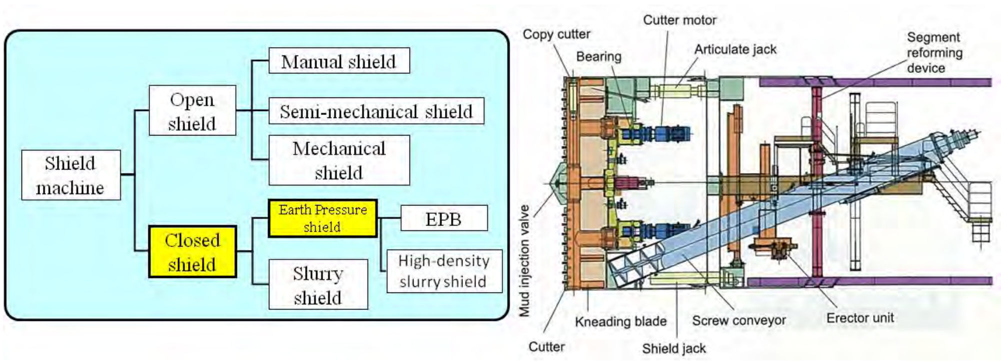
Figure 4.2.22 Types of Shield Machine

(a) Characteristics of Earth Pressure Shield

Earth Pressure Shield machine excavates the ground while securing the face to stabilize by pressurizing the muddy soil inside the chamber with shield thrust force, and discharges the excavated soil with the screw conveyor. This type of shield machine can be categorized into two, EPB (Earth Pressure Balanced) shield machine, which has an inlet for additives to improve the properties of excavated soil, and normal earth pressure shield machine, which doesn't equipped with the mechanism that EPB shield machine has. However, EPB shield machine has been more popular regardless of the use of additives.

Characteristics of face stability mechanism for the Earth Pressure shield machine are as follows;

- For EPB, excavated soils are to be improved to contain plastic flow and water tightness by adding additives and by forcing to mix using the cutter head and blades. Additive will not be applied for normal Earth Pressure shield machine, only mixing is applied.
- Muddy soil is filled in the chamber and screw conveyor, and by pressurizing the muddy soil with shield jack thrust the machine can resist the earth pressure and water pressure acting on the face.



Source: JICA Study Team

Figure 4.2.23 Overview of Earth Pressure Shield Machine

Source: JICA Study Team

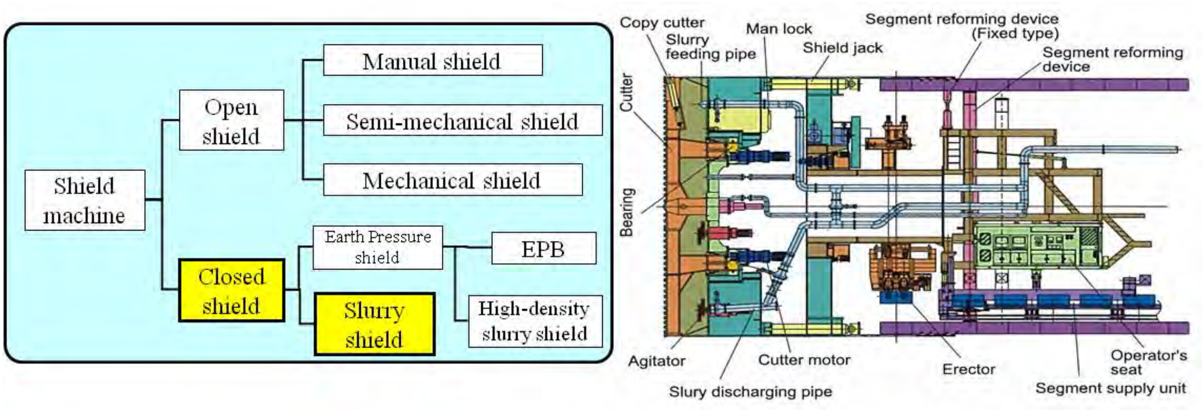
Figure 4.2.24 Reference Photo of Earth Pressure Shield Machine

(b) Characteristics of Slurry Shield

Slurry shield machine excavates the ground while stabilizing the face by pressurizing the slurry inside the chamber using the fluid transporting pump through the discharging pipe, and discharges the excavated soil with the slurry inside the chamber through the discharging pipe.

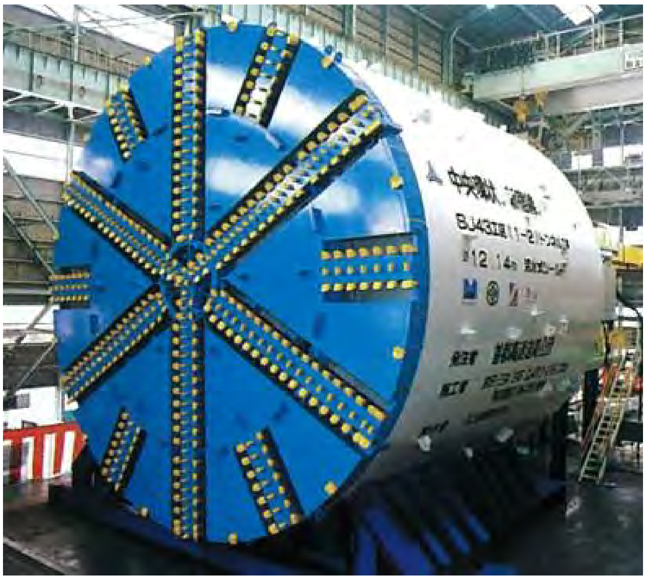
Characteristics of face stability mechanism for the Slurry shield machine are as follows:

- Impermeable mud film is formed on the face so that the pressure can effectively act on the face.
- The strength of the ground will be increased as the slurry penetrates the ground since the fine fractions such as sand and silt penetrate apertures.
- The face can be stabilized by pressurizing the slurry in the chamber that was applying to the face more than the earth/water pressure that was applying on the face while adjusting the speed of rotation for the fluid transporting pump.



Source: JICA Study Team

Figure 4.2.25 Overview of Slurry Shield Machine



Source: JICA Study Team

Figure 4.2.26 Reference Photo of Slurry Shield Machine

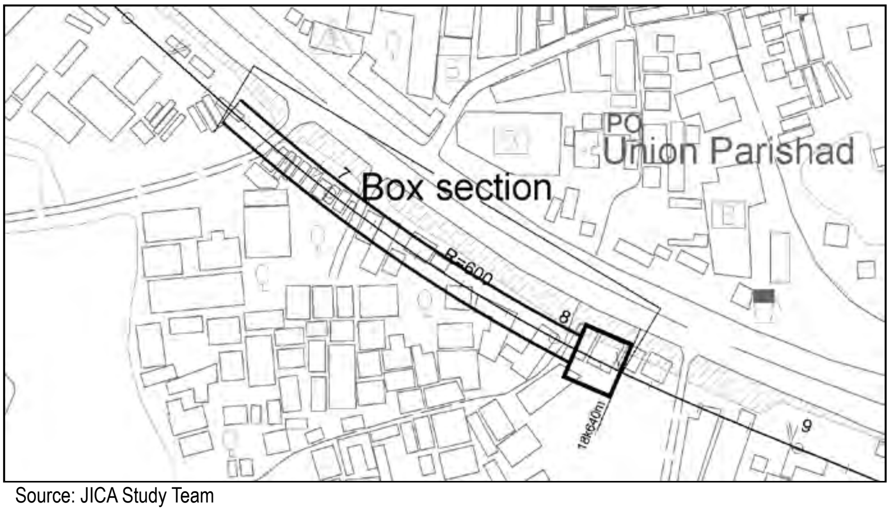
(c) Selection of Shield Machine Type

Earth Pressure Shield Machine is to be applied for MRT Line 5 due to the following reasons:

- Currently, there is no water at the depth of the ground planned for tunnelling. Slurry shield machine, which stabilizes the face using the slurry pressure, can lose balance of the face largely because of missing water. Losing balance of the face could lead to catastrophes such as settlement of the ground, cutting the underground installation for life lines and making the surrounding building tilt.
- The tunnel for MRT Line 5 will be constructed under the major congested road and it is difficult to acquire the site for launching the shield machine along the road. Therefore, it is necessary to plan the launching site in suburb and driving the machine to the center of the city. This means that it can be assumed that the excavation distance per shield machine will be over 6km. Under this condition, if the excavated soil is transported using the fluid transporting pump in case of slurry shield machine, it increases the risk of clogging the discharge pipe and it is difficult to detect the location of clogging as the pipe is extended over long distance. Once the pipe is clogged, the excavation might have to stop for a long time and that could cause extension of the construction period.
- Excavation using slurry shield machine requires slurry treatment facility and the facility must be imported from outside of the country. Therefore, the cost of transportation will be higher than that of Earth Pressure Shield machine.

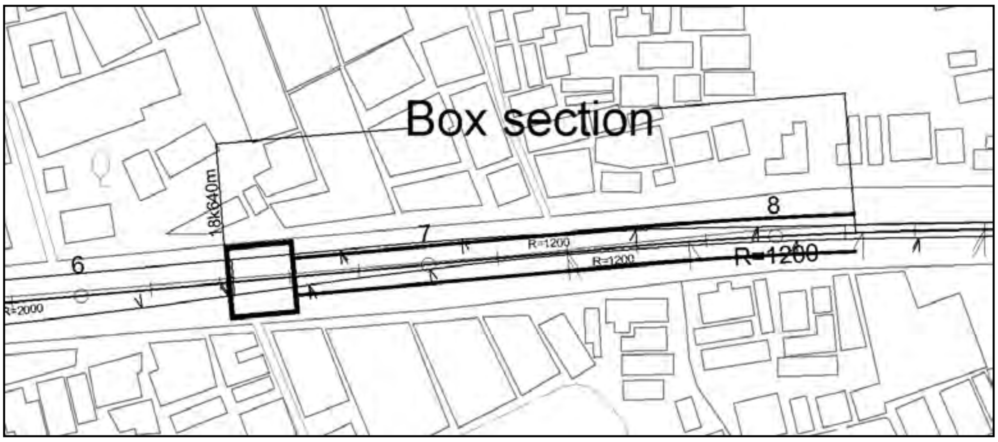
(6) Plan for Launching Shaft

MRT Line 5 transits from viaduct to underground tunnel and underground tunnel to viaduct between Amin Bazar Station and Gabtoli Station on the west side and between Notun Bazar Station and Vatara Station on the east side respectively. From the perspective of the economic efficiency and workability, the construction conducted by cut and cover should be minimized as much as possible and the section for the shield tunnel will be extended. The launching shaft for the shield machine will be necessary between the sections of shield tunnel and cut and cover tunnel. The location of the launching shaft is planned at where the sufficient overburden of 1.5 D is secured as it is safe against the buoyancy of the tunnel that could happen if the underground water returns in future. Therefore, the launching shafts are planned at 5k830m on the west side and at 18k640m on the east side.



Source: JICA Study Team

Figure 4.2.27 Location of Launching Shaft (between Amin Bazar Station and Gabtoli Station)



Source: JICA Study Team

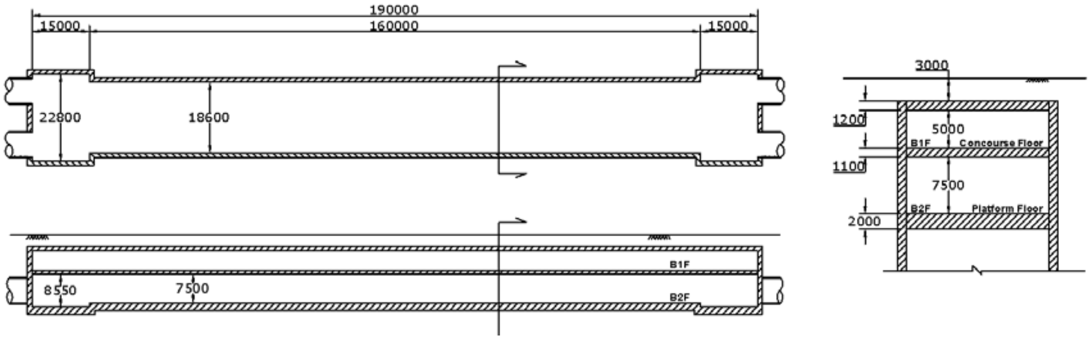
Figure 4.2.28 Location of Launching Shaft (between Notun Bazar Station and Vatara Station)

2) Station Structure Planning

(1) Study on Station Structure

Structure of an underground station is basically to be determined based on the tunnel longitudinal alignment planned considering control points on the planned route. At the station where there are no control points on the longitudinal alignment, the underground station structure is to be determined considering the conditions such as the station structure and facility locations.

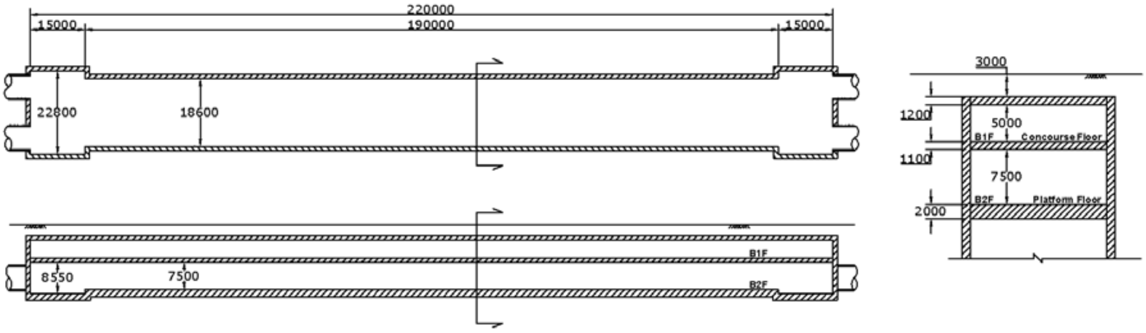
The ideal structure of the station is two-story station with Concourse floor and Platform floor, which has the minimum length of the station determined based on the length of the platform (Refer to **Figure 4.2.29**). However, this structure cannot secure the required floor area as number of mechanical equipment to be installed in the underground station is large.



Source: JICA Study Team

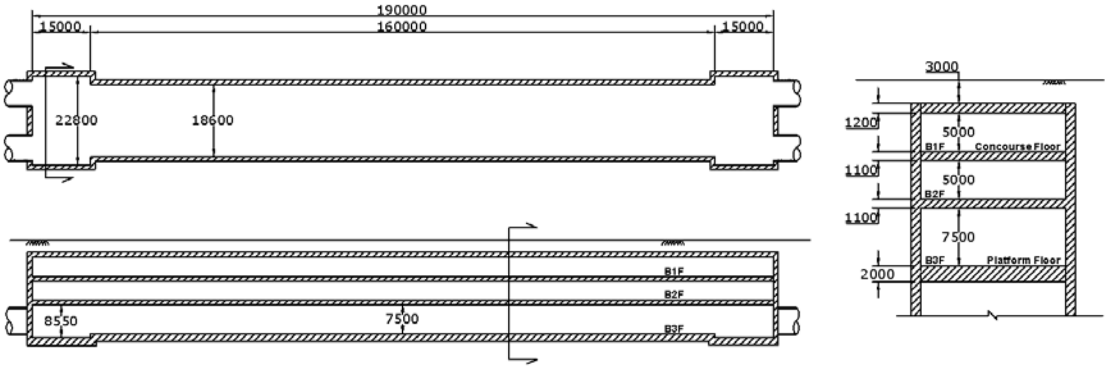
Figure 4.2.29 Ideal Shape of a Station (Two-story Structure L=190 m)

Therefore, to secure the required floor area, either two-story with longer station structure as shown in **Figure 4.2.30** or three-story with extra floor as shown in **Figure 4.2.31** shall be selected.



Source: JICA Study Team

Figure 4.2.30 Structure of a Station (Two-story Structure L=220 m)



Source: JICA Study Team

Figure 4.2.31 Shape of a Station (Three-story Structure L=190 m)

Both two-story structure and three-story structure have advantages and disadvantages and it is difficult to determine which is better. In addition, conditions required vary depending on the stations, and the structure of the station is determined in accordance with conditions for each station. Table 4.2.5 shows the characteristics of two-story and three-story stations and Table 4.2.6 shows the reasons determined station structure.

Table 4.2.5 Characteristics of Two-Story and Three-Story Station

	Two-Story Station	Three-Story Station
Advantage	・Travel distance for passengers in vertical direction is shorter. ・Number of escalators to be installed is fewer and initial facility investment and running cost are also less.	・Occupancy area can be small and utility diversion can be minimized. ・As the depth of tunnel structure is large, the risk against the ground surface displacement is smaller.
Disadvantage	・If ventilation shafts cannot be installed above the station (inside of center median), the shafts must be located in the available space on adjoining area. However, it is difficult to secure spaces for ducts within the station in case of two-story station.	・Travel distance for passengers in vertical direction is longer. ・Number of escalators to be installed is more and initial facility investment and running cost are also more.

Source: JICA Study Team

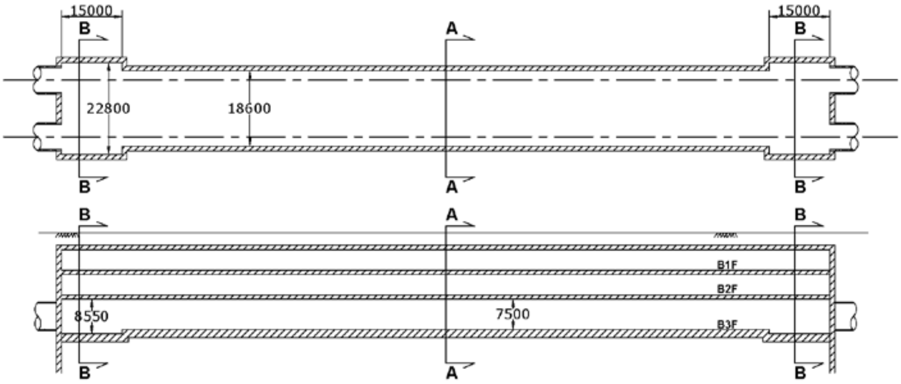
Table 4.2.6 Number of Floors for Each Station and its Reasons

No	Station	No. of Floor	Rationales
1	Gabtoli	3	The tunnel is planned to run under nearby Turag River and the depth of the tunnel is large if more than 1.5D of overburden from the river bed has to be secured. Therefore, this station is three-story structure in accordance with the longitudinal alignment.
2	Dar-us-Salam	2	It is planned to have two platforms and three tracks including a passing track at this station, and cross over road on both sides of the tracks will be installed. (Refer 4.1.6) Because of this, plan shape of the station will be large in the direction of the track and width. Therefore, even though it is two-story station, sufficient space for mechanical equipment can be secured. In addition, since there are no control points nearby this station, two-story structure is applied for this station.
3	Mirpur 1	2	If the station is extended for 15 m on both side of the station, two-story structure can be applied to this station. Therefore, considering convenience of passengers, two-story structure is applied to this station.
4	Mirpur 10	3	This station is the connecting station with MRT Line 6. Distance between platforms in the horizontal direction should be short considering the transfer. It is considered that two-story structure cannot be applied since the distance in the horizontal direction is long because of the mechanical equipment on both end of the station. Therefore, the three-story structure is applied to this station.
5	Mirpur 14	2	If the station is extended for 15 m on both side of the station, two-story structure can be applied to this station. Therefore, considering convenience of passengers, two-story structure is applied to this station.
6	Kochukhet	2	If the station is extended for 15 m on both side of the station, two-story structure can be applied to this station. Therefore, considering convenience of passengers, two-story structure is applied to this station.
7	Banani	4	The location of this station is deepened as the tunnel runs under the foundation piles below the residential area of Cantonment. In addition, the road at where the station is located is narrow and if two tunnels are running in vertical parallel, the station should be of four-story (B3F and B4F are platform floors) structure.
8	Gulshan 2	3	The tunnel runs under Banani Lake and Gulshan Lake which are located on the both end of this station. Because of these lakes, the location of the station is deep in underground and three-story structure is applied for this station.
9	Notun Bazar	3	Right before connecting to this station, the tunnel runs under the two-story station for MRT Line 1. Therefore, the three-story structure is applied to this station.

Source: JICA Study Team

(2) Shape of the End of the Station

The structure of the station shall be designed to satisfy the inner cross-section required during the construction and operation of the tunnel. It is acceptable if cross section at A-A shown in **Figure 4.2.32** can secure the track alignment considering the margin, but the cross section at B-B in the same figure must secure the space for launch and arrival of the shield machine while maintaining the space for track alignment. Therefore, width of the frame at the both end of the station is extended to secure sufficient space for launch and arrival of the shield machine.

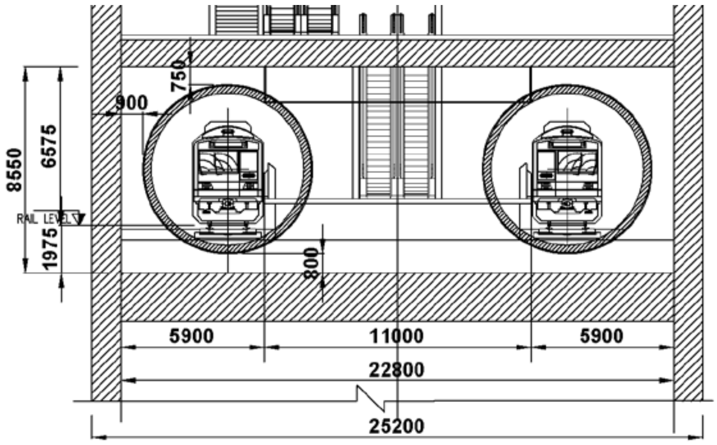


Source: JICA Study Team

Figure 4.2.32 Overview of the Station Shape

(a) Determining the cross section

Cross section at both end of the station is determined considering the sufficient space for the shield machine. The width of margin for work space on the side walls is 900 mm on both side, the width of space for staging on the bottom is 800 m, and the width of space on the top of the tunnel is 750 mm to secure 500 mm of clearance of inner height required, as shown in A-A cross-section in **Figure 4.2.32**, when transporting the shield machine. Although entrance concrete is necessary at the launch and arrival part for the shield machine, it will not be a critical point when determining the cross-section since there is 60mm margin on every side of the shield machine.

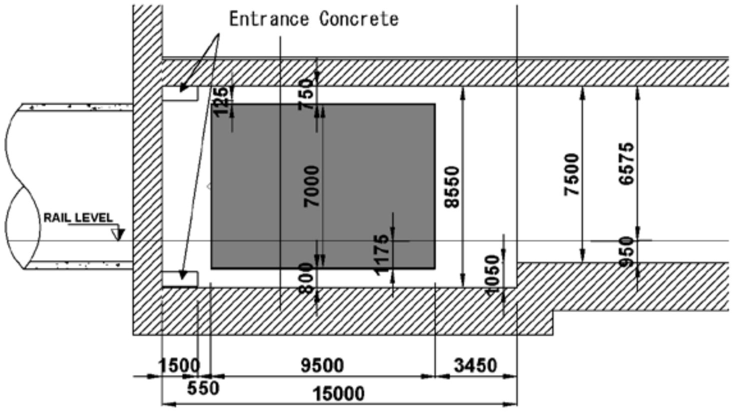


Source: JICA Study Team

Figure 4.2.33 Cross Section of the End of the Station

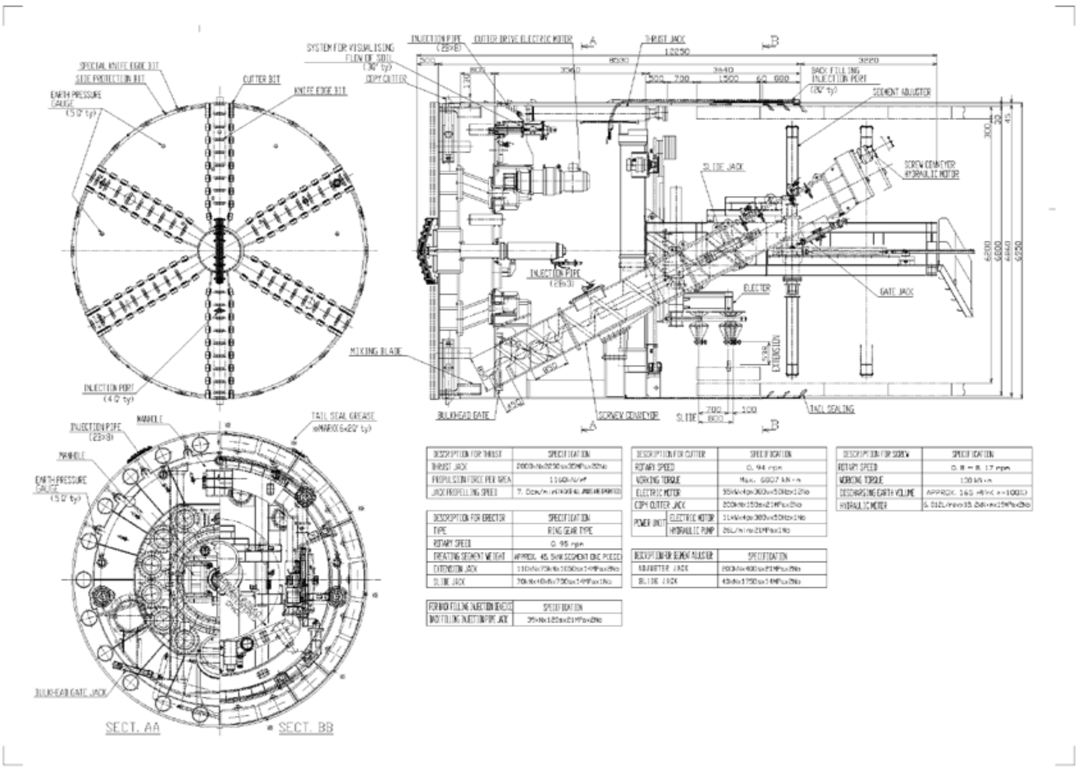
(b) Determining the cross-section in longitudinal direction

Cross Section in the longitudinal direction secures the necessary space for launch and arrival of the shield machine. As shown in **Figure 4.2.34**, the total of 15 m consisting of 1,500 mm for portal concrete including entrance packing), 550 mm for machine clearance between the shield machine and portal concrete, 9,500 mm for the length of the shield machine and 3,450 mm for space to place temporary segments and temporary reaction strut is secured for launch and arrival of the shield machine. The length of the shield machine is determined by refereeing to the same scale of EPS Shield Machine. **Figure 4.2.35** shows the figure of the shield machine referred for this project.



Source: JICA Study Team

Figure 4.2.34 Cross-section at the End of the Station in Longitudinal Direction



Source: JICA Study Team

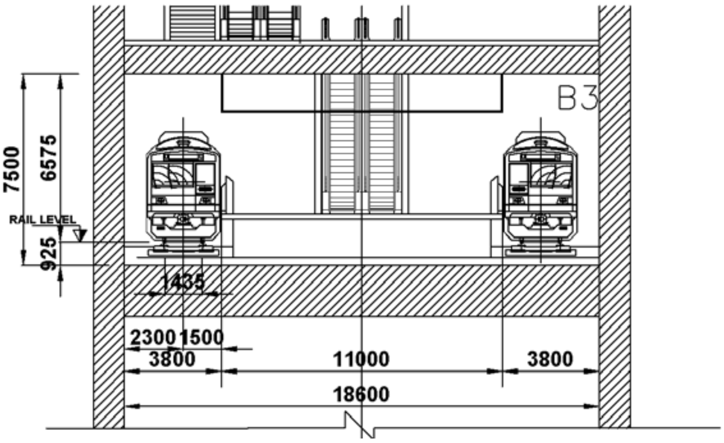
Figure 4.2.35 Figure of the Same Scale of Earth Pressure Shield Machine (Reference)

(3) Standard Cross Section of the Station

The standard cross section at A-A in **Figure 4.2.36** shall secure the cross section necessary at the time of the construction as well as the space necessary to transport the shield machine during the construction.

(c) Width of Inner space

Width of inner space at the standard cross-section is determined to be the same as that of required at the time of operation since the whole width of the platform floor is available when transporting the shield machine. Therefore, total of 18.6 m in width is consisting of the width of the platform of 11.0 m and the occupied width of the track of 3.8 m x 2.

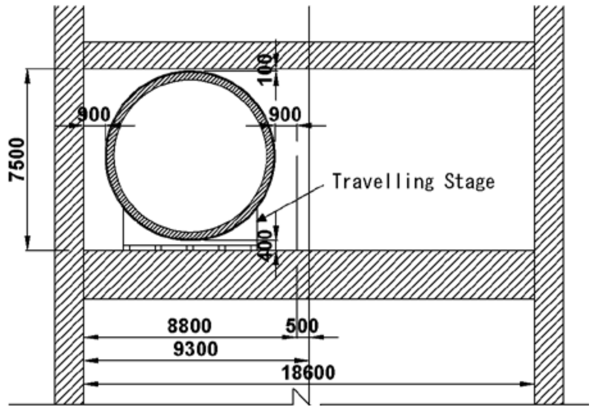


Source: JICA Study Team

Figure 4.2.36 Standard Cross Section of the Station

(d) Cross-section necessary for transporting the shield machine inside the station

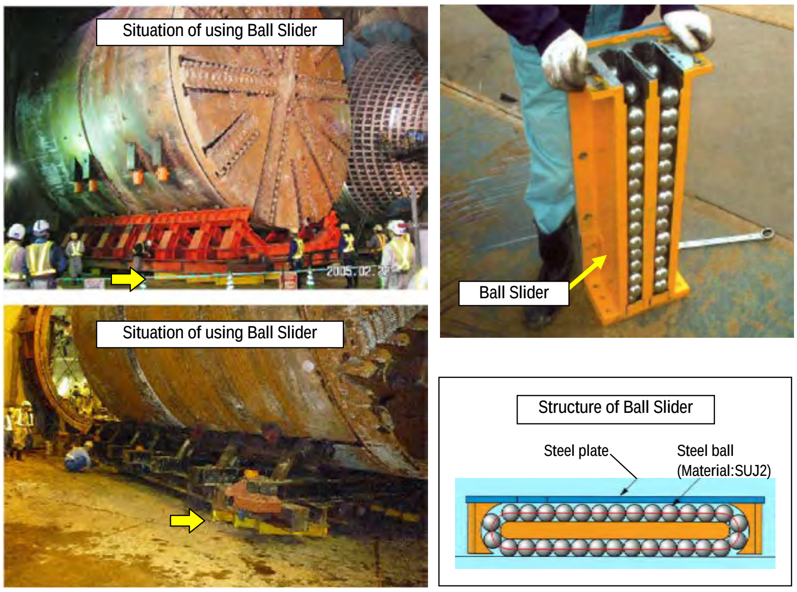
Considering the clearance between the shield machine and the upper slab is 100 mm, and 400 mm in height of the staging used to transport the machine, the total height of the inner space is 7,500 mm on the platform floor where the machine is transported. Since the 900mm of working space on the both side is necessary when transporting the machine, the total width necessary for the transportation is 8,800 mm. Therefore, as columns occupy the half of the inner space necessary for transportation of the shield machine, such columns can be arranged in the inner space, and the slab structure without columns is to be applied.



Source: JICA Study Team

Figure 4.2.37 Standard Cross Section for Transporting the Shield Machine

Considering the use of ball sliders during transporting the shield machine, it is assumed that the minimum height of travelling stage at the center is 400 mm. In the detailed design, margin necessary for the shape of the travelling stage and for putting the machine on the travelling stage shall be reviewed to confirm the validity of the inner height of 7,500 mm on the platform floor.



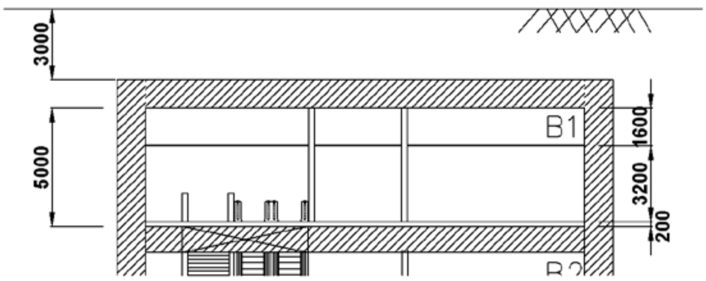
Source: JICA Study Team

Figure 4.2.38 Case of Shield Machine Transportation Using Ball Sliders

(4) Typical Overburden and Height of Inner Space on the Concourse Floor

All underground stations for MRT Line 5, except Gabtoli Station, will be constructed within the road site and it is assumed that many public utilities are buried there. Therefore, overburden of 3 m is secured to make a space for public utilities after the construction of the station.

The height of the inner space of the concourse floor is 5,000 mm in total as the space for the electrical cable duct and lightings require 1,600 mm, thickness of floor finishing including drainage requires 200 mm and occupied height of inner space for passengers requires 3,200 mm.

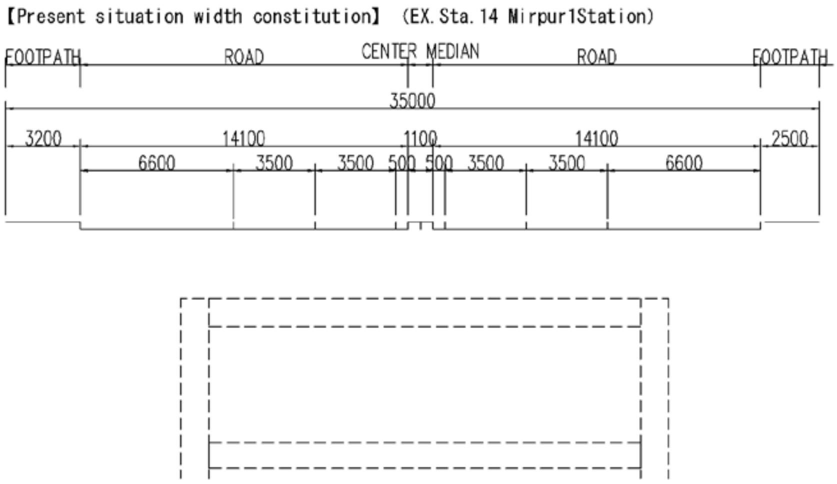


Source: JICA Study Team

Figure 4.2.39 Case of Shield Machine Transportation Using Ball Sliders

(5) Arrangement of Ventilation Shaft

Based on the previous cases, it can be said that the inner space of ventilation shaft requires 30 m^2(3.0 m x10 m) for air exhaust air and intake. This ventilation shaft occupies the station starting from the platform floor to the ground. By placing the ventilation shaft linearly to the ground, the occupying space for the ventilation shaft and the size of the station can be minimized. Basically, the ventilation shafts will be placed at the center median. However, the current width of the center median is about 1m and the ventilation shafts cannot be fit within this space. Therefore, the road width around the stations shall be changed when constructing the station and the space for the ventilation shaft will be secured. Figure 4.2.40 shows the current road width, Figure 4.2.41 shows the width changed after the station allocation including ventilation shaft.



Source: JICA Study Team

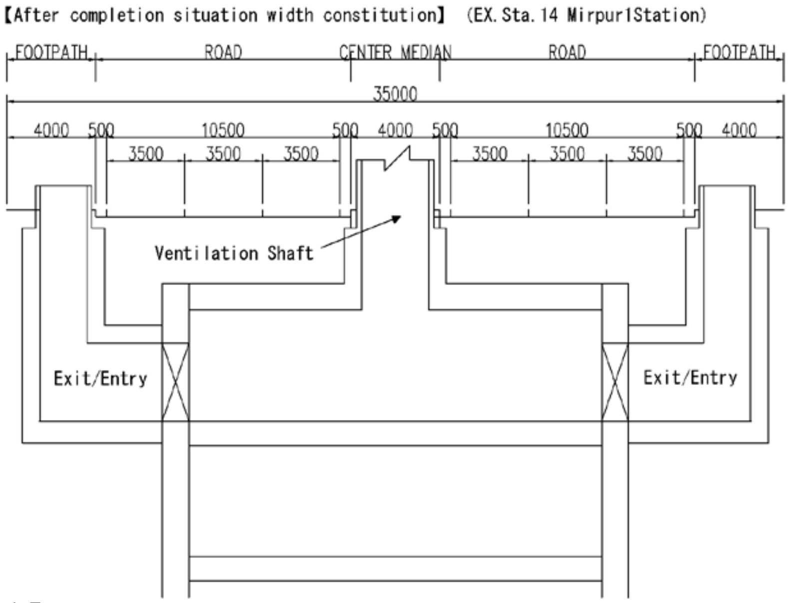
Figure 4.2.40 Current Road Width at Mirpur 14 Station

Change of current road width is planned by keeping the same number of lanes and keeping the lane width at 3.5 m, same as the current lane width. Based on the field investigation, it was confirmed that 4m width for the center median can be secured to place the ventilation shaft as shown in Figure 4.2.40, if the total width of road is more than 35 m. In addition, based on the measurement conducted during the site survey, the total road width of 35 m or more cannot be secured at only two stations, Banani Station and Notun Bazar Station, and the policy for these stations are as follows.

Banani Station: the road around this station is congested and narrow, and it is difficult to change the width even after the construction of the station. Since there is no available space along the road, possibility of land acquisition shall be discussed and the shape shall be determined in the detailed design.

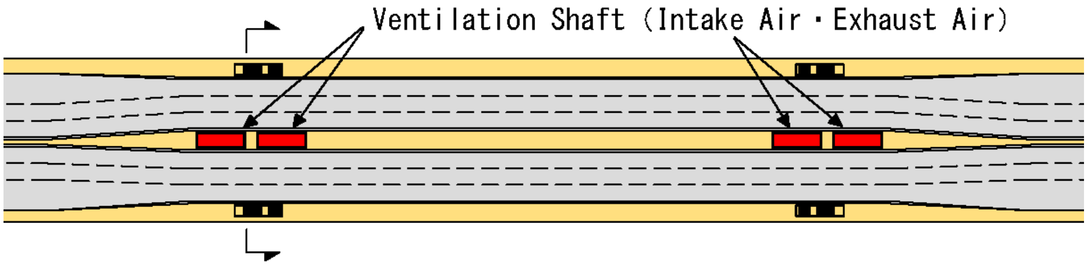
Notun Bazar Station: the road next to the sidewalk is illegally occupied and is not functioned as a road (as of June 2017). Only 2 out of 3 lanes on the road are practically available for use. Change of the road width shall be studied and the shape shall be determined in the detailed design.

Table 4.2.7 shows the width of cross section for each station measured during the site survey. The measurement for Gulshan 2 station was not conducted as it is located within the roundabout.



Source: JICA Study Team

Figure 4.2.41 Road width after the Construction of Mirpur 14 Station (Plan)

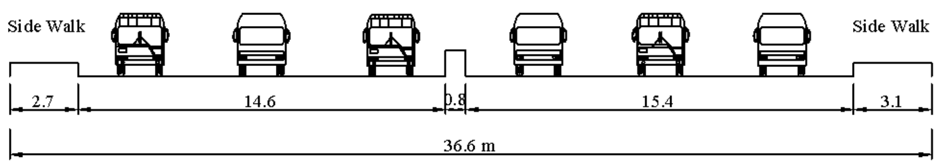


Source: JICA Study Team

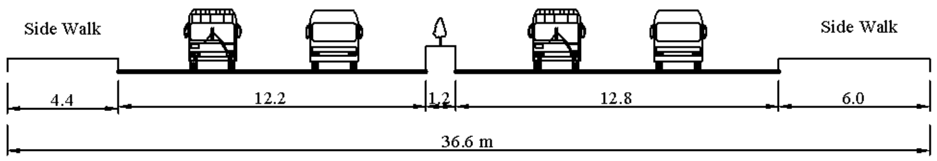
Figure 4.2.42 Plan for Arrangement of Ventilation Shaft at Mirpur 14 Station

Table 4.2.7 Measurement Results for Road Width Based on Site Survey

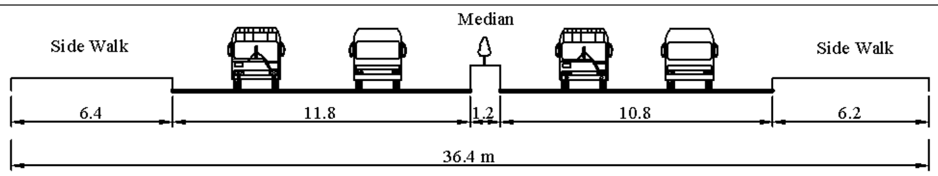
Dar-us-salam

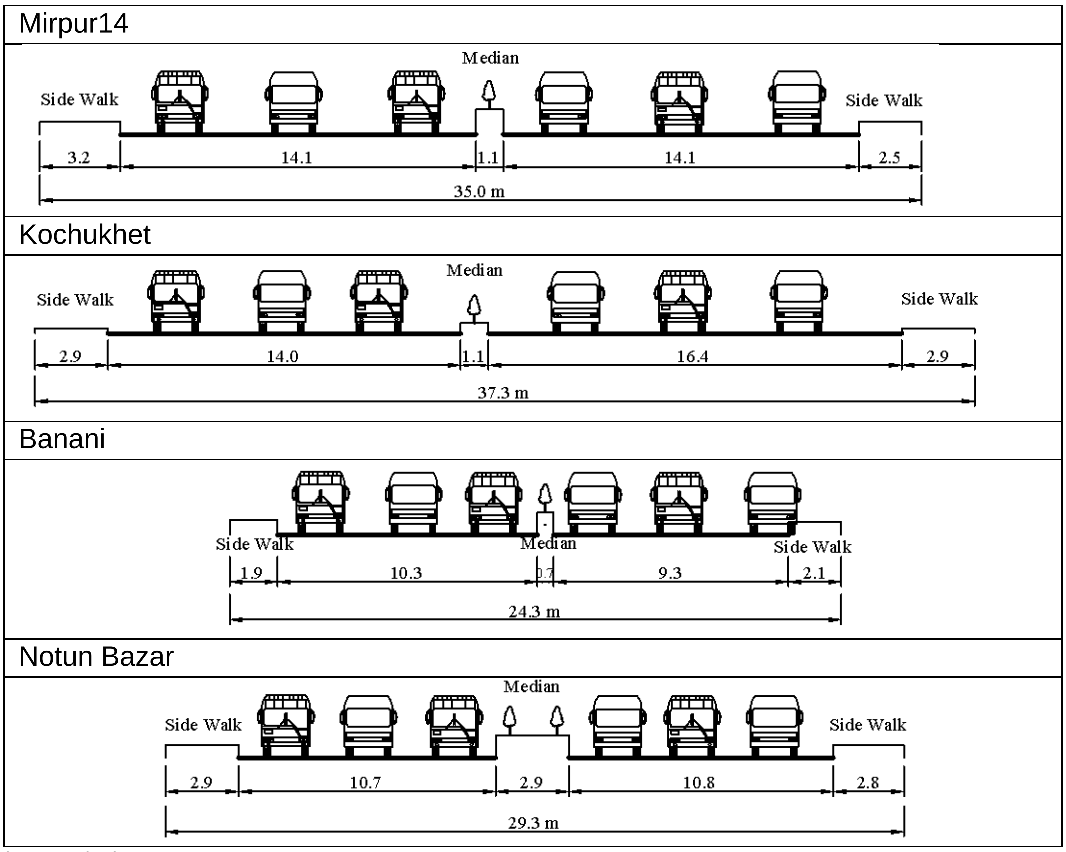


Mirpur1



Mirpur10

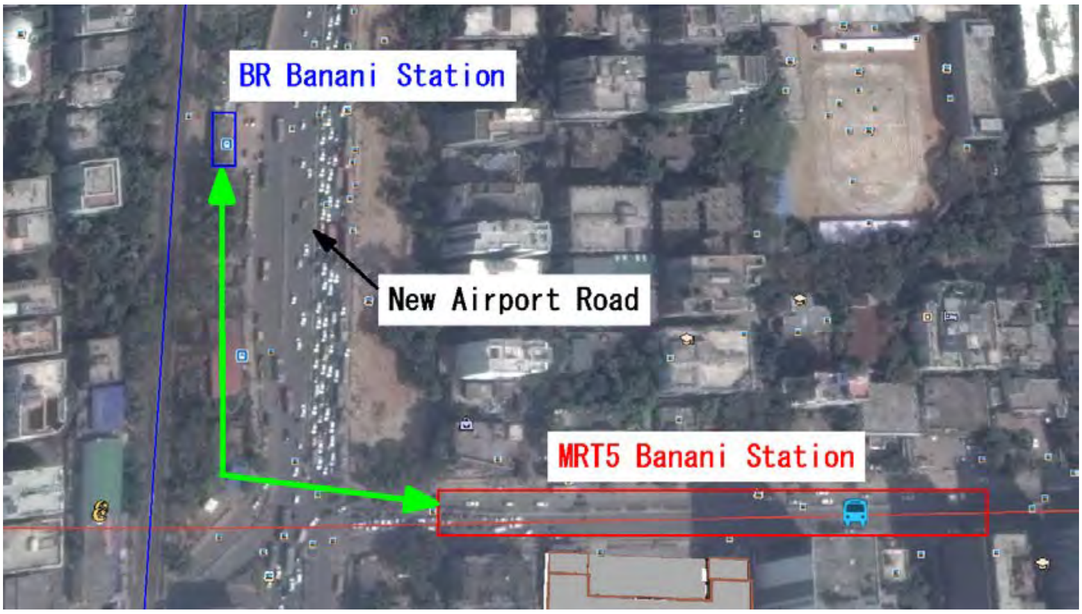




Source: JICA Study Team

3) Banani Accessway Plan

In MRT Line 5, it is planned to connect MRT Line 5 Banani Station with Bangladesh Railway (hereinafter called BR) Banani Station and Bus Stop in front of BR Banani Station. Thus, one of the Line 5 exits/entrances is allocated in front of BR Banani Station. Accessway between Banani Station on MRT Line 5 and the exit/entrance is crossed by Airport Road, therefore, the accessway is to be buried underground.



Source: JICA Study Team

Figure 4.2.43 Location of MRT Line 5 Banani Station and BR Banani Station

(1) Arrangement of Accessway

(a) Inner Section

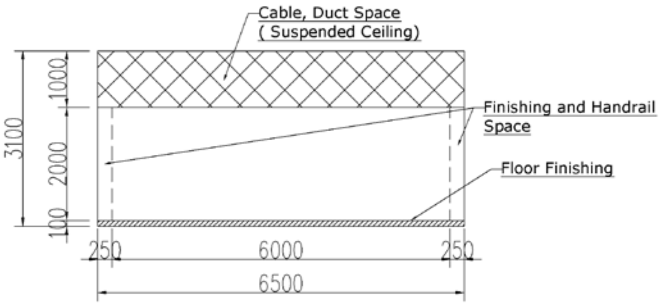
- Width of inner section: 6500mm

  *250mm of allowance for thickness of finishing on the wall surface and handrail installation is considered.

- Height of inner section: 3100mm

  *1.0m of inner section height of cable duct space is secured on top.

  *100mm of bottom finish is considered.



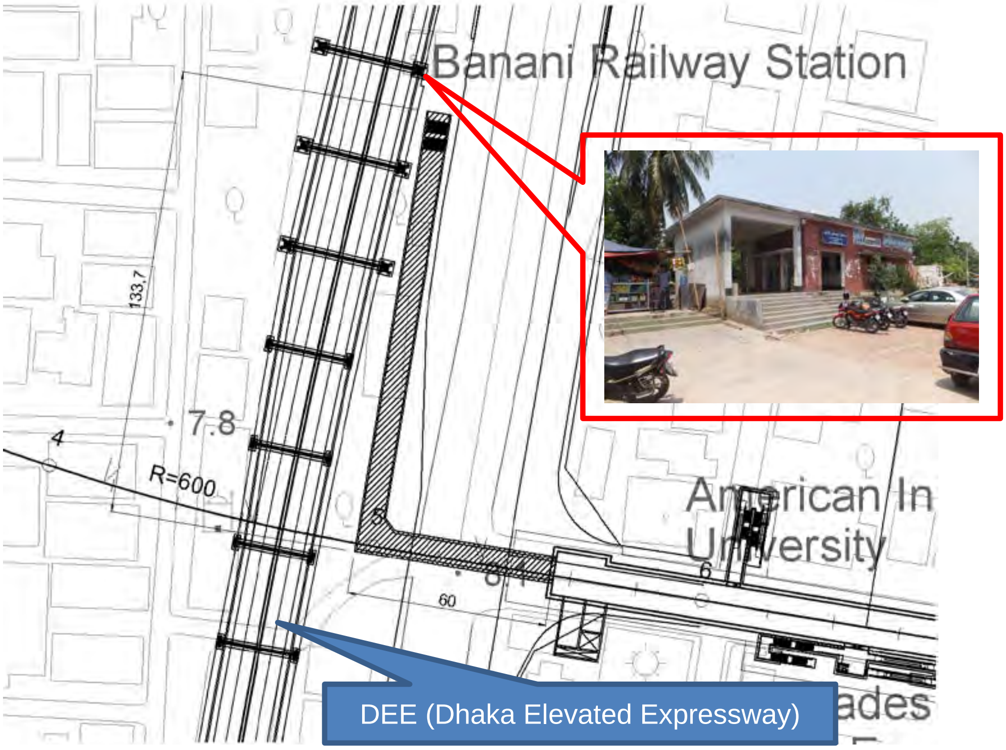
Source: JICA Study Team

Figure 4.2.44 Inner Section of Accessway

(b) Horizontal Alignment

DEE is planned on BR railway tracks, and bridge piers for this planned DEE will interfere Banani Station in future. Banani Station will probably be replaced in accordance with the location of DEE bridge piers, but the information is not available at this point. Therefore, in this Study, the plan is to allocate the exit/entrance in front of current Banani Station.

Horizontal alignment for the accessway avoids the bridge piers and the current New Airport Road.



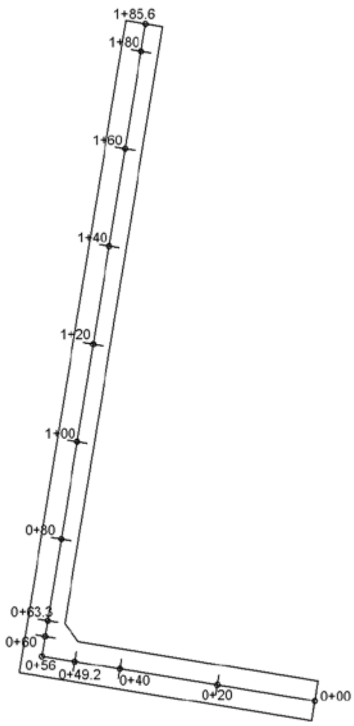
Source: JICA Study Team

Figure 4.2.45 Horizontal Alignment for the Accessway

(c) Vertical Alignment

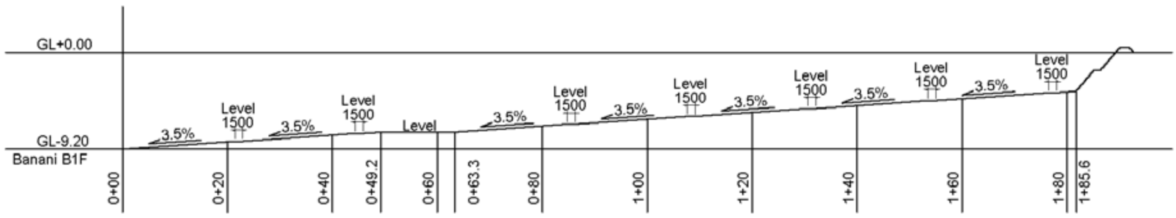
Considering wheelchair accessibility, vertical alignment satisfies the following conditions.

- Maximum longitudinal gradient: 3.5%
- 1.5m width of landing is arranged in vertical interval of every 750mm.
- Vertical alignment, determined based on the above conditions, is finalized for vertical interval and adjusted for stairs and escalators. For the wheelchair accessibility, elevators are installed. Allocation of elevator at Banani Station is to be reviewed in accordance with the rebuilding of Banani Station.
- Level of exit/entrance is to be higher than the ground level considering the maximum level of flooding.



Source: JICA Study Team

Figure 4.2.46 Ground Plan of Accessway Distance



Source: JICA Study Team

Figure 4.2.47 Profile of Accessway

(2) Construction Methodology of Accessway

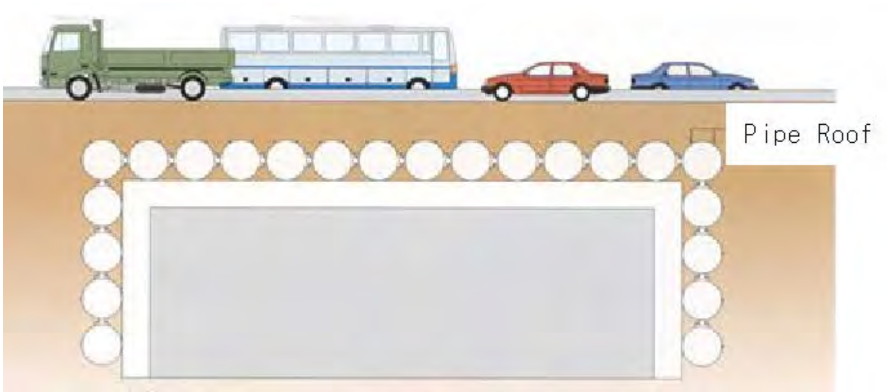
(a) Cross Section of New Airport Road

Construction method applied at New Airport Road is required to be Non-Cut-and-Cover Method. Typical methods, which can be applied for the construction with the conditions mentioned in the previous section and for the inner section dimensions mentioned above, are the Pipe Roof Method and the Element Advancing Method. Overview of these methods is explained below.

Selection of the method will be determined in the design stage considering economic efficiency and workability.

1. Pipe Roof Method

Using Small Diameter Pipe Jacking Method, steel pipes are advanced and placed one by one from the launching shaft to create a roof. The pipe roof is supported from inside and excavation can be carried out in the inside of the pipe roof. Finally, the element for the accessway is constructed with cast-in-place method.



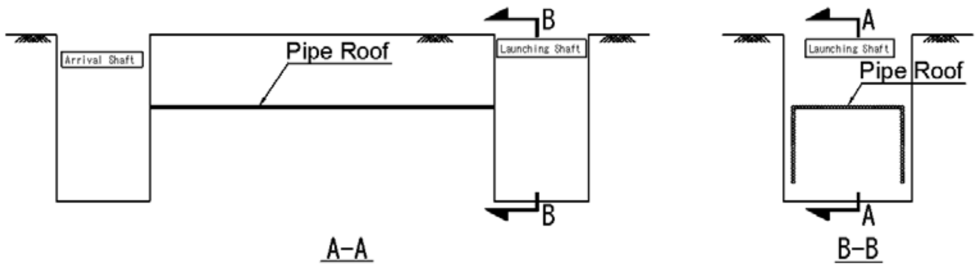
Source: ISEKI POLY-TECH, INC

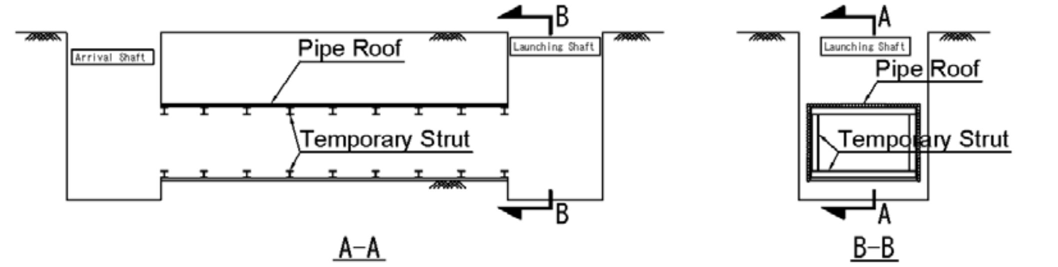
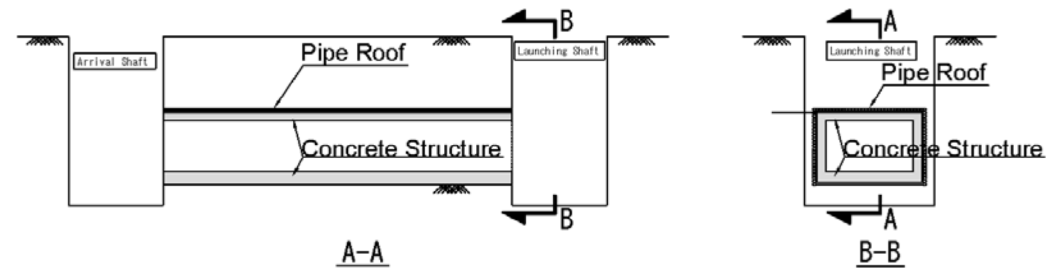
Figure 4.2.48 Conceptual view of Pipe Roof Method

Source: ISEKI POLY-TECH, INC

Figure 4.2.49 Photo of Construction of Pipe Roof Method

Table 4.2.8 Procedure for Pipe Roof Method

STEP-1	・Construct launching and arrival shafts ・Using Small Diameter Pipe Jacking Method, steel pipes are placed one by one in the ground from the launching shaft toward arrival shaft. ・Pipes are placed on the both side and the top as shown in cross section of B-B.
	
STEP-2	・Tunnel is excavated inside of the pipe roof from the launching shaft with the support of temporary strut toward the arrival shaft.

	
STEP-3	・Temporary strut is removed for one side and the frame around it is casted. ・When the frame casted is strong enough, next temporary strut is removed. ・Above two steps are repeated until all sides are casted with concrete.
	

Source: JICA Study Team

(b) Outside the Cross Section of New Airport Road

Cut-and-Cover Method is to be applied as there is no obstacle on the planned site. However, since the construction site is in the vicinity of the BR, retaining walls with appropriate rigidity shall be applied considering the impact on the adjacent structures.

Source: JICA Study Team

Figure 4.2.50 Planned Location of Accessway (Outside of the New Airport Road)

2. ESA Method

This is one of the Element Advancing Methods and applied to relatively long tunnel construction, which is longer than 30m. Since the length of the construction of Banani Access Way is 50m, Endless Shelf Advancing (ESA) method may be applied. The overview of the method is as follows.

ENDLESS SELF ADVANCING (ESA) METHOD

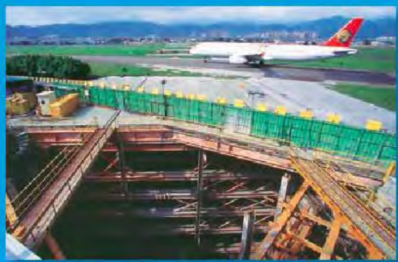
Construction method of long distance of rectangular structures

Overview of ESA method

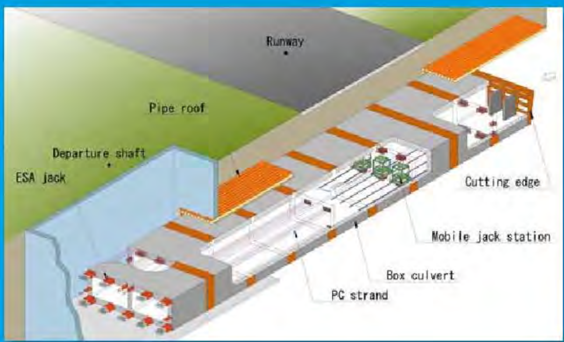
Endless Self Advancing (ESA) method is a non open-cut and covered method of constructing underground structures. Box culvert advances a long distance under the ground from one direction. Construction process is similar to the movement of the inchworm. Firstly, fix the tail (reaction force), and the head is moved forward. Then fix the head (reaction force), and the tail is pulled. Linked through the multiple (more than 3) box culverts on PC strands, and then set up hydraulic jacks on the end of the last box culvert and also between the each box culverts. One box culvert is moved forward, as using a reaction force resistance to earth pressure and friction resistance due to the deadweight of the other multiple boxes. They move sequentially one by one.

Advantages of ESA method

1. Long-distance tunnel construction is practicable.
2. Box culvert is a rigid frame (Rahmen) box of reinforced-concrete (RC) structure. Fabrication is easy and quality control is good.
3. Large cross-section tunnel construction is practicable.
4. Because box culverts become reaction force to each other, reaction force is not required to outside, basically.
5. Curved construction is practicable.



Fuhsing N. Road, Taipei Songshan Airport, Taipei City, Taiwan W22.2m * H7.8m * L100.0m
台湾 台北市 松山空港 復興北路
幅22.2m ×高 7.8m ×長 100.0m

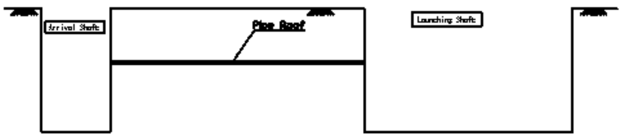
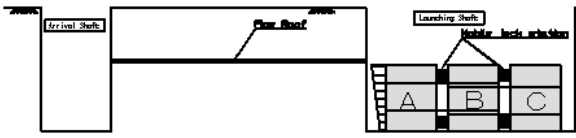
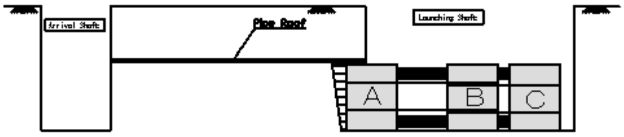
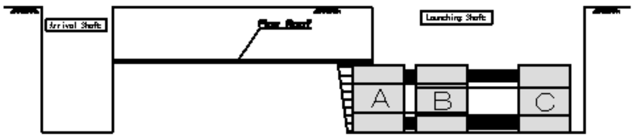
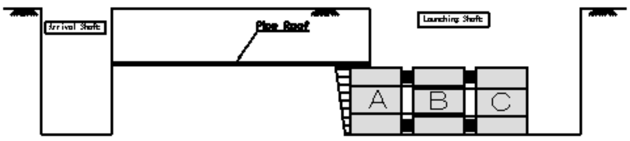
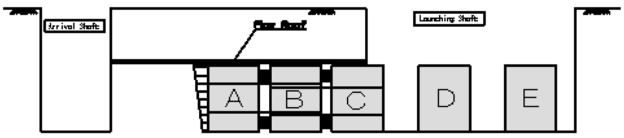
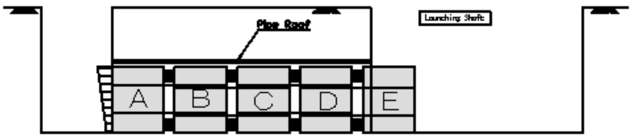
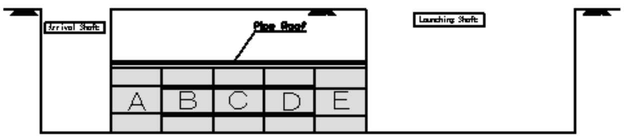


Suwon - 病店, Gyeongbu Line, Korea
W34.1m * H8.55m * L79.6m
韓国 京釜線 水源～病占間 幅34.1m×高 8.55m×長 79.6m

Source: UEMURA Engineering Co., Ltd

Figure 4.2.51 Overview of ESA Method

Table 4.2.9 Procedure for EAS Method

	Schematic View	Outline
STEP-1		・Build a launching shaft ・Construct a Pipe Roof
STEP-2		・Construct elements (A, B and C) ・Set a Mobile Jack Station
STEP-3		・Using the reaction force of deadweight of element B and C, advance the element A.
STEP-4		・Using the reaction force of element A and C, move element B.
STEP-5		・Using the reaction force of element A and B, move element C.
STEP-6		・Repeat the above procedure and advance element A, B and C. ・Construct subsequent element D and E in the launching shaft.
STEP-7		・Set Mobile Jack Station onto the element D and E. ・Repeat the same procedure to arrival shaft.
STEP-8		・Remove Mobile Jack Station, and tighten up the all elements with PC steel wires to unify. ・Remove cutting edge.

Source: JICA Study Team

4) Management of construction soil

Significant amount of soil will come out due to underground tunnel and station construction, as well as from pile works from elevated viaduct and stations to a lesser extent. Disposal of these huge soil needs careful planning and proper execution. It may be noted that these soil is not expected to be hazardous and can use used in many ways.

Considering the capacity of excavating 10m/day by one TBM, and assuming 20% looseness factor, approximately 460 m^3 soil is expected from one tunnel per day, which is equivalent to about 750 tons/ day/ tunnel TBM (γ=1.6kN/^{3}). Considering 3 packages corresponding to 6 machines, approximately 4,500 tons of soil will be generated per day from the tunneling activity. For the entire tunnel, total soil expelled would be more than 1 million tons.

Considering a typical underground station length of 220 m and width of 20 m, expected spoil is about 100,000 m^3, equivalent to 160,000 tons. For 9 underground stations, total expelled soil will be around 1.5 million tons.

Though the amount is huge, disposal may not be an issue. In case of Delhi Metro, the soil was used for filling next depot site as well as formation for at-grade tracks. Also soil was sold to private parties. Similar situations were experienced in Jakarta and Bangkok metros.

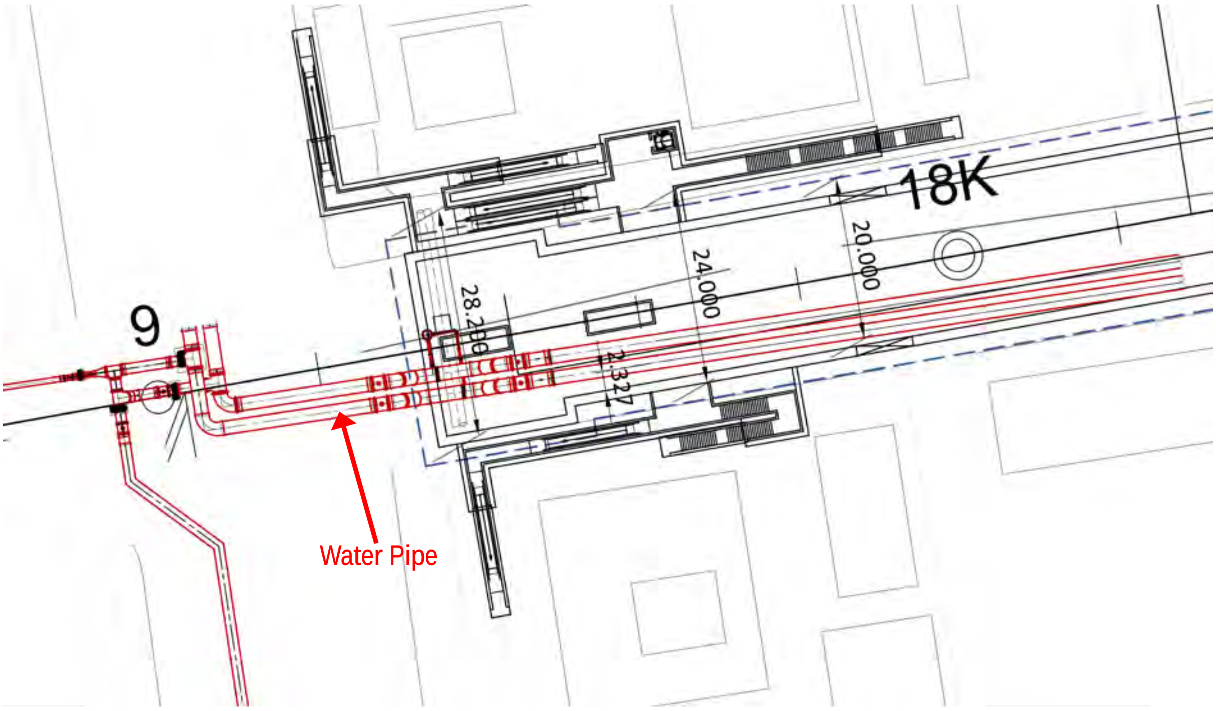
Options for soil disposal are as follows:

- Use for landfilling for next metro depot
- Use for landfilling for large infrastructure like power plant, industrial area
- Use for flood protection embankment
- Use to construct road embankment
- Use for brick manufacturing (if suitable)
- Sell to private land developer for land filling.

In this regard, more focused study is needed during detail design stage.

5) Interference with DWASA Project at Notun Bazar Station

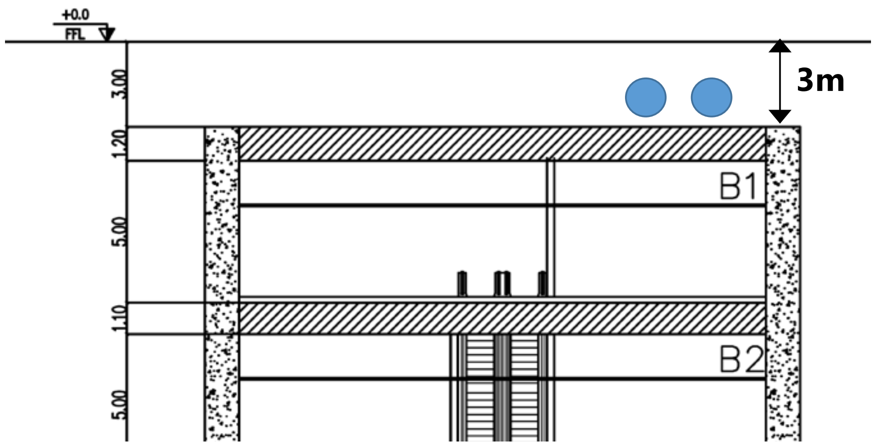
As described in 3.3.4, there is a plan to construct a water pipe along Madani Avenue, as shown below, the Notun Bazar station and the water pipe interfere with each other.



Source: JICA Study Team

Figure 4.2.52 Plan of Notun Bazar with Water Pile

According to design consultant of DWASA Project, the outer diameter of the water pipe is 1.6 m, and two piles will be arranged in parallel.



Source: JICA Study Team

Figure 4.2.53 Position of Water Pipe on Notun Bazar Station Box

Since it is possible to place two water pipes within the soil cover (3 m) after the completion of the station, countermeasures against the water pipe during construction must be considered.

There are two possible countermeasures against water pipes during construction for Notun Bazat Station.

(1) Hanging Method of Water Pipe

Source: http://www.mizunotec.co.jp/doboku/shield/maisetsubougo.htm

Figure 4.2.54 Hanging Method of Water Pipe

Water pipe is hanged from the steel deck with wires and construction of underground station is carried out while maintaining the position of water pipe. However, it is necessary to carefully protect the pipe for prevention of movement. Also, it is assumed that the construction period and the construction cost will increase with the protection work.

(2) Detour during construction

Source: JICA Study Team

Figure 4.2.55 Detour Plan of Water Pile

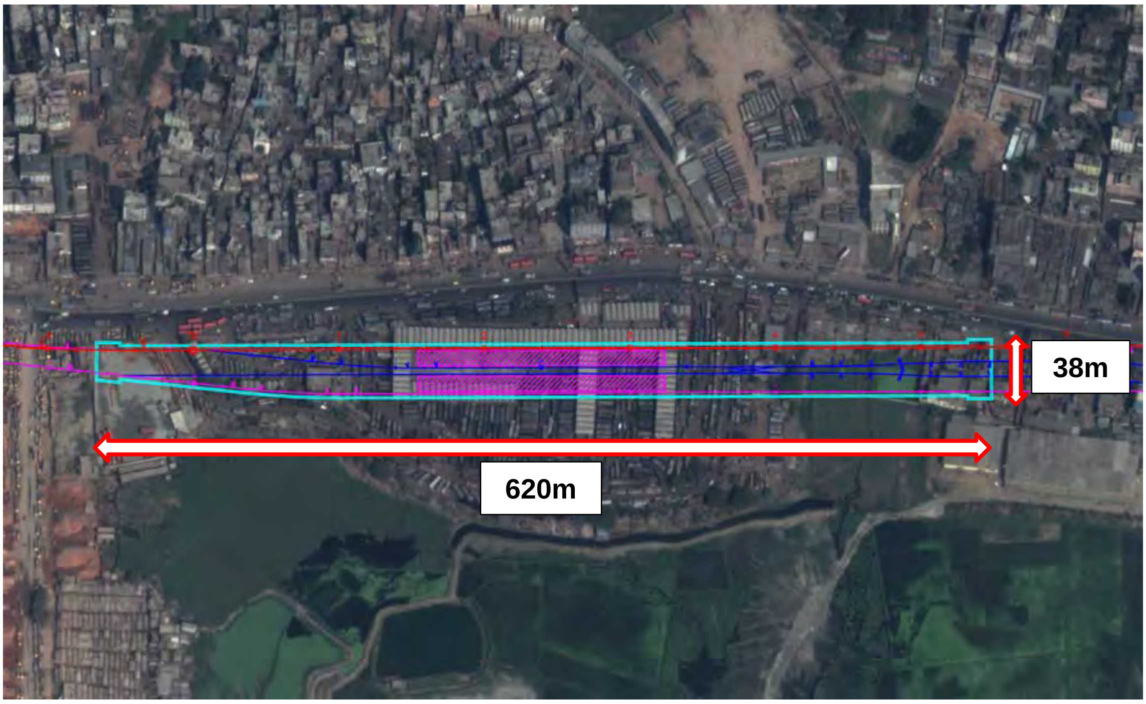
The water pipe is shifted temporary to outside of excavation area during underground station construction. And water pile is returned to original position after completion of underground station construction. The influence on underground station construction is minimized, but there is a concern that issues of land acquisition might arise against temporary relocation.

Detailed study for countermeasures will be carried out in Deail Design Stage with discussion between counterparts.

6) Temporary Relocation of Gabtoli Bus Terminal during Construction

Gabtoli station is planned under the Gabtoli bus terminal. The existing bus terminal can not be used during the construction period for Gabtoli station because the area shown in the following figure is constructed by open cut.

However, the current bus terminal is an important transportation hub for connection between outside of Dhaka and Dhaka city, so even if it is temporary it is difficult to close. Therefore, temporary relocation shall be carried out during the construction period and the function equivalent to the current bus terminal shall be maintained.



Source: JICA Study Team

Figure 4.2.56 Excavation Area for Construction of Gabtoli Station

As the temporary relocation land of the Gabtoli bus terminal, the most recommendable place is the land owned by BADC (Bangladesh Agricultural Development Corporation) located 500 m east of the Gabtoli bus terminal.

This land is currently being developed as a construction yard of Line 6 and the total area is 7.6 ha, so it is possible to construct as temporary bus terminal.

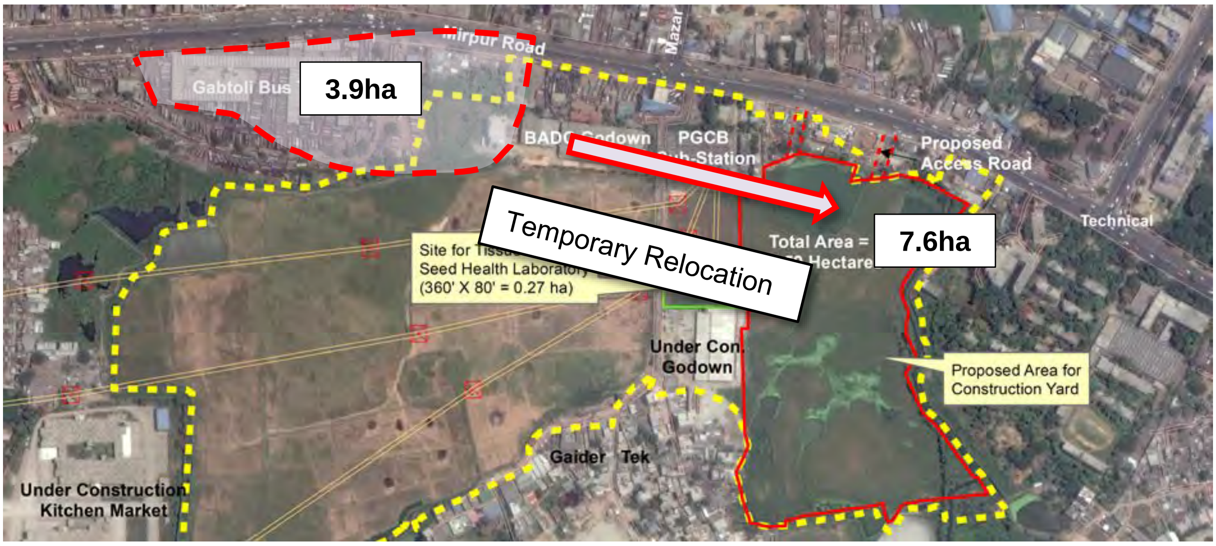
Line 6 is planned to be opened in 2022 and it is possible to relocate as temporary bus terminal after finishing Line 6 construction.

Construction cost for relocation is calculated depend on the maintenance policy of bus terminal. Including pavement and ticket counter development, it is 1.15 billion JPY as shown in the table below, which is doubled to 2.3 billion yen in consideration of temporary construction and reconstruction at original location.

Table 4.2.10 Estimated Relocation Construction Cost for Gabtoli Bus Terminal

	Local (TK)	Foreign (JPY)	Total (JPY)	
Road Pavement	235,189,000	76,271,000	405,536,000	3.9 ha
Structure (Ticket Gate)	211,511,000	410,550,000	706,666,000	1200 m^2
Toilet	12,740,000	23,674,000	41,510,000	2 nos.
Total	459,440,000	510,495,000	1,153,712,000	

Source: JICA Study Team



Source: JICA Study Team

Figure 4.2.57 Plan for Temporary Relocation of Gabtoli Bus Terminal

The bus owner association has agreed on the temporary relocation plan, and it is necessary to discuss the facility plan with DNCC in the detailed design in the future.

4.2.4 Station Architectural Design

1) Condition of Station Planning

Passenger stations are planned considering demand forecast, car numbers, alignment, civil structure, mechanical and electrical facilities, O&M planning, city planning and intermodal access.

2) Station Size

Station size is basically defined according to the following criteria.

- Concourse floor length is designed in consideration of accumulated dimension of minimum concourse length + station office + E/M rooms + station and tunnel ventilation rooms.
- Platform length is designed in consideration of number of future train sets (like 8 cars) +5m clear spaces at both ends of the platform.
- Platform width is an accumulation of minimum stairway width + Escalator + wall + reasonable width between stairway walls to Platform Screen Door (hereinafter: PSD) (Minimum 1.5m)

Station size such as platforms, concourse, stairs, and ticket gate numbers are basically defined to keep passengers' safety, comfort and serviceability at peak hour. In MRT Line 5, PSD are planned to be installed in every station. PSD can secure passengers' safety, but congested platform tends to cause troubles and delay in train operation. Vertical access routes between concourse and platforms shall have adequate capacity, so that passengers' can get out of platform before the next train arrives, and at the same time, platform shall have enough space to accommodate passengers waiting for next trains

3) Ticket Gates and Security Check Gates Planning

There are four main access routes from the street level to the B1 concourse level designated at both sides of public area (layout is shown in section 4.2.4 8). There are two ticket gates at both sides of paid concourse which are located at center of the station. In addition to normal ticket gates, security check gates will be installed at entrance. Entrance and exit are clearly separated. Number of ticket gates will be calculated based on demand forecast, and it shall be later verified by final demand forecast for each station. In this study, width of ticket gates is planned based on MRT 6 station plan.

Security check gate has to have an area of 2.5 m × 3.5 m, to arrange check gate itself plus security staff table, baggage check table. Basically 2 check gates should be provided at each entrance. There should be wide space not only in front of ticket gates, but also at security check gates as queueing in front of check gates are expected.

4) Station Office and Ticket Selling

Station office area is planned based on MRT Line 6 station plan. There are control room, station office, station master room, security guards room, maintenance room, staff mess, prayer room, first aid room, staff toilet, and storage etc.

Size of the area is estimated to be 450 m^2 including corridors.

5) Public Toilet

Passenger toilet shall be provided in paid concourse in every station. Men's toilet, Women's toilet and multipurpose toilet for physically challenged person will be provided.

6) Elevators and Escalators

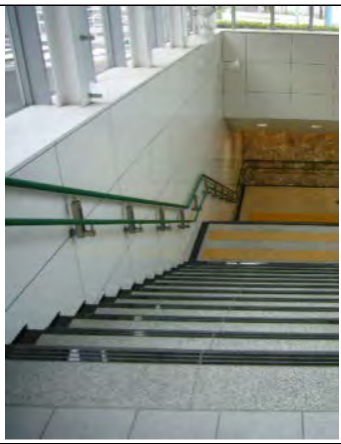
Escalators shall be provided in every station from the ground level to the concourse level, one at the north side and another one at the south side of the street. At least one set of up-down escalators shall be provided from concourse level to platform level.

At least one elevator shall be provided from ground level to concourse level and concourse level to platform level for physically challenged person.

As above mentioned spec is a basic policy, for stations with large numbers of passengers and for transfer stations, more escalators and elevators will be provided. Number of escalators and elevators will be determined by the passenger demand.

7) Barrier Free/ Universal Design

Stations, as part of public transportation system, need to be more disabled- friendly by means of installing facilities that will provide easier access to passengers with physical and visual disabilities. Disable friendly design shall basically be performed in accordance with Bangladesh code; and the design can be further improved by applying advanced design concept, referring “Barrier free guideline (Passenger facilities edition)” by Ministry of Land, Infrastructure, Transportation, and Tourism (MLITT) of Japan. Related features are shown in figure below.

	
Automatic Escalator 3 Flat Steps	Guiding/ Warning Blocks
	
2 Levels Handrail	See-Through Elevator

Platform Screen Door

Low Counter at Ticket Gate

2 Levels Bench

Multi-Purpose Toilet

Source: JICA Study Team

Figure 4.2.58 Barrier Free Design Features

(3) Access to Stations

Each station shall have at least one designated barrier free route. This is a route with elevator allowing wheel chair passengers to travel smoothly between the ground level and platform level. The approach to the elevator at the ground level should have a ramp or ramp plus stairway installed. Guiding blocks for visually impaired person shall be installed along the barrier free route.

(4) Concourse

Concourse floor should not have floor level gap, but if floor gap is unavoidable, ramp shall be provided which comply with the barrier free guideline. The floor surface of a concourse should be made of non-slip material.

(5) Ticket Gates

At least one of the ticket gates should be wide enough to allow wheelchair users to pass through easily

(6) Automatic Ticket Vending Machines

The coin slot should be at a suitable height for easy insertion of coins by wheelchair users. A knee recess beneath the ticket vending machines should be provided.

(7) Stairways

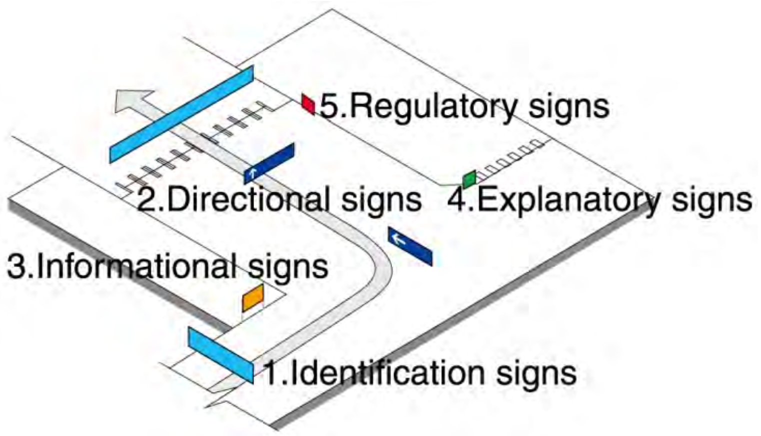
The stairways for passengers should have 2 levels of handrails which comply with barrier free guideline and matches to universal design concept.

(8) Platforms

At platform at least one designated route with guiding blocks for visually impaired person shall be provided. The surface of the platform must be made of with a non-slip material.

(9) Signage Design

In railway stations, signage shall be easy to understand for various passengers. Signage such as direction, indication, and information signs should be located in proper places and should be clearly recognized. Types of various signage and their example are given in the following tables.

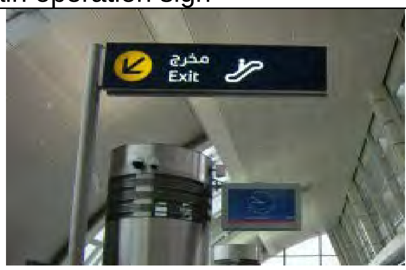


1	Identification Signs	Identify facilities
2	Directional Signs	Direct passengers to platforms etc.
3	Informational Signs	Provide information about station facilities
4	Explanatory Signs	Trains Maps, Fare Chart etc.
5	Regulatory Signs	Prohibitions, Rules

Informational sign

Train operation sign

Ceiling mounted directional sign



Standing directional sign

Source: JICA Study Team

Figure 4.2.59 Type of Signage

8) Planning of Each Station

(1) Classification of Station

In total 14 stations are proposed for MRT Line 5. Out of those, 4 stations at westernmost and 1 station at easternmost are elevated stations, while 9 intermediate stations are underground stations.

Stations are classified as below.

- Hemayetpur station and Vatara station: Elevated terminal stations.
- Baliarpur station, Bilamalia station and Amin Bazar station: Elevated intermediate stations.
- Gabtoli station: Special station (2 platforms, 4 tracks, 3 underground floors)
- Dar-us-Salam station: Special station (2 platforms, 3 tracks, 2 underground floors)
- Mirpur1 station, Mirpur14 station and Kochukhet station: Typical stations with 2 underground floors
- Mirpur1 station and Gulshan2: Typical stations with 3 underground floors.
- Banani station: Typical station with 4 underground floors, vertical stacked side platform

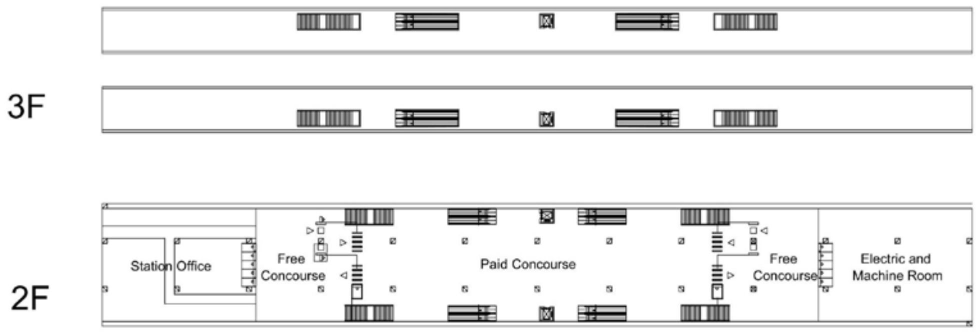
Table 4.2.11 Station Characteristics

No	Station Name	Station Type	Stories	Platform Type	No of Platform	No of Tracks	Transfer
St1	Hemayetpur	Elevated	3 stories	Lateral	2	2	
St2	Baliarpur	Elevated	3 stories	Lateral	2	2	
St3	Bilamalia	Elevated	3 stories	Lateral	2	2	
St4	Amin Bazar	Elevated	3 stories	Lateral	2	2	
St5	Gabtoli	Underground	3 stories	Island	2	4	MRT Line 5 South Route and MRT Line2 (In the future)
St6	Dar-us-Salam	Underground	2 stories	Island	2	3	
St7	Mirpur 1	Underground	2 stories	Island	1	2	
St8	Mirpur 10	Underground	3 stories	Island	1	2	MRT Line 6
St9	Mirpur 14	Underground	2 stories	Island	1	2	
St10	Kochukhet	Underground	2 stories	Island	1	2	
St11	Banani	Underground	4 stories	Lateral	2	2	BR/ BRT Line 3
St12	Gulshan 2	Underground	3 stories	Island	1	2	
St13	Notun Bazar	Underground	4 stories	Island	1	2	MRT Line 1
St14	Vatara	Elevated	3 stories	Lateral	2	2	

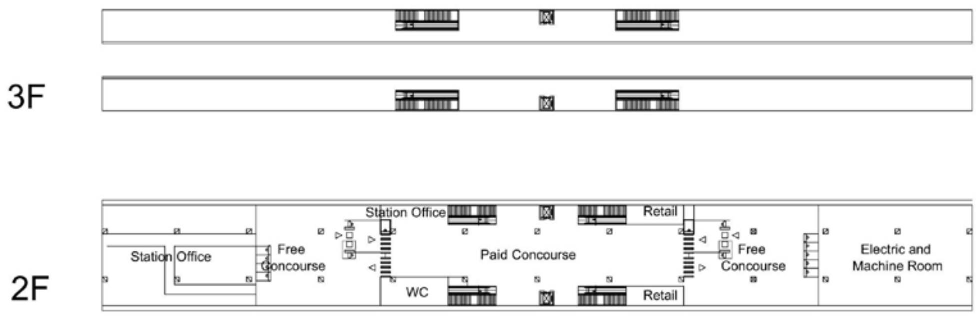
Source: JICA Study Team

(2) Elevated Stations

There are 5 elevated stations namely, Hemayetpur station, Baliarpur station, Bilamalia station, Amin Bazar station and Vatara station. All stations have 3-floors, the 2nd floor is for free and paid concourse, 3rd floor is platform. 1st Floor is the ground floor, and no station related activities are planned though there might be some underground tanks and storage facilities. Hemayetpur station and Vatara station are terminal stations of MRT Line5, thus both stations are expected to have large demand. Hemayetpur station is expected to have more than 200 thousand passengers daily. On the other hand, Baliarpur station to Amin Bazar are expected to have 20-50 thousand passengers daily. The difference of demand between terminal stations and intermediate stations are substantially big. Therefore 2 types of layout plan are prepared. In terminal stations platform, 2 sets of two escalators and two stairways are provided. Generally, 3m wide stairways are provided to handle large number of passengers. In intermediate stations, 2 sets of one escalator and stairs are provided. The exit entry locations from 1F to 2F will be finalized during detail design as those are site specific.



Terminal Station Layout (Hemayetpur station and Vatara station)



Intermediate Station Layout (Baliarpur station, Bilamalia station and Amin Bazar station)

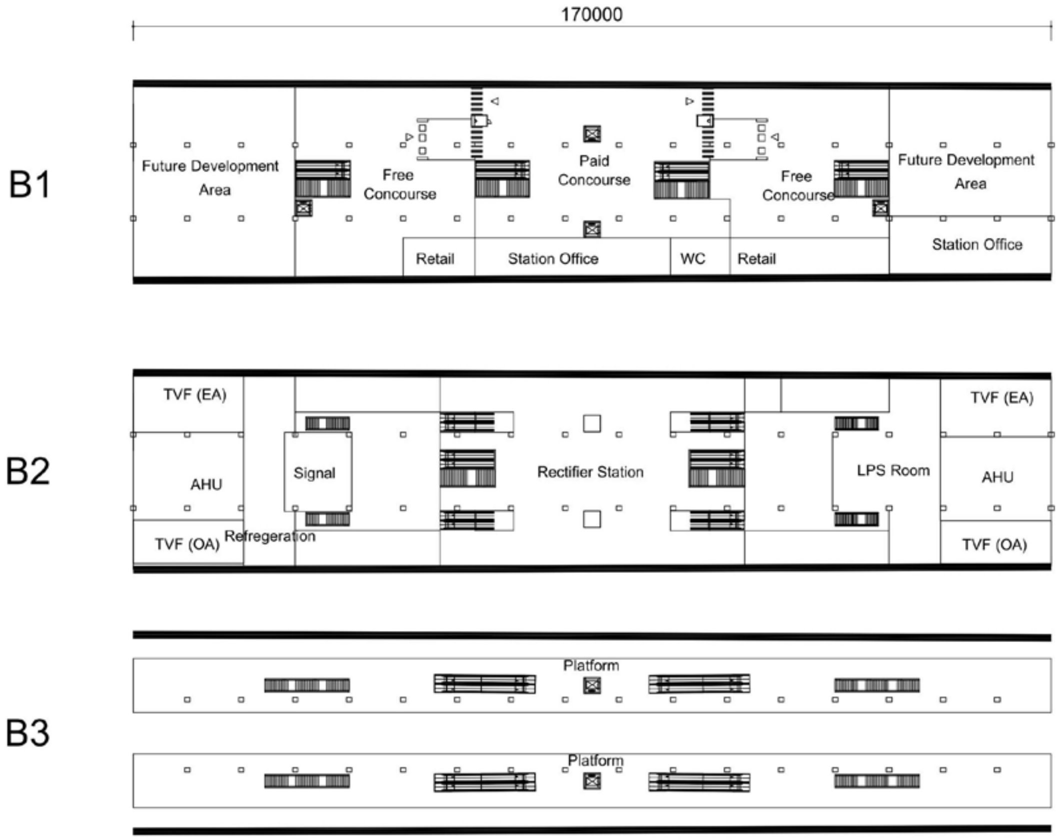
Source: JICA Study Team

Figure 4.2.60 Elevated Station Layout

(3) Gabtoli Station

Gabtoli station is planned underneath of Gabtoli bus terminal. It will have 2 platforms, 4 tracks, and 3 underground floors.

This station is wide and long because of scissors crossing and it will have especially large floor area. The first floor from the ground is for unpaid and paid concourse, the 2nd floor from the ground is for electrical and mechanical rooms and other services. The 3rd floor from the ground is platform level. Some parts of the first floor from the ground are expected to be developed as commercial area in the future. As this station is connected with bus terminal and it will be the branching point to Line 5 South Line section as well as future MRT Line 2, demand is expected to be very large. So, the width of platform is 10 m each. To handle large number of passengers, 2 sets of up-down escalators and two stairways are provided for each platform.

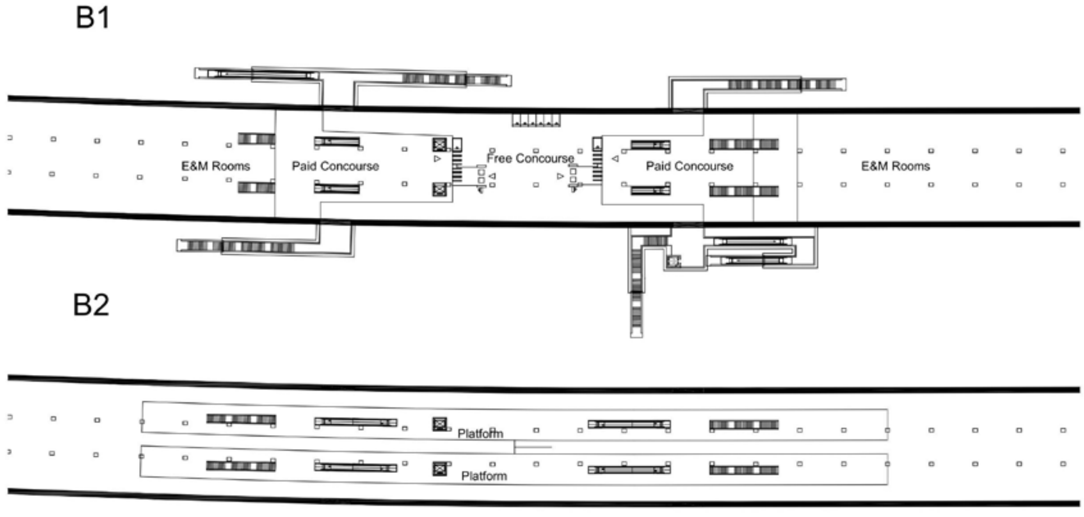


Source: JICA Study Team

Figure 4.2.61 Gabtoli Station Layout

(4) Dar-us-Salam Station

Dar-us-Salam station is planned under a relatively wide road with 2 platforms 3 tracks, 2 floors under the ground. As the station box is long and B1 floor is quite large, electrical and mechanical rooms are arranged on B1 floor at the same level of the concourse. The free concourse is located at the center of the station and it is connected with 4 main entrances. Each platform has 2 escalators, 2 stairways, and one elevator.

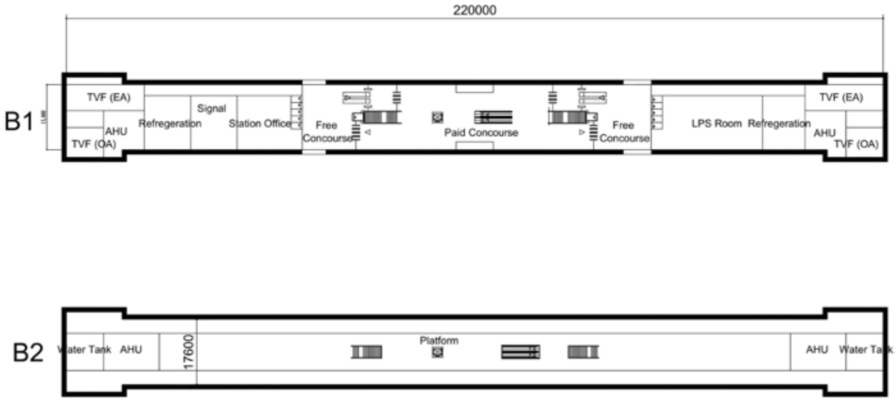


Source: JICA Study Team

Figure 4.2.62 Dar-us-Salam Station Layout

(5) 2-stories Underground Stations: Mirpur 1 station, Mirpur 14 station and Kochukhet station

Mirpur 1 station, Mirpur 14 station and Kachukhet station have common plan and have 2 floors under the ground level. Most of electrical and mechanical rooms are located in B1 level and to accommodate those rooms, station box is 220 m which is 30 m longer than normal stations of 190 m long. The paid concourse is located at the center of the station and free concourse is located both sides of the paid concourse. 2 entrances are connected to each free concourse. Platform has 2 escalators, 2 stairways, and one elevator.

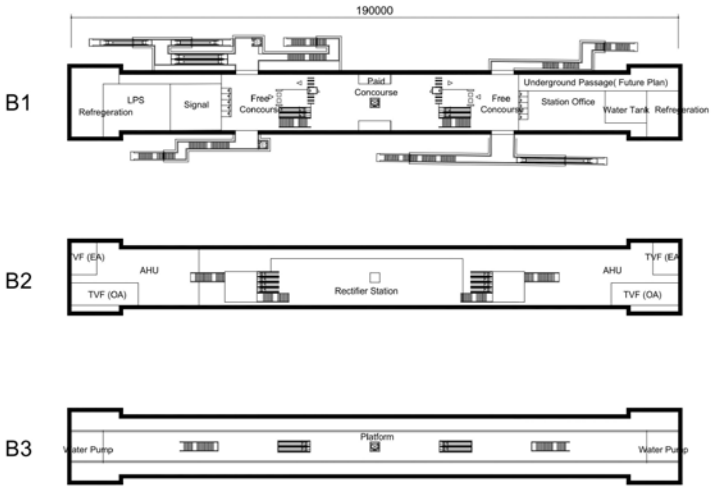


Source: JICA Study Team

Figure 4.2.63 2-stories Underground Station Layout

(6) Mirpur10 station

Mirpur 10 station will have 3 floors under the ground level, it will have 1 platform and 2 tracks. Large demand is expected as this station is a transfer station to MRT Line 6. The paid concourse is located at the center of the station and free concourses are located at both sides of the paid concourse. MRT Line 6 station is an elevated station with 3 floors and it is located at the north eastern side of MRT Line 5 station. At this moment transfer route is supposed to be through normal entrance because of the limitation of land use, but it is of a concern that the width is not enough for big number of transfer passengers. Therefore; space should be kept for future transfer route at north eastern side of the station box. The 2nd floor from the ground level is for rectifier station, fan room, and AHU room. From concourse to platform, 2 sets of up-down escalators and two stairways are provided.



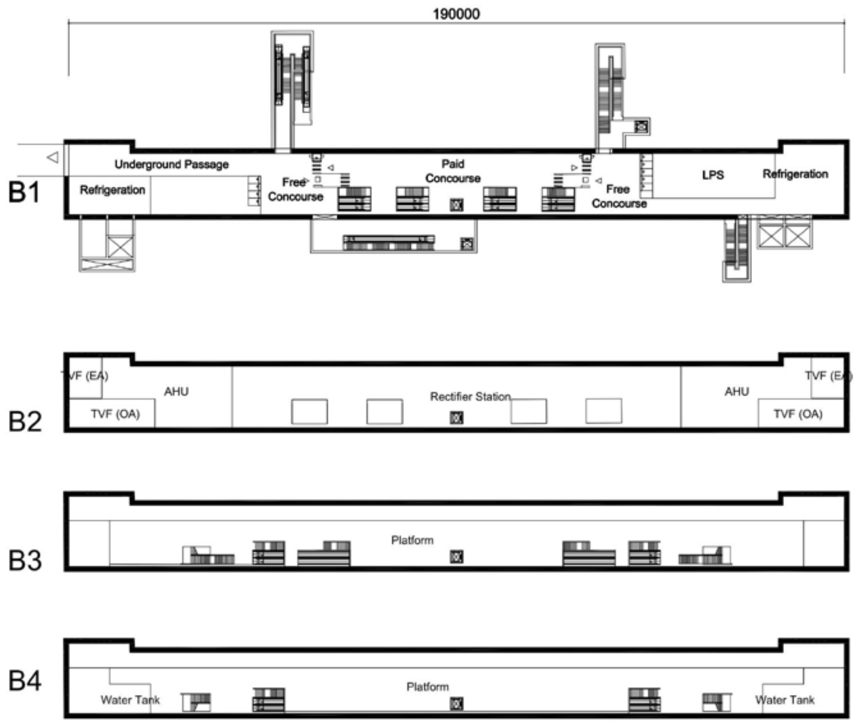
Source: JICA Study Team

Figure 4.2.64 Mirpur 10 Station Layout

(7) Banani station

Banani station has 4 floors under the ground level, has two platforms with one track each. To pass under piles of buildings of cantonment area, the track level at this station is lower than other stations, and the road above the station is narrow. So, the station box width is limited. The station is not wide enough to arrange island type platform with 2 tracks, so in this station, one- sided platforms are stacked vertically. The passenger demand of this station expected to be large, so vertical access route shall have large capacity and arranged to optimize passenger flow. For that, direct escalators from B1 concourse to B3 platform and B1 concourse to B4 platform are proposed. This can avoid congestion caused by changing escalators at each floor, and make passenger route simpler. Vertical distance between B1 and B4 is about 21 m meters, and it is quite long, but there are some precedents of such deep escalators in Japanese stations. It is necessary to verify in detail design study if there are no technical problems when it is installed in Bangladesh.

In west side of B1 floor, pedestrian walkway to the cantonment direction is planned. It is also used as transfer route to BR station and BRT Line 3 station.

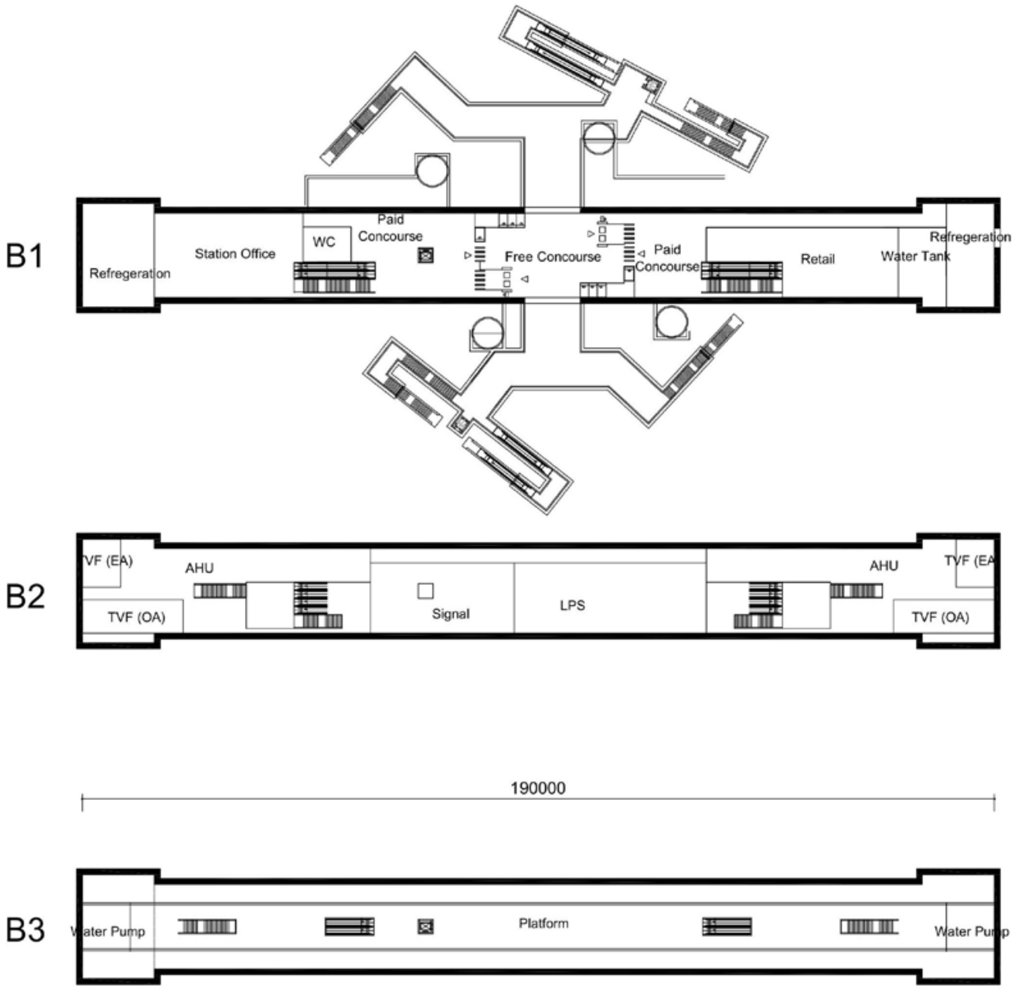


Source: JICA Study Team

Figure 4.2.65 Banani Station Layout

(8) Gulshan 2 station

Gulshan 2 station has 3 floors under the ground level, has one island platform with 2 tracks. This station is located under a circle shape crossing. Four entrances follow that circular shape and access routes from entrances concentrate to the centre of the station, accordingly free concourse is located at the center. Gulshan 2 has 3 floors similar to Mirpur10 station, but it doesn't have rectifier station, so it has more space on B2 level, and this can generate space for commercial area on B1 level. From concourse to platform, 2 sets of up-down escalators, two stairways, and one elevator are provided.

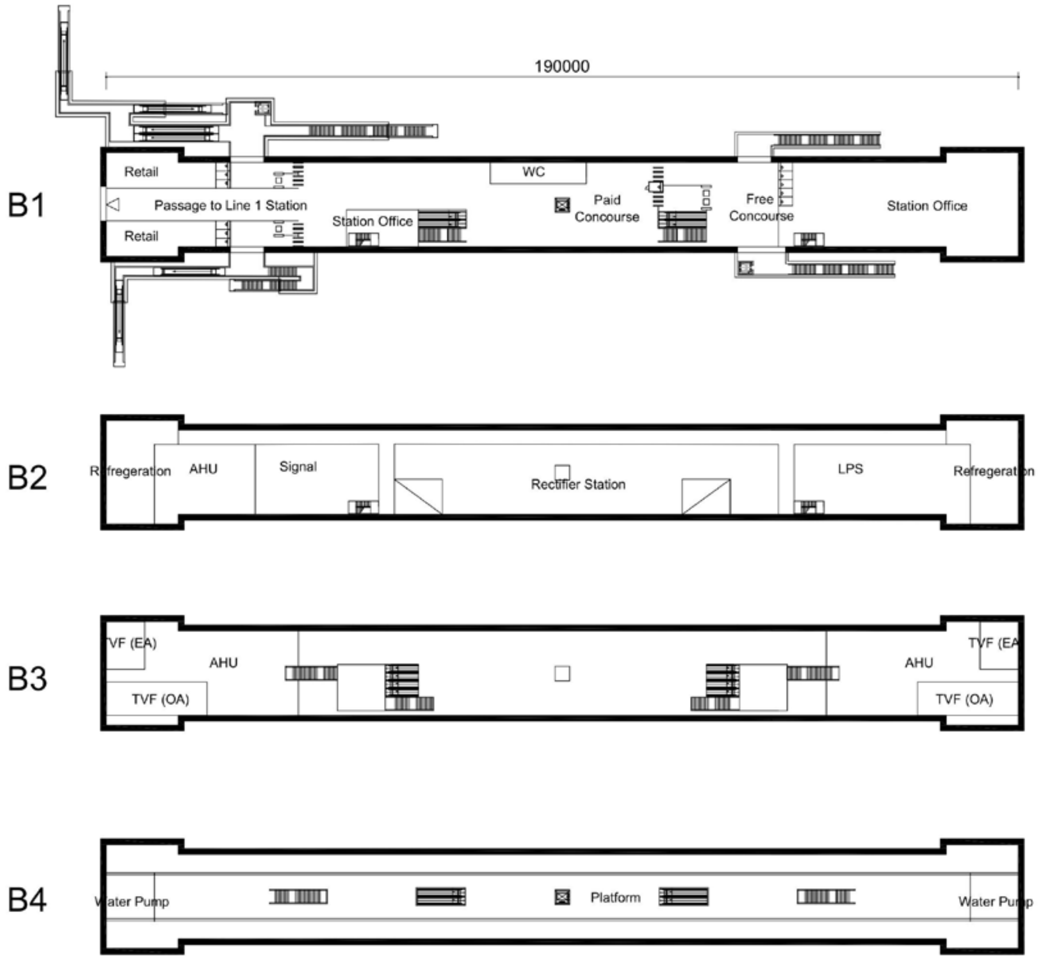


Source: JICA Study Team

Figure 4.2.66 Gulshan 2 Station Layout

(9) Notun Bazar station

Notun Bazar station has 4 floors underground, and it has island type platform with 2 tracks. It is a transfer station to MRT Line1. Track level of this station is lower than other stations because track of MRT Line 5 passes under the MRT Line 1. At western side of B1 level, there is a transfer passage way to MRT Line1. Those two stations shall be connected inside paid concourse area because Line1 and Line5 have common ticket system. On B2 level, there are Traction Sub-Station (hereinafter: TSS), Lighting and Power Station (hereinafter: LPS), refrigeration machine room etc. On B3 level there are fan rooms, air handling unit machine room. Arrangement of stairs and escalators are same as Mirpur 10 and Gulshan 2, that is, 2 sets of up-down escalators, two stairways, and one elevator are provided.



Source: JICA Study Team

Figure 4.2.67 Notun Bazar Station Layout

4.2.5 Track Structure

As proposed by RSTP, Dhaka MRT is planned to connect each other and to a suburban transportation network. All operations of MRT are carried out by DMTC.

Therefore, it is desirable to keep the specification consistent for each line for the track structure from the viewpoint of equipment and maintenance.

MRT Line 6, which is currently under construction, adopted the following track specifications, and MRT Line 5 is also recommended to adopt the same specifications.

Table 4.2.12 Specifications of Track Structure

Item	Specification	Applicable Section
Gauge	1,435 mm	All Track
Track Structure	Concrete bed track (Slab Track or Plinth Track)	Main Line (Elevated, Underground), Depot Access Line
	Concrete vibration-reducing bed track (Slab Track or Plinth Track)	Main Line (Steep curve section / Noise and vibration reducing point)
	Ballasted track	Depot
Track width	Concrete bed track 2,060 mm (Plinth Track)	Main Line
	Ballasted track 4.440 mm	Depot
Thickness of Track	Concrete bed track 600 mm (Including drainage concrete)	Main Line
	Ballasted track 600 mm (Ballast bed depth 250 mm)	Depot
Classification of Rail	UIC60, Head-hardened Rail	All Track
Welding of Rail	Flash butt welding or Alumino-thermic welding	Main Line
Rail fastening device	Wire spring type or Plate spring type	All Track
Sleeper	Concrete bed track, PC Sleeper or Monoblock	Main Line
	Ballasted track, PC Sleeper	Depot
Simple turnout	1 in 7 type or T1 in 9 type Turnout	All Track
Cross over	Ditto	All Track
Scissors cross over	Ditto	All Track
Expansion Joint	UIC60 type	Continuous welded rail section of Main line
Car stop	Buffer type	All Track

Source: JICA Study Team

4.3 Train Operation Plan

4.3.1 Overview

1) Train Operation Policy

The route characteristics of MRT Line 5 is that there are many transit stations with exisitng, under construction and planned MRT, BRT and BR lines. Table 4.3.1 shows the number of daily passenger and transit passenger of MRT Line 5. More than forty percent passengers are transit passenger in 2028 and 2035. Therefore, it is very important to consider the transit passengers for train operation.

Table 4.3.1 The Number of Daily Passenger of MRT Line 5 and Transit Passenger

Transit stations	2028			2035		
	MRT Line 5 Daily passenger (person)	Transit passenger (person)	Transit passenger ratio (%)	MRT Line 5 Daily passenger (person)	Transit passenger (person)	Transit passenger ratio (%)
Natun Bazar station (MRT Line 1)	186,000	101,300	54%	171,000	92,400	54%
Gabtoli station (MRT Line 2)	-	-		221,000	97,300	44%
Mirpur10station (MRT Line 6)	206,000	98,200	47%	206,000	104,200	51%

Source: JICA Study Team

In general, transition resistance has elements of horizontal movement distance, vertical movement distance and waiting time[1]. Horizontal and vertical movement distance can be minimized by alignment and station structure, and waiting time can be minimized by train operation plan. Therefore, the train operation policy is to minimize the waiting time at the station in order to shorten the headway both for peak time and off-peak time.

In addition, there are many embassies and comparatively high income residences around Natun Bazar station, and these people are considered as passengers of MRT Line 5. The risk of the crime such as pickpocket will be higher if the congestion ratio is high. Thus, passenger ratio shall be set lower as much as possible.

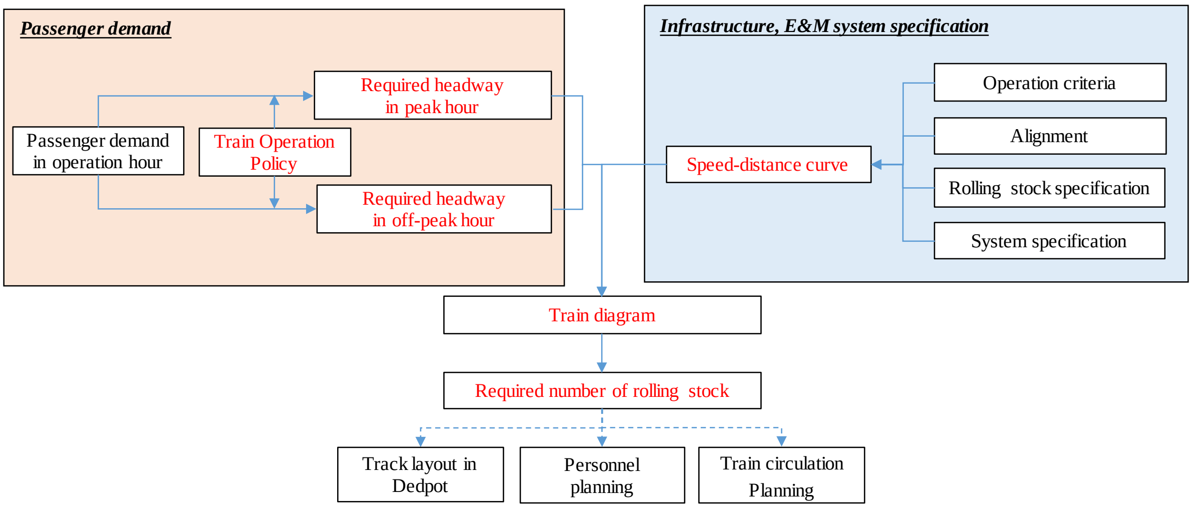
In case of the Japanese definition about congestion ratio, maximum congestion ratio of comparatively comfortable for passenger is approx. 150%.

Under the circumstance, the train operation policy is formulated to minimize the operation headway for transit passengers and to set the lower congestion ratio approximately at 150%. It may be noted that MRT Line 6 congestion ratio is 180%.

2) Work Flow of Train Operation Planning

The work flow of train operation planning is shown in Figure 4.3.1. The headway of peak time and off-peak time is determined by the passenger demand forecast and train operation policy. The travelling time is calculated by the speed-distance curve based on the operation criteria, alignment, rolling stock and system specification.

[1] Ministry of Land Infrastructure, Transport and Tourism: Evaluation Method for Convenience of Transport Nodes Based on Generalized Time, 2006.



※Red color means the scope of train operation plan

Source: JICA Study Team

Figure 4.3.1 Work Flow of Train Operation

4.3.2 Passenger Demand and Transport Capacity

1) Hourly Passenger Demand

Estimated daily passenger demand at each station and cross section passenger volume are described in section 3.4.

Hourly passenger demand in each direction in 2018, 2035 and 2058 are based on the hourly trip ratio mentioned in section 3.4.

Maximum demand in peak hour of eastbound in 2028 is 27,930, westbound in 2028 is 16,655, eastbound in 2035 is 28,600, westbound in 2035 is 15,885, eastbound in 2058 is 36,101 and westbound in 2058 is 21,270.

2) Transport Capacity in a Train Set

An end car and a middle car have different capacities according to the rolling stock plan mentioned in section 4.4. Passenger capacity of congestion ratio 100% is as follows;

- An end car: 153 passengers
- A middle car: 165 passengers

The transport capacity of each train set and congestion ratio in a train set is summarized in

Table 4.3.2. Though the congestion ratio is accepted up to 180% to increase the capacity, for this line operation headway is set for approx. congestion ratio of 150% to follow the operation policy.

Table 4.3.2 Transport Capacity of Train Sets for different Congestion Ratios

	Congestion ratio		
	100%	150%	180%
4-car	636	954	1,144
6-car	960	1,449	1,738
8-car	1,296	1,944	2,332

Unit: Person

Source: JICA Study Team

4.3.3 Operation Headway

Table 4.3.3 summarizes the PHPDT (Peak Hour Peak Direction Traffic) and its sections, as calculated in Section 4.3.2 1). Peak time is considered during 8:00 – 9:00 for all years and lines.

Table 4.3.3 PHPDT and Its Section

Year	PHPDT	Section
2025	27,930	Mirpur14 station – Kochukhet station
2035 North line	28,600	Gabtoli Station -Dar-us-Salam Station
2035 South line	28,730	S2 Station -S3 Station
2055 North line	34,840	Gabtoli Station -Dar-us-Salam Station
2055 South line	35,100	S2 Station -S3 Station

Source: JICA Study Team

Operation headway shall be determined based on the transport capacity mentioned in

Table 4.3.2 in order to carry all the passengers. Transportation capacity per hour is summarized in Table 4.3.4 by operation headway and congestion ratio.

Table 4.3.4 Hourly Transport Capacity among Congestion, Train Set and Headway

Headway (min)	100%			150%			180%		
	4-car	6-car	8-car	4-car	6-car	8-car	4-car	6-car	8-car
5.0	7,632	11,592	15,552	11,448	17,388	23,328	13,737	20,865	27,993
4.5	8,268	12,558	16,848	12,402	18,837	25,272	14,882	22,604	30,326
4.0	9,540	14,490	19,440	14,310	21,735	29,160	17,172	26,082	34,992
3.5	10,812	16,422	22,032	16,218	24,633	33,048	19,461	29,559	39,657
3.0	12,720	19,320	25,920	19,080	28,980	38,880	22,896	34,776	46,656
2.5	15,264	23,184	31,104	22,896	34,776	46,656	27,475	41,731	55,987

Unit: Person

Source: JICA Study Team

The congestion ratio will be 180% to meet the PHPDT demand by 4-car train set in 2028. On the other hand, 3 min. operation can be realized by 6-car train set and 4 min. operation can be realized by 8-car in a train set.

3 min. 30 sec. headway operation is required for 6-car train set and its congestion ratio will be 161%. It is mostly acceptable for passenger comfortability, although the congestion ratio slightly higher than the train operation policy set.

Comfortability can be increased by operating more frequently, however initial cost will be high because the required number of rolling stock is increased accordingly. Considering the operation headway, comfortability and initial cost, train operation in 2028 shall be 3 min. 30 sec. headway by 6-car train.

It is possible to operate 3 min. headway by 6-car train set to carry PHPDT in 2035 with same strategy of 2028.

It is not possible to carry PHPDT in 2058 by 6 car train set even in 2 min. 30 sec. headway, thus it is planned to operate in 3 min. headway by 8-car train set in 2058. Train operation headway in 2058 is same as that of 2035 because demand is estimated by annual growth rate and it is possible to carry all passenger by 8-car train set. Another 2-car train set shall be procured in 2038 according to the analysis of annual growth rate from 2035 to 2058.

	0:00–6:00	6:00–7:00	7:00–11:00	11:00–17:00	17:00–20:00	20:00–22:00	22:00–24:00
Weekday	Maintenance	Headway 5' 00" 12 trip	Headway 3' 30" 18*4 trip	Headway 4' 30" 14*6 trip	Headway 4' 00" 15*3 trip	Headway 4' 30" 14*2 trip	Headway 6' 00" 10*2 trip
Weekend	Maintenance	Headway 10' 00" 6 trip	Headway 7' 00" 8*15 trip				Headway 10' 00" 6*2 trip

Source: JICA Study Team

Figure 4.3.2 Train Operation Headway in 2028

	0:00–6:00	6:00–7:00	7:00–11:00	11:00–17:00	17:00–20:00	20:00–22:00	22:00–24:00
Weekday	Maintenance	Headway 5' 00" 12 trip	Headway 3' 00" 20*4 trip	Headway 4' 00" 15*6 trip	Headway 3' 30" 18*3 trip	Headway 4' 30" 14*2 trip	Headway 6' 00" 10*2 trip
Weekend	Maintenance	Headway 10' 00" 6 trip	Headway 7' 00" 8*15 trip				Headway 10' 00" 6*2 trip

Source: JICA Study Team

Figure 4.3.3 Train Operation Headway in 2035

	0:00–6:00	6:00–7:00	7:00–11:00	11:00–17:00	17:00–20:00	20:00–22:00	22:00–24:00
Weekday	Maintenance	Headway 5' 00" 12 trip	Headway 3' 00" 20*4 trip	Headway 4' 00" 15*6 trip	Headway 3' 30" 18*3 trip	Headway 4' 30" 14*2 trip	Headway 6' 00" 10*2 trip
Weekend	Maintenance	Headway 10' 00" 6 trip	Headway 7' 00" 8*15 trip				Headway 10' 00" 6*2 trip

Source: JICA Study Team

Figure 4.3.4 Train Operation Headway in 2058

4.3.4 Travel Time

Travel time is calculated by considering 1) Rolling stock specification, 2) Speed limit, 3) Stopping time at station and 4) Turnback time of terminal stations. Operation simulation is done by these conditions.

1) Rolling Stok Specification

Table 4.3.5 shows the rolling stock specification, which are described in section 4.4.

Table 4.3.5 Rolling Stock Specification

Item	Condition
Rolling stock type	JR East E233 Type
Congestion ratio	150% (up to 180%)
Maximum speed	100 km/h
Acceleration ratio	0.92 m/sec^2
Deceleration ratio	0.97 m/sec^2

Source: JICA Study Team

2) Speed Limit

Speed limit is required at curve section and turn out section. It is referred to “Technical Standards for the Metrorail in Bangladesh”.

Table 4.3.6 Speed Limit at Radius

Radius (m)	Maximum speed (km/h)
160	45
200	50
230	60
250	70
300	75
350	80
400	85
450	90
500	95
More than 550	100

Basic formula
$V=4.3\times\sqrt{R}$
V：Speed (km/h)
R：Radius (m)

Source: Technical Regulatory Standards on Japanese Railways, MLIT Japan

Table 4.3.7 Speed Limit at Turnout

Turn out (m)	Maximum speed (km/h)
#7	30
#9	35

Source: JICA Study Team

3) Stopping Time at Stations

Stopping times at stations are determined by the daily passenger demand as summarized in Table 4.3.8. Hemayetpur station and Vatara station are not included here because those are the turnback stations.

Table 4.3.8 Stopping Time at Stations

Daily passenger (person)	Stopping time (sec.)
100,001～	45
70,001～100,000	40
40,001～70,000	35
20,001～40,000	30
0～20,000	25

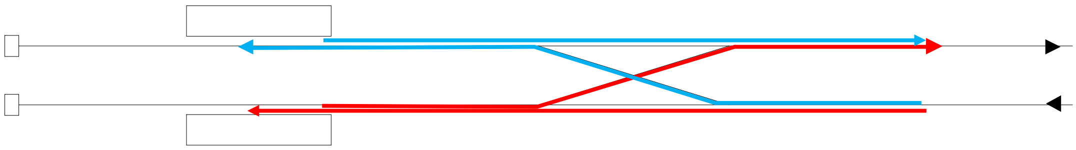
Source: JICA Study Team

4) Turnback Time

Hemayetpur station has a turnback at platform because scissors crossing is installed at the front of the station. On the other hand, Vatara station has its turnback via lead track because scissors crossing is installed behind the station.

(3) Turnback at Platform (Hemayetpur station)

After a train arrives at platform No.1, passengers alight the train and new passengers who are going to Baliarpur station direction board the train. After the train departs platform No.1 with passengers, the train passes the scissors crossing to enter the other side and goes to next stations (red line of Figure 4.3.5). In case a train have already stopped at platform No.1, a train passes the scissors crossing and arrives at platform No.2. Passengers alight from platform No.2 and new passenger who are going to Baliarpur station direction board the train from platform No.2. After boarding the passengers, the train runs along the same side and goes to next station (blue line of Figure 4.3.5).



Source: JICA Study Team

Figure 4.3.5 Schematic Figure of Turnback at Platform (Hemayetpur station)

Required time of turnback at platform is summarized in Table 4.3.9.

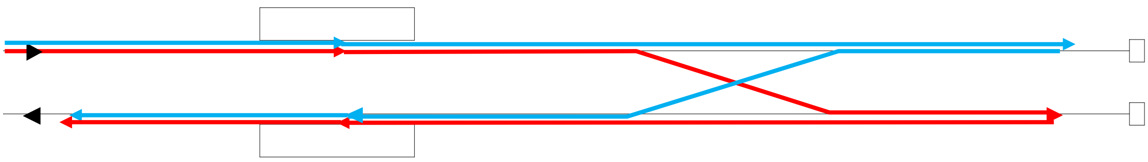
Table 4.3.9 Required Time of Turnback at Platform (Hemayetpur station)

Item	Required Time(sec.)
Train arriving	-
Position confirmation by driver	5
Opening door (train and PSD)	5
Preparation of cab equipment	50
Walking to another cab and car body check	90
Preparation of departure	50
Closing door (train and PSD)	5
Safety confirmation by driver	5
Train departing	-
Total	3 min. 30 sec.

Source: JICA Study Team

(4) Turnback via lead track

Turnback via lead track is passenger friendly because the function of platform is not changed by turnback operation. Platform No.1 is used for departure and platform No.2 is used for arrival only. The train is shunted after all passengers alight at the station.



Source: JICA Study Team

Figure 4.3.6 Schematic Figure of Turnback via Lead Track (Vatara station)

Required time of turnback via lead track is summarized in Table 4.3.10.

Table 4.3.10 Required Time of Turnback via Lead Track (Vatara station)

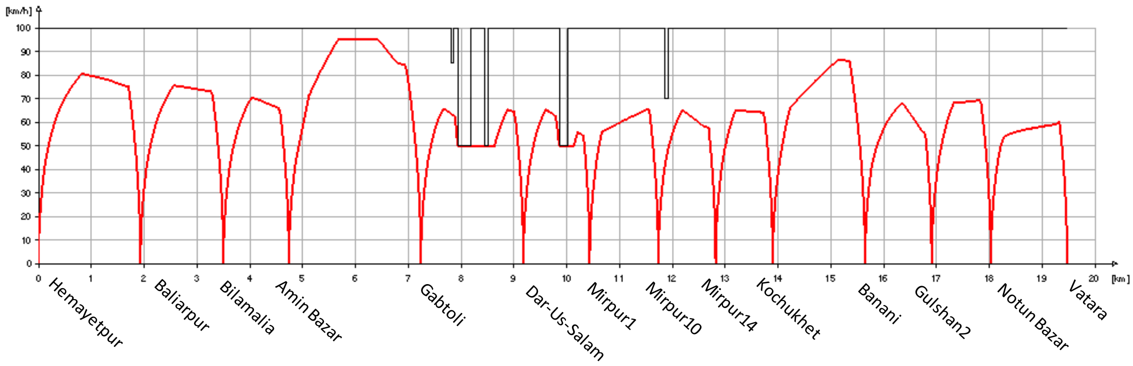
Item	Required Time(sec.)
Train arriving	-
Position confirmation by driver	5
Opening door (train and PSD)	5
Passengers get off	90
Closing door (train and PSD)	5
Safety confirmation by driver	5
Shunting to lead track	75
Preparation of cab equipment for turnback	30
Walking to another cab	90
Preparation of departure	30

Item	Required Time(sec.)
Shunting to platform	75
Position confirmation by driver	5
Opening door (car and PSD)	5
Passengers get on	40
Closing door (car and PSD)	5
Safety confirmation by driver	5
Train departing	-
Total	7 min. 50 sec.

Source: JICA Study Team

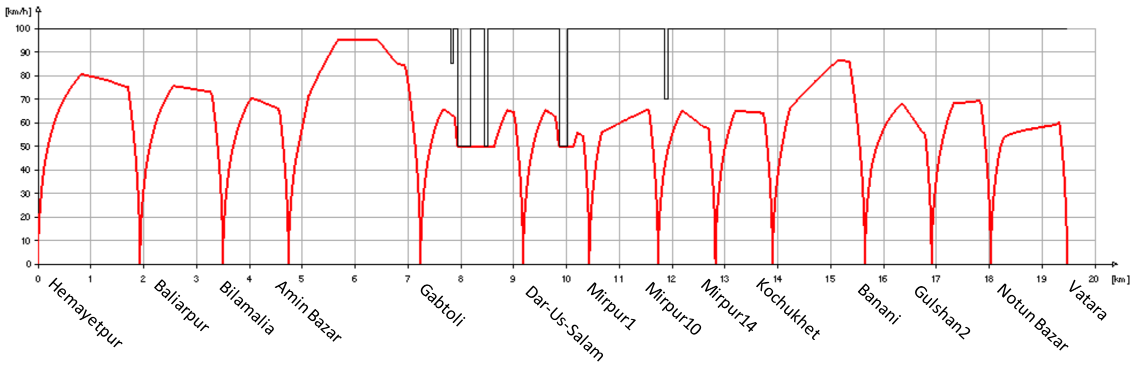
5) Travel Time

As the result of operation simulation considering the abovementioned condition, total operation time for one-way trip of eastbound (Hemayetpur station to Vatara station) takes 32 min. 27 sec. and that of westbound (Vatara station to Hemayetpur station) takes 30 min. 26 sec. Scheduled speed is calculated as 39 km/h in both way.



Source: JICA Study Team

Figure 4.3.7 Speed-Distance Curve (Eastbound)



Source: JICA Study Team

Figure 4.3.8 Speed-Distance Curve (Westbound)

4.3.5 Required Number of Rolling Stock

Required number of rolling stock is calculated by operation headway and scheduled speed as summarized in Table 4.3.11. A total of 30 train sets of 6-car in 2028, 42 train sets of 6-car in 2035 and 42 train sets of 8-car in 2058 are required to deal with the passenger demand. Extra 3 train sets as spare are included in each of those target years.

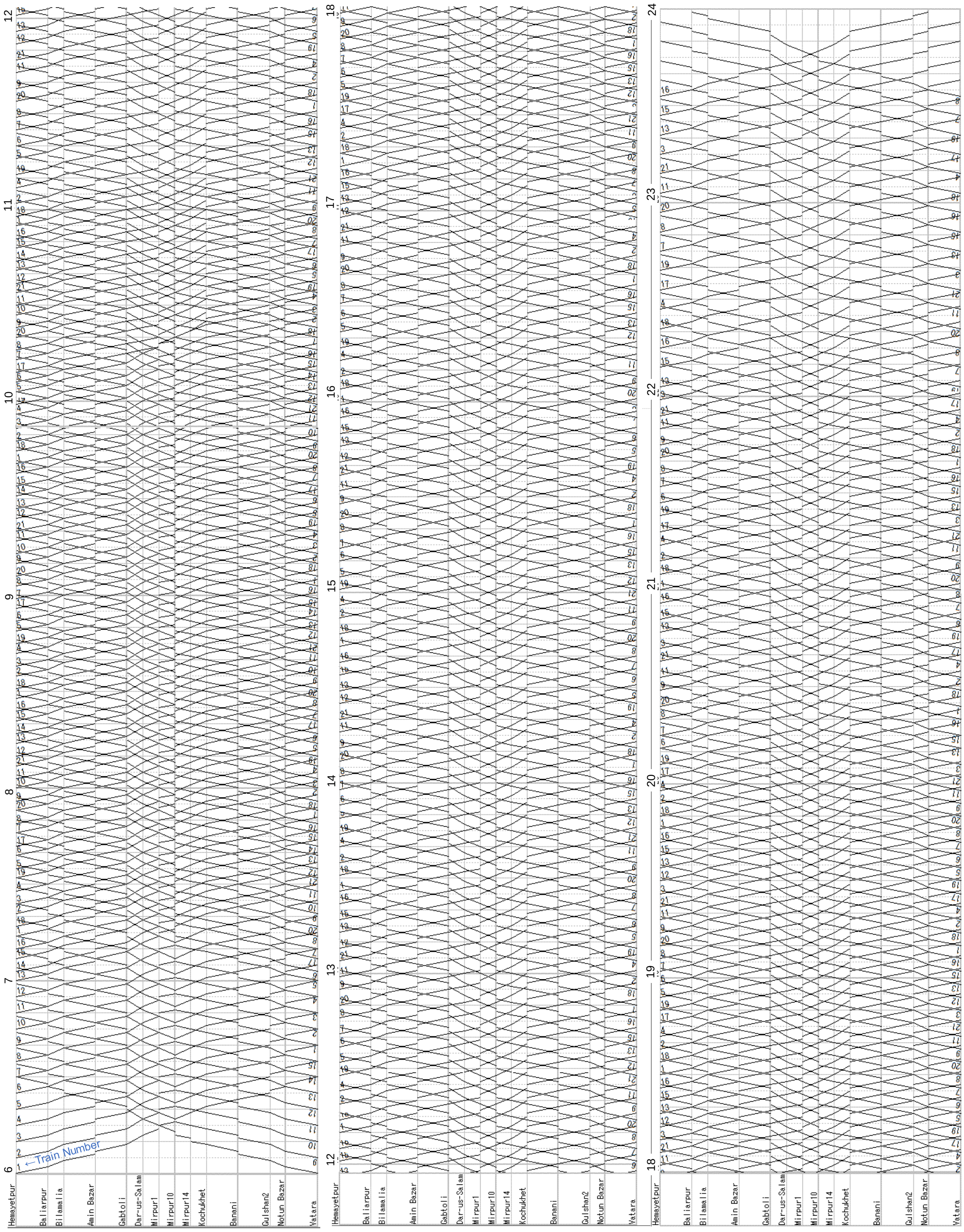
In addition, it shall be considered to stable MRT Line 5 south line rolling stock also at depot. Required number of rolling stock of MRT Line 5 south line is also calculated preliminary by the route length and scheduled speed of MRT Line 5 north line. Thus, the depot will accommodate a total of 61 tarin sets of 8 car configuration.

The basic idea for spare train set is one train set for overhaul maintenance and another two train sets for daily maintenance, so the total three train set is planned for spare train set. The spare train set for Line South after 2035 is one train set as minimum for overhaul maintenance because depot can be shared with MRT Line 5 North.

Table 4.3.11 Required Number of Rolling Stock in each Year

	2028	2035		2058	
	Phase1	Phase1+ Extension (east side)	Extension (South line)	Phase1+ Extension (east side)	Extension (South line)
PHPDT	27,930	28,600	28,730	36,010	36,140
Length (km)	19.8	28.6	17.3	28.6	17.3
Train set (car)	6	6	6	8	8
Headway	3min. 30sec.	3min. 0sec.	3min. 0sec.	3min. 0sec.	3min. 0sec.
Required No. of train set	21	35	20	36	21
Spare	3	3	1	3	1
Total No. of train set (train set)	24	38	21	39	22
Total No. of cars (car)	144	228	126	312	176

Source: JICA Study Team



Source: JICA Study Team

Figure 4.3.9 Proposed Timetable (2028 year)

4.4 Rolling Stocks

As MRT is a high-speed public transportation system transporting many passengers, safety assurance is essential. The equipment and facilities of rolling stock with high reliability are required to prevent the train derailment and collision accidents. Rolling stock should be safe, comfortable and long-life system to transport the passengers on Dhaka MRT system throughout the specified design life.

4.4.1 Outline

The specifications of the rolling stock shall be based on a common architecture with existing systems of Dhaka Line 6 as much as possible. High capacity and highly reliable trains shall be supplied to accommodate the passenger demand. A train configuration is to be employed to minimize components and weight and maximize redundancy.

- The rolling stock shall be of a proven design validated by statistical reliability data from revenue operation.
- As the trains run the underground section, it must satisfy the fire protection standards.
- The rolling stock shall withstand the effects of high temperature and high humidity, with every consideration for the environmental conditions including the climate and pollution levels at Dhaka.

4.4.2 Design Criteria

1) Line Profile of MRT Line 5

The line profile of MRT Line 5, and prevailing climatic condition are explained below.

(1) Line profile of MRT Line 5

Table 4.4.1 Line profile of MRT Line 5

No.	Items	Specifications
1	Truck Gauge	1,435 mm
2	Minimum curve radius on a main track	160 m
3	Steepest gradient in a running area of Rolling Stock	35‰
4	Design speed	110 km/h
5	Maximum train operating speed At the elevated section and At the underground section	 100 km/h 90 km/h
6	The train loading for civil structure	16 tons/Axle

Source: JICA Study team

(2) Climatic Condition

Considerable climate condition is shown in the table below.

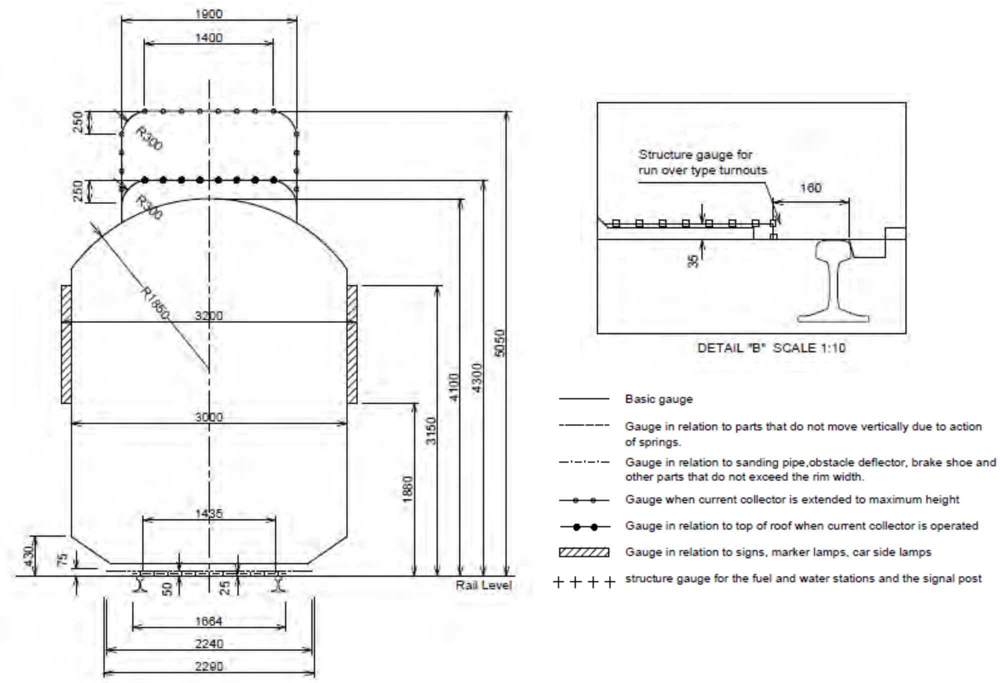
Table 4.4.2 Climatic Condition

No.	Items	Specifications
1	Ambient Temperature	Maximum temperature record: 41◦C
		Average maximum reading: 36 ◦C
		Minimum temperature record: 5◦C
		Maximum Variation during 24 hours: 22 ◦C
2	Relative Humidity:	During June to November: 100 %
		During December to May: 75 %
3	Rainfall:	Normally around 3050 mm during a year, but varies over time and 80 % of total rainfall usually occurs during the period from June to October (monsoon season).
		Maximum Rainfall during 24 hours: 630 mm
4	Maximum wind velocity	140 km/h

Source: JICA Study team

2) Rolling Stock Gauge

The car body should comply with the Rolling Stock Gauge, and it should keep sufficient gap with the Structure Gauge, shown in following figure, so that, even when in motion at maximum operational speed, the car body never infringes with the Structure Gauge.



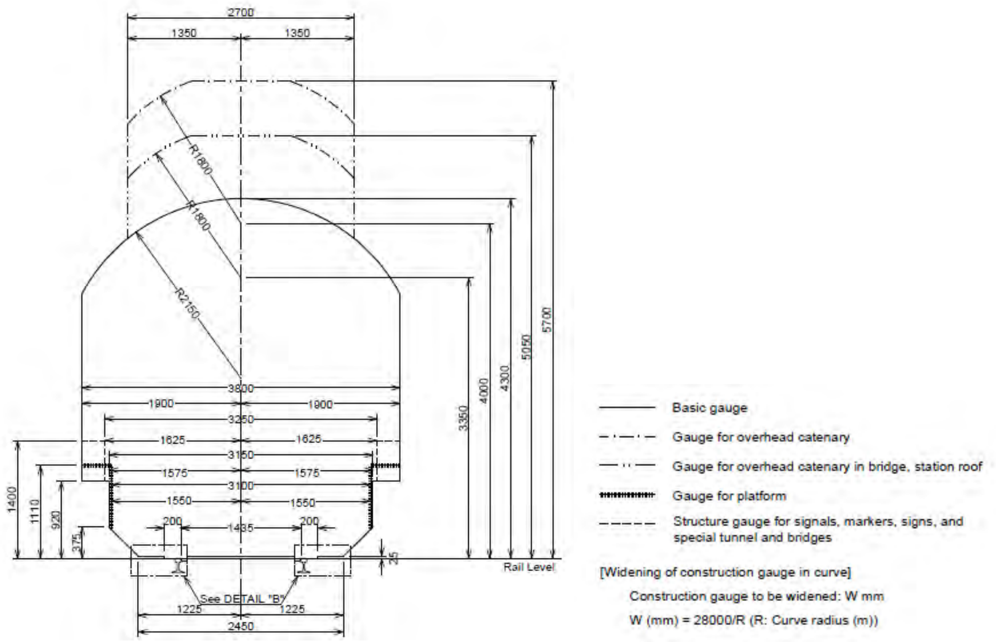
Source: Technical standards for the MRT in Bangladesh

Figure 4.4.1 Rolling Stock Gauge for Straight Track at the Stopped State

3) Structure Gauge

(1) Structure Gauge for the elevated section

Structure gauge for the elevated section is considered following the “Technical Standard for the Metrorail in Bangladesh”.

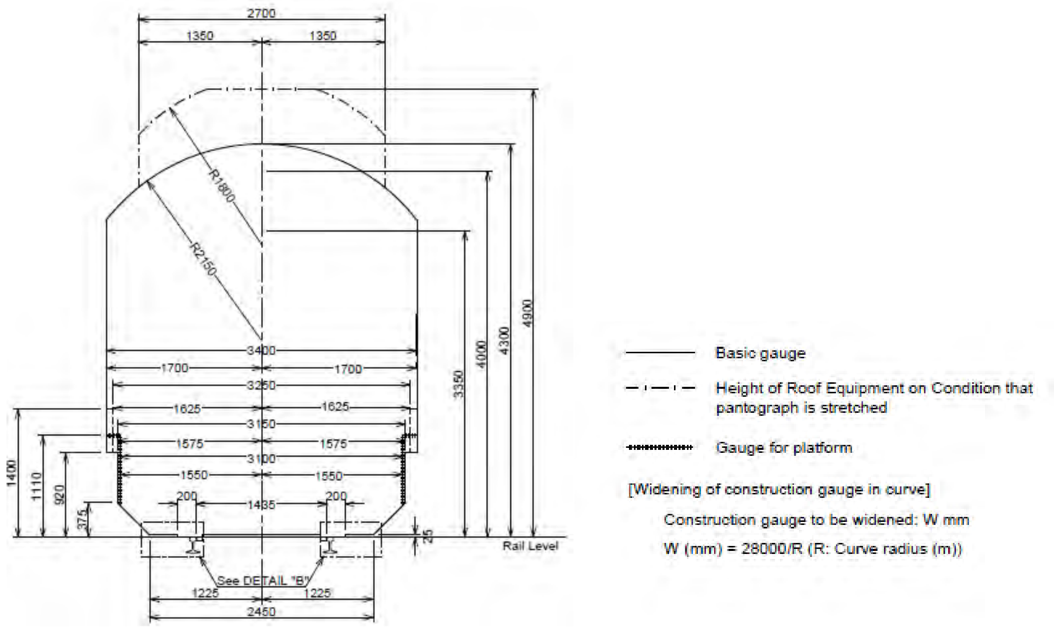


Source: Technical Standards for the Metrorail in Bangladesh

Figure 4.4.2 Structure Gauge for Straight Lines at the Elevated Section

(2) Structure Gauge for the Underground Section

The construction cost of the structure to be built at the underground section is roughly proportional to the section size of the structure. For this reason, Structure Gauge for the underground section is reduced compared to elevated section. Structure Gauge for the underground section is reduced both in vertical and lateral sides compared to Structure Gauge for the elevated section.



Source: JICA Study team

Figure 4.4.3 Structure Gauge for Straight Lines at the Underground Section

4) General System Requirements

(1) Reliability, Availability and Maintainability

A quality management system based on ISO 9001 shall be followed.

Table 4.4.3 Quality Management System

Reliability target	The Mean Distance between Failure shall be more than 120,000 km per train for failures causing train service disruptions of 30 minutes or more and service withdrawal.
Availability target	Availability target shall be not less than 95 % of the coaches, cleaning & scheduled maintenance will be excluded from the availability calculation.
Maintainability	The cars shall be maintenance friendly and shall require minimum maintenance.

Source: JICA Study team

(2) Design Life

The train design life, during which the train is to provide continuing service under all operating conditions, is a minimum of 30 years.

(3) Maximum Axle Load

The maximum axle load of a car is 15.2 tons with maximum passenger loading at (AW3) condition.

(4) Fire safety and Emergency system

The rolling Stock shall comply with Technical Standard for the MRT in Bangladesh requirements for fire safety and emergency. This MRT technical standard prescribes that the car body structure and the materials of interior and exterior of rolling stocks should comply fire safety and emergency requirements. Emergency evacuation system is also prescribed, such as evacuation in case of fire.

(5) OCS (Overhead Contact System) Power Supply

The rated voltage is DC 1,500V, and the contact wire height above the rail is within the pantograph working range of 4300 to 5200 mm at the elevated section, and it is within the pantograph working range of 4300 to 4900 mm at the underground section for Overhead Contact System (hereinafter: OCS).

(6) Train Protection system

The train is provided with Cab signalling under the control of an Automatic Train Protection (hereinafter: ATP) system. Additionally, an Automatic Train Operation (hereinafter: ATO) system under ATP control is provided. Manual operating capability is also required. In all ATO or manual operating modes, ATP is to remain operative.

(7) Train information system

Train information system (hereinafter: TIS) have the multi-train control functions of Fault log, Data transmission of wayside and Passenger services. It should connect with the on-board subsystems.

(8) On-board service facilities

The on-board service facilities are provided for passengers including air conditioning, public address, and information display.

(9) Propulsion System

Propulsion system is summarized in the table below.

Table 4.4.4 Propulsion System

Traction Motor	• AC 3 phase cage type induction motor mounted on bogie frame. • The traction motor provides traction force and braking force (regenerative braking). • Traction Motor Characteristics: Rated voltage: 1,100 V, Capacity: Around 220 kW, this item shall be reviewed during detail design stage together with other MRT Lines of Dhaka and operating condition i.e. running curve calculation.
Traction inverter	• Variable Voltage Variable Frequency (hereinafter: VVVF) control traction inverter. • Input voltage: DC 1,500 V (minimum 900 V, maximum 1,800 V) • Output voltage: AC 3-phase from 0 to 1,100V (rms) at DC 1,500V input.

Source: JICA Study team

5) System Specific Requirements

(1) Codes and Standards

"Technical standards for the Metrorail in Bangladesh", Japanese standards and International standards shall provide the 'base line' for the minimum standards for design, manufacturing, installation, testing and commissioning and hand over. The main codes, standards and specifications applicable for the Rolling Stock are listed below:

Table 4.4.5 Codes and Standards

No.	Item	Codes and Standards
1	Design of Rolling Stock	
	UIC - 605-1 - International union of railways codes JIS E7103 - Rolling stock -- General requirements of car body for passenger car JIS E 7106:2006 Rolling stock -- General requirements of car body structures for passenger car JIS E4047 - Design methods for arc welded joints of steel for railway rolling stock	
2	RAMS	
	IEC 62278 - Railway applications - Specification and demonstration of reliability, availability, maintainability and safety (RAMS)	
3	Electromagnetic Compatibility	
	EN 50121, Railway Applications – Electromagnetic Compatibility JIS E4018- Railway rolling stock -- Measuring methods of leakage magnetic field	
4	Electrical	
	IEC 60034-25 - Guide for the design and performance of cage induction motors specifically designed for inverter supply (2007) EN 50155 – Railway applications – Electronic equipment used on Rolling Stock IEEE Std. 16-2004, Standard for Electrical and Electronic Control Apparatus on Rail Vehicles IEEE Std. 1476-2000, Passenger Train Auxiliary Power Systems Interfaces IEEE Std. 1478-2001, Environmental Conditions for Transit Rail Car Electronic Equipment JIS E6102- AC traction motors for rolling stock	
5	Fire Safety	
	Technical Standards for the Metrorail in Bangladesh, Section 9.19 Ministerial Ordinance to Provide Technical Regulatory Standards on Railways of Japan	
6	Lighting	
	JIS E4016 Illuminance for Railway Rolling Stock	
7	Overhead Catenary System	

No.	Item	Codes and Standards
	EN 50163: railway applications supply voltages of traction systems	
8	Ventilation and Air Conditioning System	
	JIS E4015- Measuring methods for air conditioning and heating temperature of railway rolling stock JIS E4024 - Railway rolling stock -- Test methods of ventilation	
9	Wheels and Axles	
	JIS E4501 - Railway rolling stock -- Design methods for strength of axles JIS E5402-1 - Railway rolling stock -- Solid wheel -- Part 1: Quality requirements JIS E4504 - Wheel sets for railway rolling stock -- Quality requirements	
10	Noise and Vibration	
	ANSI S1.4, Specification for Sound Level Meters IEC 61373, Railway Applications - Rolling Stock Equipment - Shock and Vibration Tests JIS E4021 - Railway rolling stock -- Test methods inside noise	
11	Testing	
	IEC 61133 - Railway applications - Rolling stock - Testing of rolling stock on completion of construction and before entry into service JIS E4041 – Testing of Rolling on Completion of Construction and before entry into service	

Source: JICA Study team

(2) Train performance

The following conditions shall be applicable to the 6-car train formation and to the future 8-car train formation:

- The train is capable to achieve a speed of 100 km/h on clean, dry, level, well maintained tangent track on the elevated section with half worn wheels and AW3 loading throughout the complete train.
- Propulsion and brake performance requirements are met using the following conditions: half worn wheels and AW3 loading throughout the complete train.

Table 4.4.6 Performance requirements of Propulsion and Brake System

No.	Items	Specifications
1	Maximum acceleration	Greater than 0.92 m/s^2
2	Degraded operation (Motor Cutout Operation)	Start and accelerate with AW3 load on a 35‰ gradient by the two motor cars
3	Abnormal operation (Rescue Operation)	An AW0 loaded train shall be able to push another AW3 loaded train at least 1000 meters from stopped condition on a 35‰ gradient
4	Maximum deceleration of Electrical braking	Greater than 0.97 m/s^2
5	Minimum operating speed of Regenerative brake	Not fade at any speed above 8 km/h
6	Maximum Service brake deceleration	More than 0.97 m/s^2
7	Maximum emergency brake deceleration	More than 1.25 m/s^2
8	Jerk Control	Not exceed 0.7 m/s^3 except emergency brake
9	Accuracy of Station Stopping	Stopping within 350 mm of the designated station stopping point with service braking in ATO mode.

Source: JICA Study team

6) Subsystem Configurations

(1) Car body

The outline of Car body is shown in the following table.

Table 4.4.7 Outline of Car Body

No.	Items	Specifications
1	Body Length of Middle car	19,500 mm
2	Body Length of End car	19,800 mm
3	Body Width	2,950 mm
4	Body roof Height above Rail Level	3,650 mm
5	Air-condition height above Rail Level	4,100 mm
6	Floor height (above rail level):	1,150 mm
7	Maximum Gap between Platform edge and Car body entrance floor	70 mm
8	Longitudinal compressive load at coupling point	490kN (50t)
9	Car body material	Stainless steel or aluminum alloy

Source: JICA Study team

(2) Body length

The body length of the intermediate car (M) is 19,500 mm. The body length of the leading car (Tc) is 19,800 mm. The maximum length of 6-car train (coupler face to coupler face) shall be 121 m. When the 8-car train is introduced the maximum length of the 8-car consist, coupler face to coupler face, is 161 m.

Source: JICA Study team

Figure 4.4.4 Conceptual Diagram of the Leading Car and the Intermediate Car

(3) Passenger comfort

(a) Passenger entrance doors

Each car will have four sets of power operated bi-parting, pocket type sliding entrance doors on each side. Door opening width of the entrance door size is 1400 mm and Door height is 1850 mm.

(b) Gangways

Gangways to be provided on each car. Gangway doors is provided between cars. The gangway size between coaches: approximately 900 mm width. The gangway size at the end of the Tc cars: approximately 650 mm (not less than 600 mm) width.

(c) Dropping window

Dropping window of 400 mm height will have an opening area greater than 8% of the total floor area. This opening dimension will provide the expected passenger comfort in case of power failure. The fully opening area is placed 1,350 mm above the body floor. The passenger must not be able to touch the PSD frame placed on the platform through this opening.

(d) Passenger seats

Longitudinal 3 seats and 7 seats are used, the seat size per person is 430 mm width and

550 mm depth.

(e) Hand grips and Overhead luggage

Hand grips, Poles to support hand hold rollers, and hanging arrangements for the roller, Strap handles and Overhead luggage racks is provided.

(f) Train communication equipment

Table 4.4.8 Train Communication Equipment

No.	Items	Specifications
1	PA system	Two exterior speakers on each side wall of car body
2	Passenger emergency communication system	Four call stations in each car at door bays
3	PID system	Display for End and Side Destination, Passenger Saloon
4	End destination display	Illuminated with three colors LED
5	Side destination display	Illuminated with three colors LED
6	Passenger saloon display	Each side door, multi colors with high resolution LCD
7	Door chime	Passenger Doors

Source: JICA Study team

(4) Lighting

The interior lighting is designed to give an even light distribution without glare. The lighting level is more than 200 lux. over the whole saloon room at height of 0.85 m above floor

(5) Bogie

The principal data of bogey are shown in the table below,

Table 4.4.9 Bogie Principal Data

No.	Items	Specifications
1	Gauge	1,435 mm
2	Distance between two bogies	13,800 mm
3	Bogie wheel Base	2,100 mm
4	Wheel Diameter	860 mm (New), 780 mm (Fully Worn)

Source: JICA Study team

(6) Driving cab

The cab environment is designed ergonomically and allow for all drivers to operate the train comfortably and efficiently. The cab design maximizes outward visibility to provide the driver full observation of track area and station platform area.

Table 4.4.10 Main Equipment of the Driving Cab.

No.	Items
1	Operating devices for control facilities
2	Operating devices for service brake devices
3	Transmitting devices and receiving devices for sign and communication.
4	Speedometer
5	Aspect facilities of onboard signal equipment
6	Operating device for raising and lowering the pantograph
7	Transmitting devices and receiving devices for security communication.
8	Warning generating devices and transmitting devices for alarm signal facilities
9	Horn activation device
10	Pressure gauge including pressure of main air tank piping
11	Receiving devices for emergency communication devices
12	Door closed and locked confirmation device for passenger doors
13	Operating devices for service brake devices

Source: JICA Study team

(7) Brake system

The brake system comprises of regenerative and pneumatic friction braking. Motor bogie is equipped with Tread brake with composite brake brocks and Trailer bogie is provided with Disc brake. The braking system is fail-safe.

(a) Brake control scheme and Service brake

The brake control scheme consists of electro-pneumatic service brake with blending control between electric and air braking. In case the train separates, the brake system detects the separation and operates the emergency brake.

(b) Parking brake

Parking brake is the spring applied parking brake. There is a spring applied air-release parking brake on trailer cars with driving cab.

(c) Security brake

There is a security brake that operates automatically in the case that the service brake fails.

(d) Electric brake

The electric brake takes priority over the friction brake to use the regenerative energy and minimize friction brake wear.

(8) Coupler Devices

Coupler devices are as follows;

- Front of leading cars (both ends of the train) is a semi-automatic tight- lock coupler and draw-gear.
- Intermediate portion between cars is semi-permanent couplers.
- The electric couplings for train control and communication between cars and between trains for shunting and/or emergency operation will be provided.

(9) Pantograph

Pantograph is as follows;

- A single-arm type pantograph is used. This type is widely used in the world as standard system.

- The pantograph has sufficient current carrying capacity to supply the propulsion power for eight traction motors and the auxiliary power for 4 cars of an 8-car train.

(10) Auxiliary power supply system

(a) Characteristics of Auxiliary Power Supply Unit (hereinafter: APU)

Table 4.4.11 APU Specifications

No.	Items	Specifications
1	Control Method	Constant Voltage / Constant Frequency
2	Output Voltage	Three-phase AC 380 V 50 Hz
3	Basic designed APU Capacity	Approx. 260 kVA x 2 sets/train (6 cars)

Source: JICA Study team

(b) Redundancy system of auxiliary supply

In case of one APU fails, the remaining APU provides power subject to reduced operating load requirements.

Table 4.4.12 Auxiliary Machine Load

No	Items	Quantity/train	Specifications
1	Air Conditioner	6 cars	Capacity 50,000 kcal/h (58.1 kW) x 2 sets/car, Input power:38 kVA x 280 kw/car
2	Motor driven air compressor	2 sets	Capacity 2000 l/min/set, Input power: 2 kW/set
3	Lighting	6 cars Train set	40 W x 16 sets = 0.64 kW/car And other lights: 2 kW/train
4	Battery charging system	2 sets	Around 15 kW/set

Source: JICA Study team

(11) Air Conditioning

Air conditioning is as follows;

- All saloon air conditioning units is of the self-contained package type.
- Any refrigerant having zero ozone depletion potential indexes for the life of the train in compliance with Montreal Protocol can be accepted. Coolant of Non-pollution refrigerant, R407C is preferable.
- Inside saloon temperature of 24ºC and 60% Relative Humidity is maintained under the outside conditions of 41ºC, 98% Relative Humidity.

(12) Data Recorder

The data recorder accurately records selected operation data of the train pertinent to investigation of an accident/incident. Two data recorders are installed in each driver's cab.

4.4.3 Passenger Capacity

The passenger capacity at AW1, AW2 and AW3 of 6 and 8-car train is as follows:

Table 4.4.13 Passenger Capacity of each Train Formation

No.	Items	6-car train (Pax)	8-car train (Pax)
1	AW1	306	414
2	AW2	966	1,296
3	AW3	2,308	3,088

Source: JICA Study team

4.4.4 Train formation

1) Congestion Ratio and Target Number of Passengers

A 6-car train system consists of three-motor cars and three-trailer cars. The train configuration for 6 cars is: Trailer car with driving cab (Tc) + Motor car (M) + Trailer car (T) + Motor car (M) + Motor car (M) + Trailer car with driving cab (Tc).

i.e.: Tc – M – T – M – M – Tc

An 8-car train consist is introduced into operation at some time in the future. The additional one trailer and one motor car is inserted in the existing 6-car composition. The train configuration for 8 cars is: Trailer car with driving cab (Tc) + Motor car (M) + Trailer car (T) + Motor Car (M) + Trailer Car (T) + Motor Car (M) + Motor Car (M) + Trailer Car with driving cab (Tc).

i.e.: Tc – M – T – M– T – M – M – Tc

4.4.5 Integrity with MRT Line 6

All facilities of Dhaka MRT Line 6 are planned for the elevated sections, and the facilities of MRT Line 1 and MRT Line 5 consists of the elevated sections and the underground sections. For these reason, there are differences in the fire safety standard and Structure gauge.

2) Fire safety standard at the underground sections

The technical standards for the rolling stocks of the MRT in Bangladesh have the same criteria of Japanese standard of the fire protection standards in the underground section.

The fire protection standards of the rolling stocks regulated by the incombustibility of the car body and installation of the gangway: the rolling stocks for MRT Line 5 are compliant with the technical standards for the MRT same as the rolling stocks of Line 6.

3) Structure Gauge for the underground section

Structure Gauge for the underground section is applicable to the underground stations and the tunnel sections. Some of the items of the Structure Gauge for the underground section will be different from the elevated section as shown in the following table.

Table 4.4.14 Structure Gauge for the underground section in relation to elevated section

Item	Rolling stocks for MRT Line 5	Rolling stocks for MRT Line 6
Working height of pantograph at the elevated sections	5,050 mm	5,050 mm
Working height of pantograph at the underground sections	4,650 mm	Not applicable
Structure of the side windows	Not allowing passengers to extrude their bodies from windows.	Not allowing passengers to extrude their bodies from windows.
Maximum speed Elevated sections Underground sections	 100 km/h 90 km/h	 100 km/h Not applicable

Source: JICA Study team

The pantograph operates over wide working range at the elevated section, so it can be used at the underground section. The specification of the side window is such that the passengers can't extrude their bodies from the windows. The maximum operating speed is assumed to be 90 km/h, because of the underground section is closed area.

4.5 Depot Plan

4.5.1 Prerequisite

MRT Line 5 adopts the system which complies with the "Technical Standards for the Metrorail in Bangladesh" as well as prior development project of MRT Line 6 and MRT Line 1. These three MRT routes will form the Dhaka urban mass transit railway network of which MRT Line 5 intersects MRT Line 6 and MRT Line 1. Since maintenance and stabling of trains will be performed separately for each line, it is necessary to construct the dedicated depot of MRT line 5. Three candidate depot locations were selected by RSTP Supplement Study for MRT Line 5 (JICA, 2016) at western side of Turag river near Hemayetpur. Philosophy of depot plan for MRT line 5 is shown in Table 4.5.1.

Table 4.5.1 Philosophy of Depot Plan form MRT Line 5

No.	Item	Description
1	Capacity (Ultimate)	The depot with the capacity of 61 train sets of 8 car-train which is the required number of trains in the year 2058, for case "Phase 1 + east extension of North + south Phase 1" will be planned. If the train numbers are increased due to the extension of route, etc., the capacity of depot can be physically expanded by enlargement of the area. However, if too many trains are concentrated in one depot, it becomes an issue that trains take long time to enter to and exit from the depot. Therefore, when the train numbers exceed 61, it is proposed that another stabling yard is constructed to accommodate the additional trains.
2	Capacity (Initial stage)	In order to save on the initial investment cost, the stabling tracks that are constructed in the initial construction period are moderated to the capacity of 35 trains which are the required numbers in 2037. Meanwhile, all maintenance tracks are constructed in the initial construction stage.
3	Land reclamation	The required area for the depot with the capacity of 61 of 8 car-train for the ultimate stage shall be prepared by the initial investment. The perimeter road and the perimeter fence are constructed around the depot area. Also, the external road is constructed at the outside of the fence. Heightening of land of depot area shall be done in order to avoid flood. Moreover, whole of depot area shall be allocated in a plane area and the tracks in depot shall be level.
4	Facilities	As the maintenance facilities for rolling stock, heavy maintenance shop, light maintenance shop, automatic train wash plant, under floor wheel lather equipment, test track and air blowing track are installed. A car delivery entrance is equipped at vicinity of the heavy maintenance shop. Two stabling yards are allocated, one of which is constructed in initial investment stage (for 35 trains) and the other is in future expansion (for 25 trains). And the stabling facility for the maintenance vehicles is allocated as well. Depot approach track shall be double tracks. Furthermore, administration building, warehouse, guardhouse, traction substation, perimeter road and multipurpose parking space, water supply and waste water treatment system are provided. In the detailed design stage, illumination for yard, lightning facility for yard, drainage, cable duct, etc. will be designed.
5	Layout	An efficient layout shall be secured for a series of events which includes train entry, washing, maintenance and inspection, and stabling. Furthermore, the required land area shall be minimized.
6	Building	OCC, depot control room and DMTC office will be located at administration building.

Source : JICA Study Team

4.5.2 Depot Location

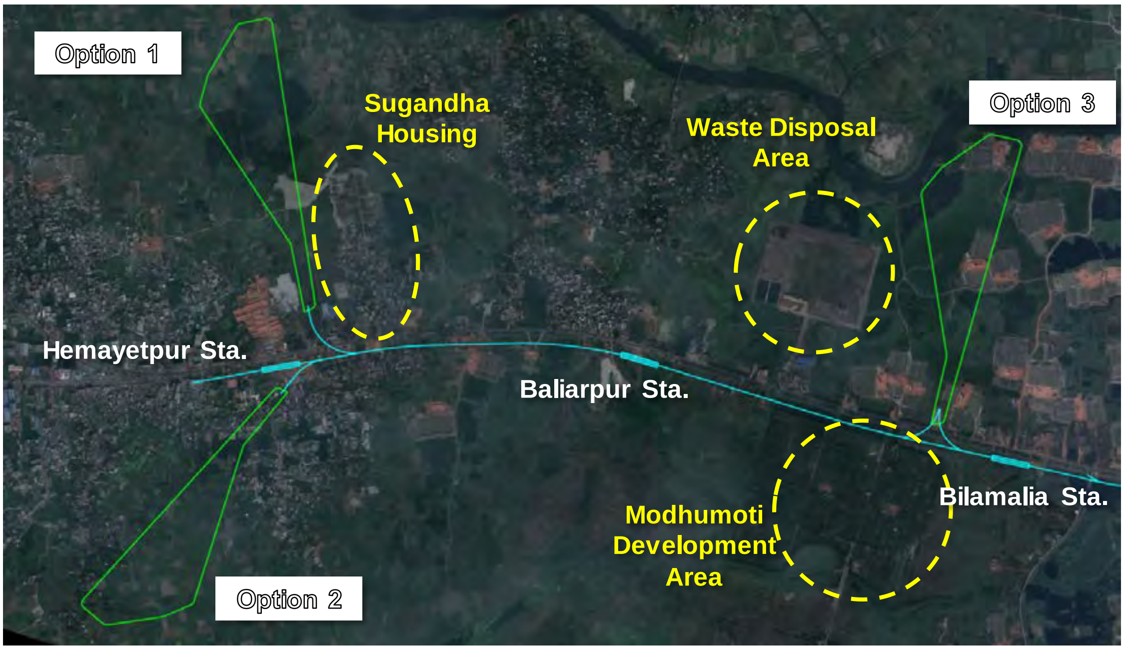
1) Location Selection

Three candidate depot locations were selected between Hemayetpur and Gabtoli in RSTP Supplement Study for MRT Line 5. The locations are shown in Figure 4.5.1. As a viewpoint of resettlement, flood damage and land use, Option 1 was selected as the best option. Candidate sites overview and evaluation is shown in Table 4.5.2.

Table 4.5.2 Selection of Candidate Depot Location

	Option 1	Option 2	Option 3
Location	North side of Hemayetpur station	South side of Hemayetpur station	West side of Bilamalia station
Overview	This option has an advantage to connect the approach line to Hemayetpur station. Embankment will be required because ground level is approx. 5 m lower at 200 m far area from the road.	This option has an advantage to connect the approach line to Hemayetpur station. However, housing will be obstacle because approach line crosses the housing.	Approach line diverts from the main line at 250 m far from Bilamalia station. Embankment and soil improvement with removal of soft Alluvium will be required because depot area is low ground.
RAJIK Land Use Plan (2015)	Partially within conservation area	Growth management area	Completely within conservation area
Flood damage	Flood impact is less, possible to get approval	No flood impact	Flood impact is high, difficult to get approval
Condition as of May 2016 (The beginning of Monsoon)	No water	Not confirmed	Totally flooded
Condition as of April 2017*	No water. It is vacant area but brick is stacked.	There are housings along the road. Not confirmed behind the road.	Totally flooded
Land ownership	Individual with one large owner (7 ha)	Individual ownership	Individual ownership
Current land use	Vacant site and farm land	Farm land and housing	Vacant area, farm land and wet land
Resettlement	Limited	Yes	No
Evaluation	Good	Fair	Not recommended

Source：JICA Study Team based on RSTP Supplemental Study for MRT Line 5 *) By site survey in the Study



Source：RSTP Supplemental Study

Figure 4.5.1 Candidate Depot Locations

JICA Study Team confirmed through the site survey of April 2017 that the existing condition has not been changed until now from that of RSTP supplemental study. Therefore, Option 1 is selected as the best location for depot.

2) Train Operation During in-out from Depot

MRT Line 5 depot is planned to be developed between Hemayetpur station and Baliarpur station and the access line to main line is planned to be connected to Baliarpur station.

In this case, It is necessary to go through Baliarpur station once in order to arrive at Hemayetpur station. Some trains are going to Hemayetpur station by turn back at Baliarpur station (Figure1) and the other trains are going to Vatara station (Figure2).

A total of 11 train set which are seven train set for morning first train and four train set for peak time occur at Baliarpur station. Direct operation from Depot to Vatara station is 10 train set which are eight train set for morning first train and two train set for peak time.

3) Issues and Countermeasures

As shown in figure2, if the first departure is from Hemayetpur station, operation loss is occurred during in-out from depot though line capacity is enough.

To avoid the operation loss, below countermeasures shall be conducted in the next detail design stage.

(1) Direct Access from Hemayetpur station to Depot

Direct access from Hemayetpur station to Depot shall be considered. If it difficult to access both tracks, single track is enough for connection. Hemayetpur station can be moved to install the access line if it is possible.

(2) First Departure from Baliarpur station or Gabtoli station

Several trains can be start departure from Baliarpur station and/or Gabtoli station before the morning peak time to reduce the turn back operation loss. It should be considered by the demand and operation plan.

4.5.3 Methodology of Rolling Stock Inspection Plan

The size of inspection facility is determined by the cycle and required period of each rolling stock inspection. It is practical that the contents, cycle and time required of inspections in MRT line-5 follow to those of inspections in MRT Line 6. However, MRT Line 6 is now under construction stage, so the inspection method in MRT Line 6 has not been evaluated yet. Because of this, rolling stock inspection of Delhi Metro in India is referred as precedent of MRT project in South Asia in this study.

Table 4.5.3 is the excerpt of the report of the Sub-Committee on Operation and Maintenance System for Metro Railways organized by Government of India Ministry of Urban Development.

Table 4.5.3 Maintenance Schedule for Rolling Stock adopted at DMRC

S/No	Activity	Interval	Manpower Required for 4 Car Train		
			Downtime	Required Manpower	Required Man-Hour
1	Daily Check	-	30 minutes	02	01
2	A Service Check	5,000km, (15days)	02 hours	04	08
3	B1 Service Check	15,000km, (45days)	08 hours	07	56
4	B2 Service Check	30,000km, (90days)	08 hours	07	56

S/No	Activity	Interval	Manpower Required for 4 Car Train		
			Downtime	Required Manpower	Required Man-Hour
5	B4 Service Check	60,000km, (180days)	08 hours	12	96
6	B8 Service Check	120,000km, (360days)	16 hours	13	208
7	B16 Service Check	240,000km, (720days)	16 hours	13	208
8	C1 Overhaul	420,000km, (3.5years)	-	-	3065
9	C2 Overhaul	840,000km, (7.0years)	-	-	7910
10	C3 Overhaul	1,560,000km, (10.5years)	-	-	
11	C5 Overhaul	2,250,000km, (15years)	-	-	
12	Daily Internal Cleaning (turn-around in platform)	Every turn around	Activity not performed		
13	Daily Internal Cleaning (Stabling Yard)	Daily	1	1	1
14	Internal light Cleaning	Weekly	-	-	-
15	Monthly Heavy Cleaning (Exterior & Interior + Roof)	Monthly	6	8	48
16	External Washing (Window cleaning)	Daily (Automatic Train Wash Plant)	2	2	4
17	Pest and Rodent Control	Bi-monthly	01 hours	02	02
18	Air dust cleaning	Half yearly	-	-	-

Source : Report of the Sub-Committee on Operations and Maintenance Systems for Metro Railways (Government of India Ministry of Urban Development, November 2013)

Based on the above condition, the number of inspection of MRT Line 5 depot is calculated. Prerequisites are as follows;

- Future stabling number of rolling stock is 61 train sets of 8-car
- Operation hour of inspection is 8 hours per day and monthly working days are 25 days.
- Figures shown in table above is for 4 car-train sets and MRT Line 5 adopts 8-car train. It is assumed that MRT Line 5 can refer the same index by doubling the manpower of maintenance staff.

Table 4.5.4 Calculation of the Required Number of Inspection Line of MRT Line 5

S/No	Activity	Interval	Category	Location	Number of required tracks
1	Daily Check	Daily	Start-up test	Stabling yard	For 61 trains
2	A Service Check	15 days	Light Inspection	Light maintenance tracks	Required time: 1 day/train Number of required tracks: (61-3) x (1/15) =4 tracks
3	B1 Service Check	45 days			
4	B2 Service Check	90 days			
5	B4 Service Check	180 days			Required time: 2 days/train Number of required tracks: (61-2) x (2/180) =1 track
6	B8 Service Check	360 days			
7	B16 Service Check	720 days			
8	C1 Overhaul	3.5 years	Overhaul	Heavy maintenance tracks	Require time: 1 month/train Number of required tracks: 61 trains/42 months =2 tracks
9	C2 Overhaul	7.0 years			
10	C3 Overhaul	10.5 years			
11	C5 Overhaul	15 years			
12	Daily Internal Cleaning	n/a	n/a	Turn back station	
13	Daily Internal Cleaning	Daily	Light Cleaning	Stabling yard	For 61 trains
14	Internal light Cleaning	Weekly			
15	Monthly Heavy Cleaning	Monthly	Heavy Cleaning	Train wash line (Hand wash line)	Require time: 1 day/train Number of required tracks: (61-2) / 25 = 3 tracks (1 AWP)

S/No	Activity	Interval	Category	Location	Number of required tracks
16	External Washing	Daily	Automatic wash plant (AWP)	Train wash line	1 track with AWP
17	Pest and Rodent Control	Bi-monthly	Included in A Service Check		
18	Air dust cleaning	Half yearly	Included in B4 Service Check		

Source : JICA Study team

The under-floor wheel lather, the air blowing unit and the unscheduled maintenance track are the facilities outside of the scheduled inspection, and are installed as shown in table below.

Table 4.5.5 Facilities in addition to the scheduled inspection

S/No.	Line Name	Number of tracks	Remarks
1	Track for under-floor wheel lather	1	Capability of which 976 bogies (81 of 8 car trains) can be treated twice a year shall be secured. Required time is assumed as 1 hour per 1 bogie.
2	Track for Air blowing	1	An air blowing is carried out in B service check and C service check.
3	Unscheduled maintenance track	1	This track is installed in the heavy maintenance shop for unscheduled maintenance and repair.
4	Stabling tracks for maintenance vehicles	2	Track inspection car, rail grinding car, Overhead wire measuring car, and motor car, etc. are assumed as maintenance vehicles.
5	Test track	1	It is used for test run after heavy maintenance.
6	Track for car delivery entrance	1	In order to make car delivery easily by trailer and cranes, the track which has no catenary is installed beside the unloading area.

Source : JICA Study team

4.5.4 Train stabling plan

Although the depot has some allowance and all trains can be stabled at depot, one train will be parked at the station during nighttime in the case of “Phase 1 + EX1” in order to make the train operation easy in early morning from the east-end station which is located far from the depot.

Table 4.5.6 Train Stabling Plan in MRT Line 5

Year	Number of trains	stabled at the stabling yard of depot	Stabled at the maintenance tracks of depot	Parking at the station in nighttime
2008 Phase 1	24 of 6 car train	24	0	0
2037 Phase 1+EX1	38 of 8 car train	32	5	1
2058 Phase 1 + EX1 EX2	61 of 8car train	57	3	1

Source : JICA Study team

4.5.5 Depot Layout

Facilities of depot of MRT Line 5 are proposed as shown below.

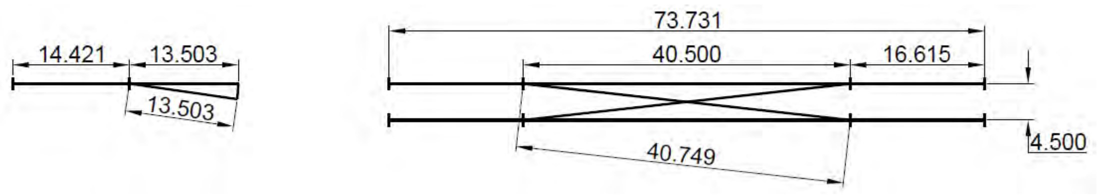
Table 4.5.7 Depot Facilities for MRT Line 5

S/No.	Location	Facility	Tracks	Remarks
1	Stabling yard	Stabling tracks	16	Constructed in the initial construction stage, accommodating 32 of 8 car-trains. Each track secures two 8-car train sets in series per track.
		Stabling tracks	15	Constructed as the future expansion. Accommodating 25 of 8 car-trains.
2	Light maintenance shop	Light maintenance track	4	For A, B1, B2 service check
		Light maintenance track	1	For B4, B8, B16 service check
		Air blowing track	1	With air blowing unit
3	Heavy maintenance shop	Heavy maintenance track	2	
		Unscheduled maintenance track	1	
		Track for car delivery entrance	1	In order to make car delivery easily by trailer and cranes, the track which has no catenary is installed beside the unloading area.
4	Train wash track	Automatic train wash plant (AWP)	1	AWP is installed at the location where trains can be easily washed when it enters to depot.
		Hand wash track	3	Platforms for hand washing are equipped.
5	Track for under-floor wheel lather		1	Before and after the lather equipment, the track with one train length are provided to avoid the treated train disturbing to other trains. This track has a facility for the under floor wheel lather equipment.
	Test track		1	It shall be straight track with 1 km long.
	Track for car delivery entrance		2	It shall be installed where the vehicles can easily depart to main line. Suitable track length in which several vehicles can be parked in series shall be provided.

Source : JICA Study team

Alignment conditions in depot are assumed and the layout of depot is planned, as follows.

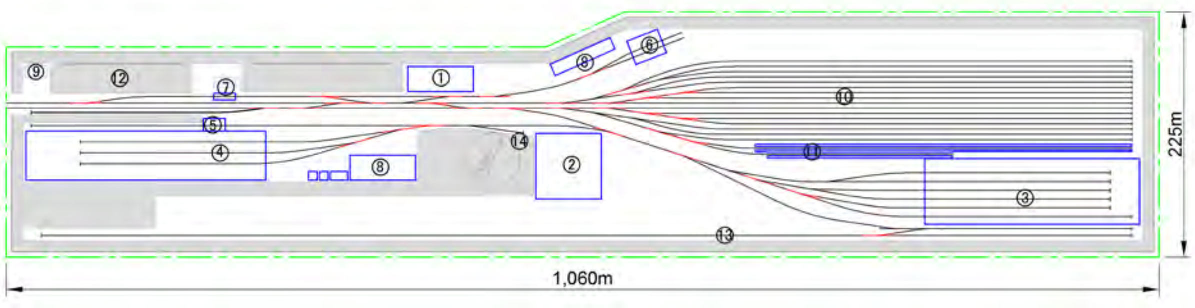
- Approach track shall have double tracks and the distance between tracks is 4.5 m.
- In the approach track, the slope section is inserted between main line and entrance of depot so that the rail level is down from the viaduct to at grade.
- The minimum curve radius in depot is R min=200 m. Transition curve and super elevation (cant) is not set.
- 1 in 7 (turning radius=190 m) track switch is adopted. As for the size, the track switch which is used in India Metro project is referred. A scissors crossing of 1 in 9 type is proposed on the approach tracks (distance between tracks is 4.5 m). The scissors crossing which is planned to be installed in Varanasi metro in India is referred for the size.
- Based on the size of track switch and minimum curve radius, the distance between stabling tracks is defined as 4.8m except the tracks which are the extension of approach track.



Source : JICA Study team

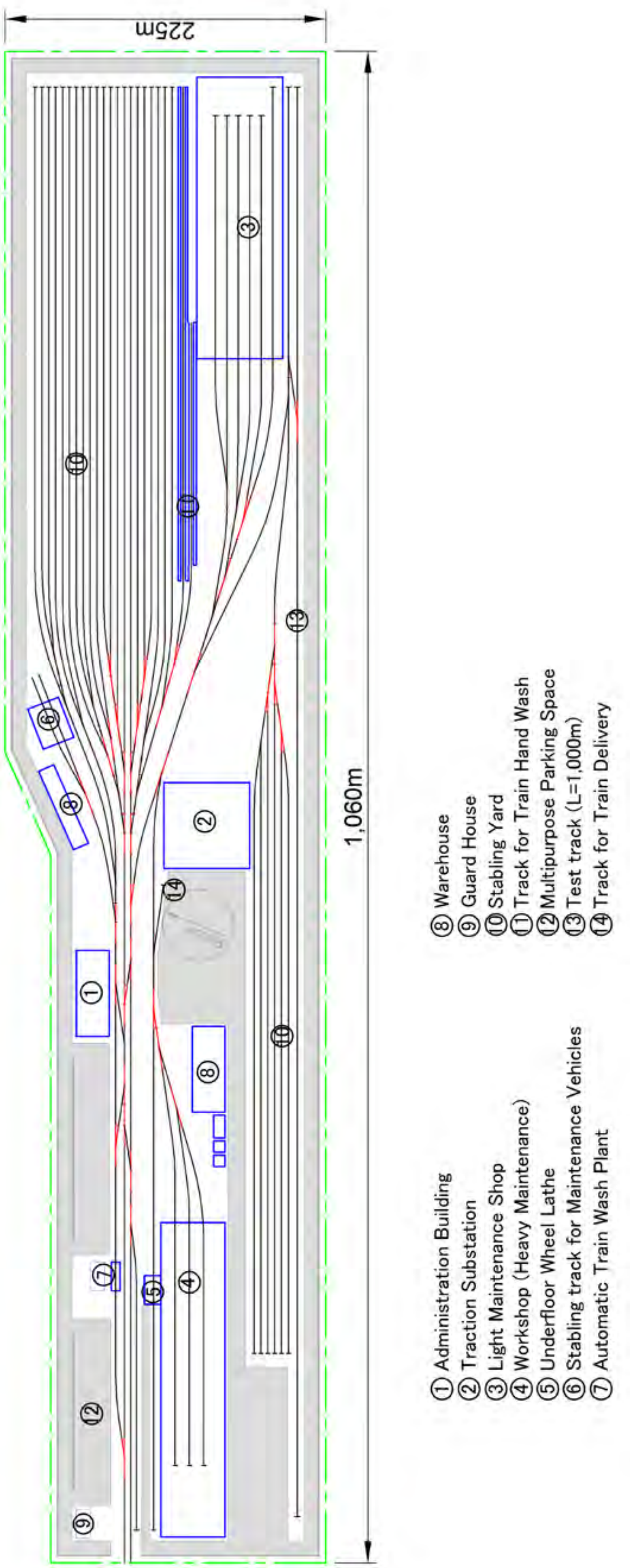
Figure 4.5.2 Track switch (1 in 7) and scissors crossing (1 in 9) in Depot

In depot, the perimeter road with width of 10 m is installed around the facilities. The perimeter fence is installed for security to the outside of the perimeter road. Furthermore, the slope for heightening of depot land and the external road are installed to the outside of the fence: this road can be used by general public. Depot area is as following figure and total area is about 22ha.



Source : JICA Study team

Figure 4.5.3 Depot Layout (Initial Stage)



Source : JICA Study team

Figure 4.5.4 Depot Layout (Ultimate)

4.5.6 Structure Type Possibility of Simulteneous Public Use of Depot area

There are several examples to utilize the upper/ over or under space of depot for property development and/or public space such as a park by constructing a viaduct or underground depot.

Issues and evaluation of three-dimensional usage for MRT Line 5 depot are described below.

1) General Conditions

Capacity to accommodate 61 trains of 8 car train is required and it is estimated that 22 Ha land is necessary to construct the stabling facility, inspection facility and other related facilities over embankment type structure.

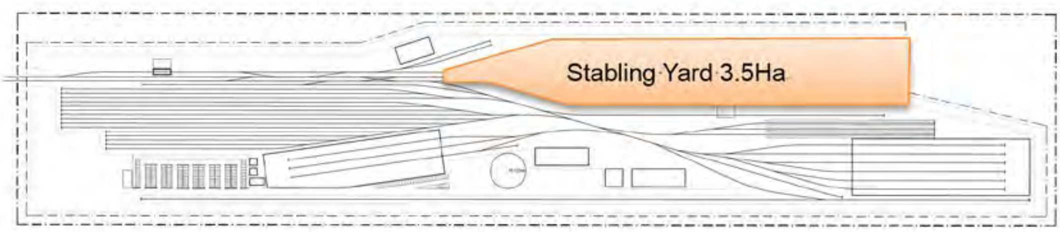
From the efficiency point of view, it is desirable to allocate all facilities on the same flat ground to minimize the train movement in depot. If depot is three-dimension structure, slope/ ramp is to be installed to adjust the differences of the level. In such case, movement distance is much longer and movement speed is slower, thus work efficiency will be low.

In this Section, in addition to the original plan of (1) Embankment only, and three types of three-dimension structures cases of (2) Embankment + Over-track building, (3) Underground only, and (4) Elevated are compared as the probable structures of depot.

Since the planned area of depot in the case of (1) Embankment only is large as 22Ha, the underground structure plan and/or the elevated structure plan for whole depot area are not realistic due to the extreme cost requirement. Therefore, only the stabling yard of 3.5Ha is considered for alternate analysis in the study. This portion can stable the 32 train sets of 8-car in 16 lines.

2) Analysis of Stabling Yard based on Structure Type

As for the option (2) Embankment + Over-track building case, if the substructures can be constructed without any interference to the structure gauge of stabling tracks by using the space of 4.8m between tracks, the same depot layout as (1) Embankment only case can be adopted.



Source : JICA Study Team

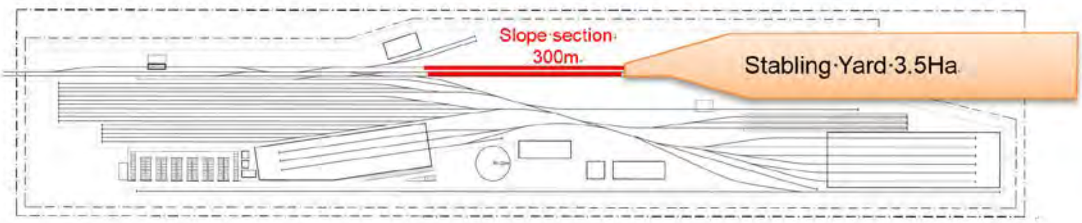
Figure 4.5.5 Embankment Only Case, Embankment + Over-track Building Case

Above two cases, (1) and (2), have an advantage from the viewpoint of the efficiency of depot work, which includes train cleaning, stabling, and inspection. Also, the required area is smaller than that of case (3) and case (4). Furthermore, In the case of (2), the over-track building provides the additional space of the property development and fulfills the role of the roof for the stabling tracks. Although the roof (building) can protect the trains from sunshine and weather, the illumination becomes needed on a daily basis in the stabling yard. O&M cost of case (2) becomes costly than that of case (1).

In the case of (3) Underground only, the stabling yard is constructed underground and is covered with the artificial ground. The created space on the artificial ground can be used for the parking and/or park, etc. Also, the artificial ground has a role to hide the depot facility from the urban landscape if needed. From the viewpoint of the operation, this case has an advantage that trains can be protected from the sunshine and weather. However, O&M cost becomes costly compared with that of case (1) because of the daily operation of the illumination and mechanical ventilation. The most concerning issue is flooding. Entrance of the rain water to the stabling yard must be protected and pumps shall be installed at the proper place.

In the case of (4) Elevated, the stabling yard is constructed above the viaduct and space under the viaduct is utilized as the parking lot, etc. As a viewpoint of the operation, compare to the embankment structure, it has the disadvantage that maintenance staff and driver has to access to the viaduct structure.

As for the depot layout of the case (3) and case (4), it is necessary to install the transition section of 300 m to the stabling yard. It means that the required land area becomes larger than that of case (1) and (2). Also, the layout of case (3) and case (4) have negative impact to efficiency of depot work because the stabling yard is located far from other facilities.



Source：JICA Study Team

Figure 4.5.6 Underground Only Case, Elevated Case of Alternate Depot Structure

3) Evaluation

When the efficiency of depot work has a priority, (1) Embankment and (2) Embankment + over-track building are recommended because of the functionality of depot. Latter shall comply with the condition that the substructure constructed between stabling tracks does not intrude to the structure gauge of track.

Underground structure is not recommended because of the high initial and O&M cost and the risk of flood. In addition, development advantage of viaduct + Utilization of Underneath Viaduct option is limited to parking lot usage.

Table 4.5.8 Comparison among Structures Type

	Embankment (Original)	Embankment + over-track building	Underground	Elevated
Construction cost	Fair	High	Highest	High
Operation cost of depot	Fair	A bit High	Highest	A bit High
Functionality as depot	Fair	A bit Less	Less	Less
Potential of Property Development	N/A	Better	Better	Partially
Evaluation	Best	Better	Fair	Fair

Source：JICA Study Team

4.5.7 Waste Water Treatment System

AWP is installed on the train wash track located beside the approach track. Each train goes into the washing track at the time of returning to depot once per day, and passes AWP with low speed. In AWP, car body is washed by the brush using the natural detergent and recycle water, and then the car body is rinsed.

The Waste water treatment system (hereinafter: WWT) installed in depot, will collect the waste water from AWP, hand wash track, bogie and air conditioner washing area, inspection and maintenance area.

Waste water which is containing oil is gathered separately at Waste water treatment system from AWP, train wash track, bogie and air conditioner washing booth, maintenance facilities, etc. Furthermore, rainwater caught at the train washing area also comes to WWT.

In WWT, the activated sludge process will be adopted. For the wastewater with oil, an oil trap system will be installed before the activated sludge process. The treated water will be reused for train washing. Required capacity of WWT is estimated as 120m^3 per day.

Table 4.5.9 Quantity of Sewage Water

No.	Generation source	Daily Maximum volume (Litter/day)	Remarks
1	AWP	57,300	61 trains/day
2	Hand wash track	800	
3	Bogie, Air conditioner washing	2,700	
4	Inspection/maintenance work	10,000	
5	Others	2,000	
6	Inflow rain water	46,000	Assumed maximum rainfall: 340 mm/month
	Total	118,800	= 120 m^3/day

Source：JICA Study Team

Required processing capacity of WWT is shown in table below.

Table 4.5.10 Required Treatment Quality of WWT

No.	Parameters	Units	Expected quality of influent water	Target level of quality of treated water	Remarks
1	pH		8-10	7 ± 0.5	
2	Odour		n/a	n/a	
3	Total Suspended Solids	Mg/l	200 -450	<10	
4	Chemical Oxygen Demand	Mg/l	600-800	<60	
5	Biological Oxygen Demand	Mg/l	250-350	<20	
6	Oil & Grease	Mg/l	50	<2	
7	Residual chlorine concentration	Mg/l	-	≧1	

Source：JICA Study Team

4.6 Project Implementation Plan

4.6.1 Construction Plan and Schedule

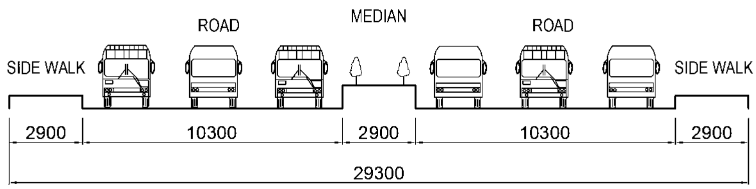
1) Elevated Section

(1) Viaduct Section

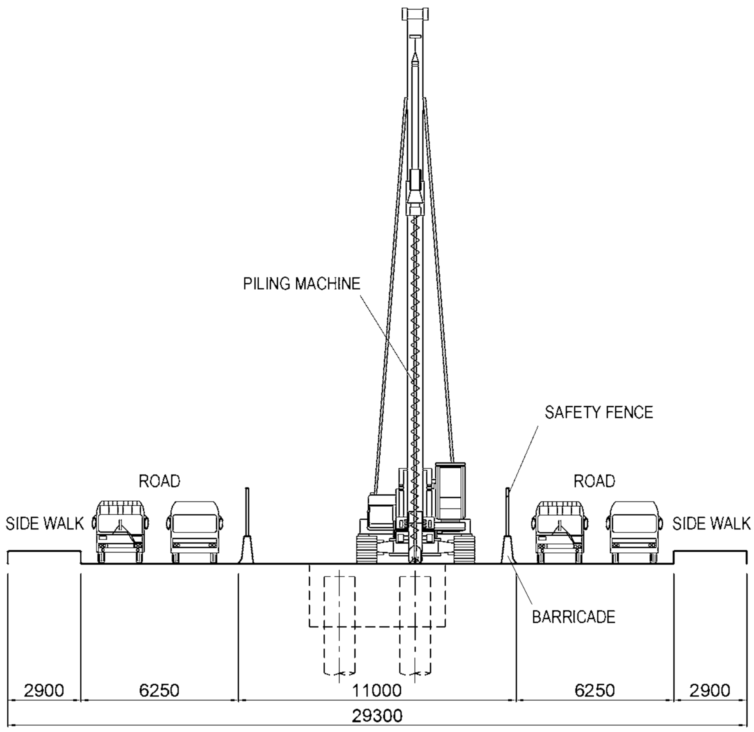
(a) Foundation and Substructure

Elevated section is divided into the western section from Hemayetpur to Amin Bazar and the eastern section from Notun Bazar to Vatara. Since the western section is constructed beside of the existing road (Dhaka Aricha Highway), the road is not interfered by railway structures. On the other hand, since the eastern section is constructed in the center of the existing road (Madani Avenue), it is necessary to consider construction plan to minimize the impact on road traffic during construction. The construction steps of the foundation work and substructure work in the east side section constructed in the middle of the current road are shown below.

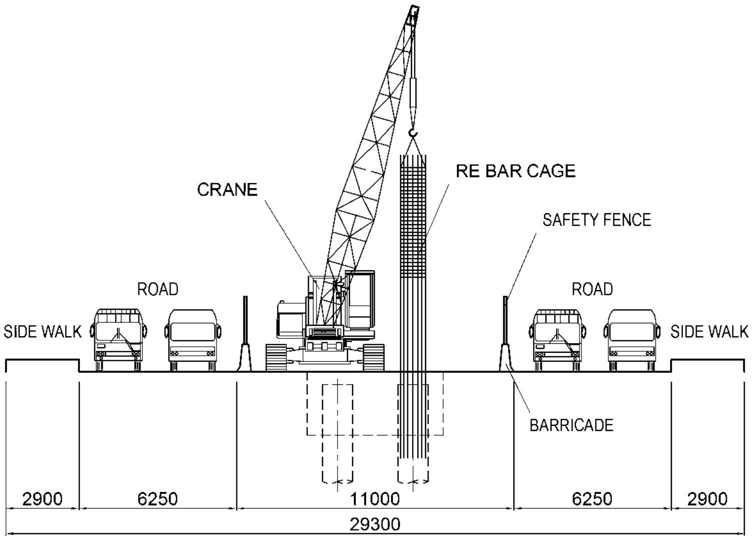
(i) Current Situation



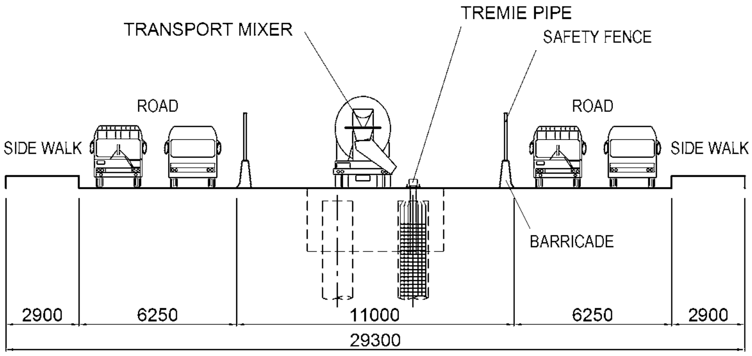
(ii) Excavation



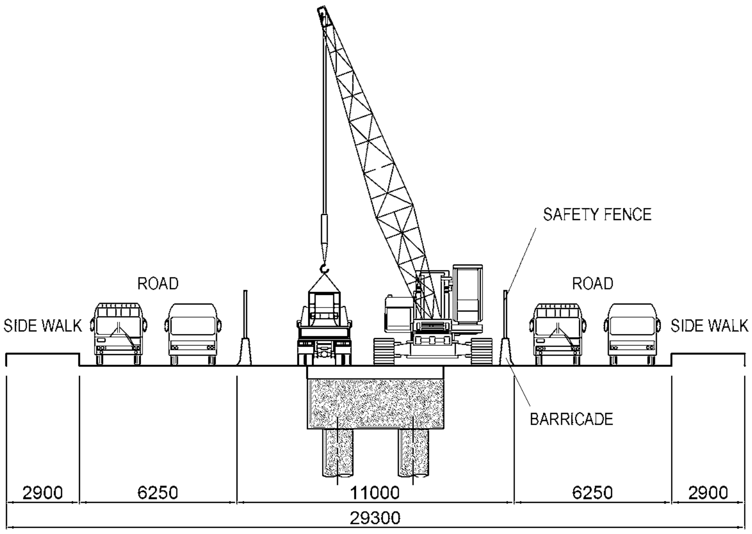
(iii) Reinforcement Work



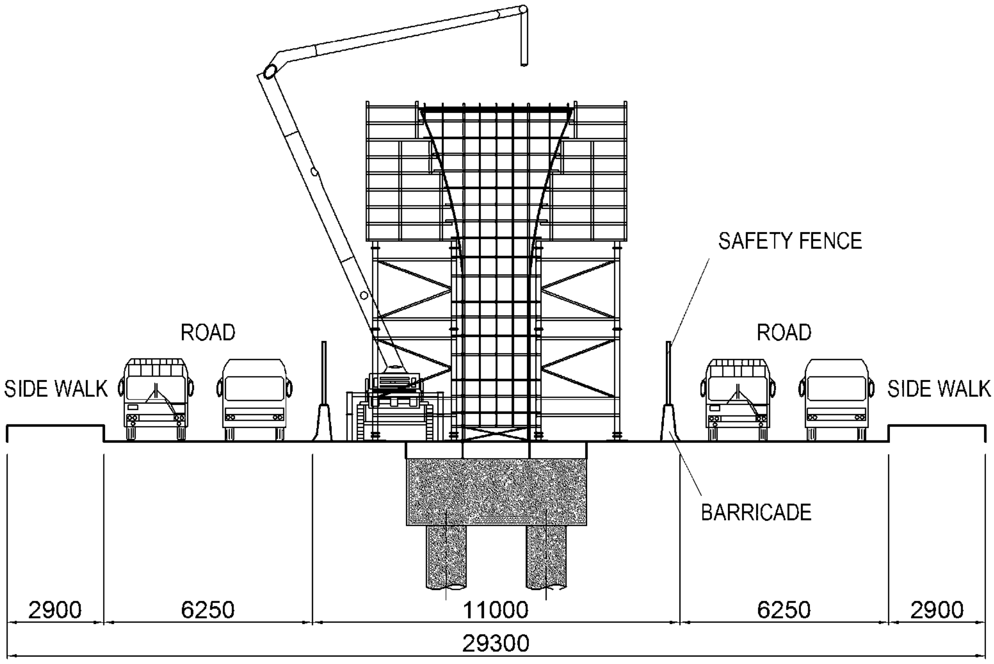
(iv) Concrete Work of Pile



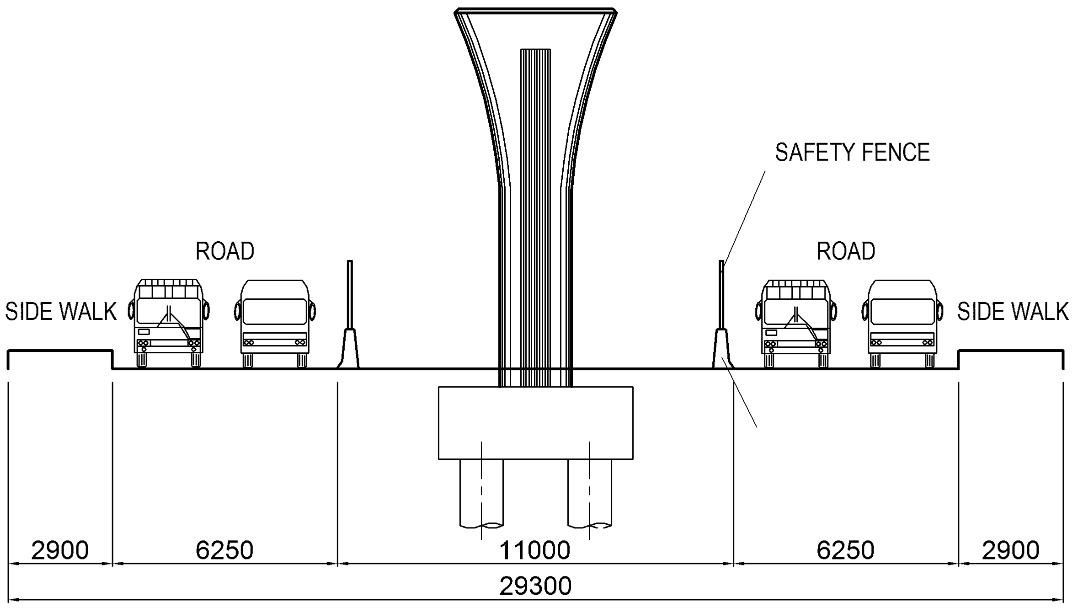
(v) Scaffold Work



(vi) Concrete Work of Substructure



(vii) Finish



Source: JICA Study Team

Figure 4.6.1 The Construction Steps of the Foundation Work and Substructure Work

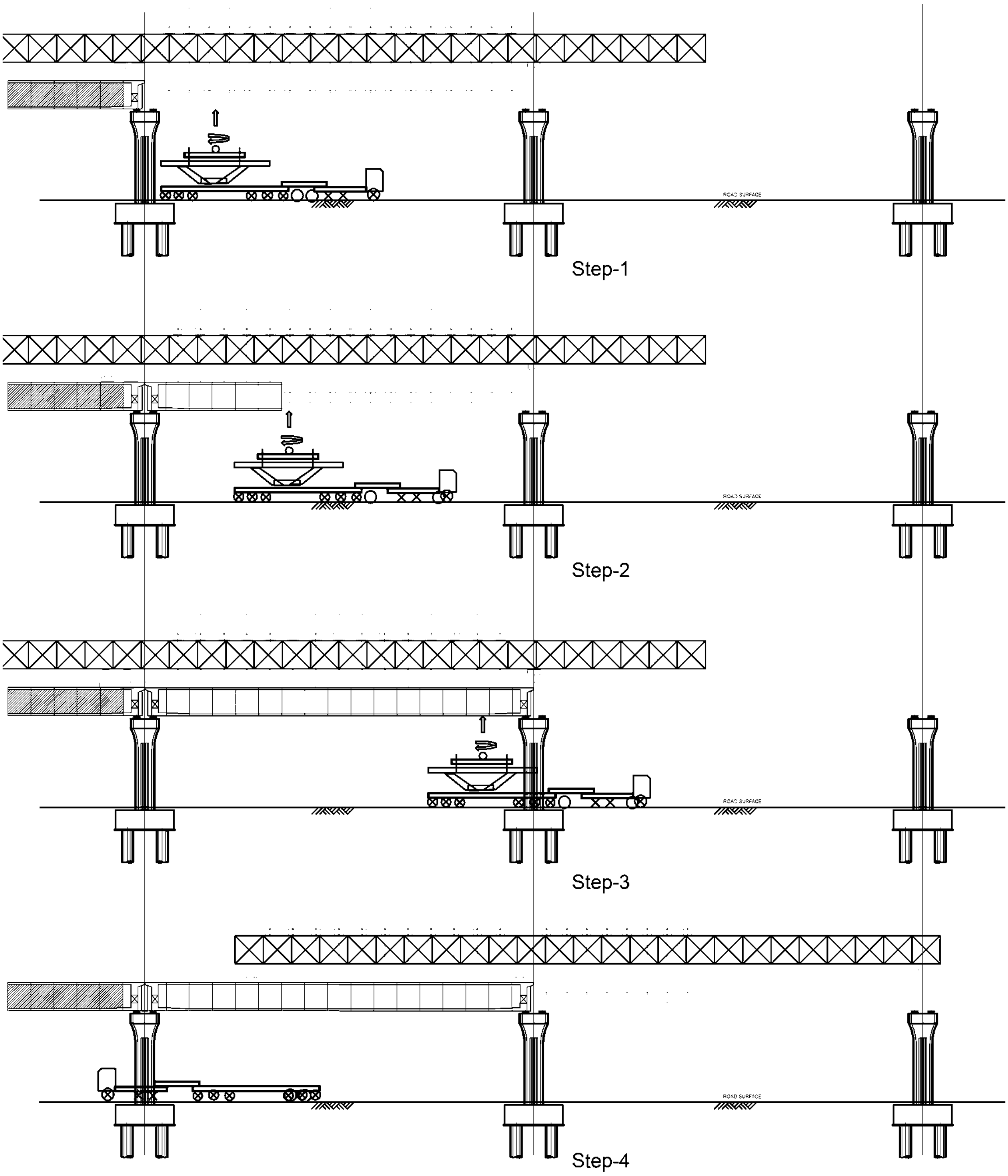
(b) Superstructure

For minimizing the influence on surrounding traffic, it is preferable to apply it by the span by span construction method same as MRT Line 6. This is a construction method in which a precast block manufactured by a segment yard is lifted from the road by erection girder, installed in a predetermined position above the sky, and tensioned by a PC cable to be integrated. Construction and tension work is carried out in the sky, so it is possible to minimize the construction yard on the road. In order to minimize the influence on existing traffic, it is desirable to transport the precast block to the site at night time.

The construction procedure is as shown below.

Source: http://www.fujips.co.jp/results/r-bridge/sub21090/2072

Figure 4.6.2 Girder Erection by Span by Span Method



Step 1 : Erection Girder (EG) is in position. 1st precast segment (edge segment) is transported by a long trailer from the construction yard and its position should be just under EG. The segment is hanged by suspension cables with EG and turned by 90 degree and is in placing.

Step 2 : 2nd segment also is repeatedly in placing and this segment is pulled and connected to the previous segment after application of epoxy resin to the joint of matched cast segment . This operation should be repeated up to the end of this span.

Step 3 : PC work should start and be complete for connection of all segments for single span girder. The girder should be lowering to the required position and level.

Step 4 : The rear leg of EG should be shifted to the end position of the girder completed and the front leg of EG will be shifted on to the next pier head and EG is in position for next span erection.

Source: JICA Study Team

Figure 4.6.3 Construction Sequence of Span by Span Method

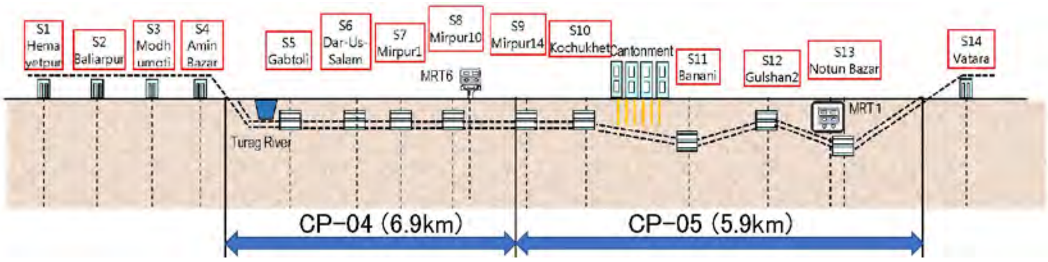
1) Underground Section

In this section, schedules are proposed for each package and construction method, in terms of civil construction period for the underground section. This will be utilized when the whole construction schedule is compiled.

(1) Packages

Considering the serious traffic congestion in city center, the underground section is divided into two packages in order to reduce the construction vehicles in the city center. In both packages, the plan is to construct a launching shaft outside the city as a principle. In addition, the plan to divide the underground section into three packages is also considered in order to shorten the construction period.

(c) Plan for 2 packages



Source: JICA Study Team

Figure 4.6.4 Division of Packages (2 Packages Option)

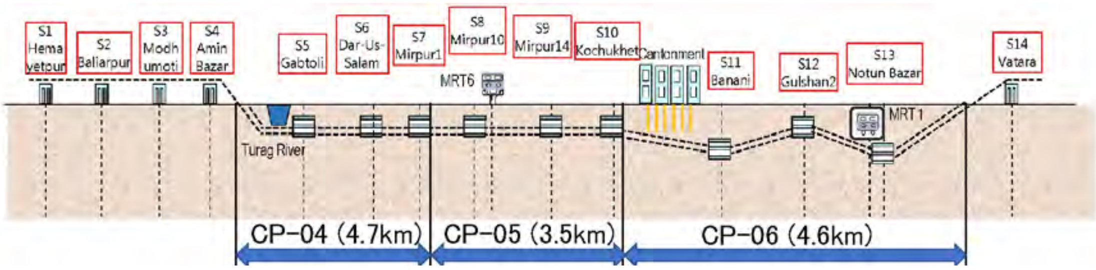
[Advantage]

- As the location of launching shaft is outside of the city and the traffic congestion is less than other parts of the city, construction vehicles can travel in the area for 24 hours a day.
- As the location of launching shaft is outside the city, it is easy to secure the site for launching shaft.
- As the number of shield machines is 4 compared to 6 for the 3-package plan, it is much more economical.

[Disadvantage]

- Compared to the 3-package plan, excavation length for one shield machine gets longer and as a result the period of construction also gets longer.
- Travel distance for transportation of segment and excavated soil inside the tunnel gets longer and as a result the risks for troubles gets higher.

(d) Plan for 3 packages



Source: JICA Study Team

Figure 4.6.5 Division of Package (3 Package)

[Advantage]

- The excavation length for one shield machine gets shortened and as a result the construction period also gets shortened.
- Travel distance for transportation of segment and excavated soil inside the tunnel gets shortened and as a result the risks for troubles also get lower.

[Disadvantage]

- Launching site for CP-05 is planned to be at Kochukhet Station, but since it is located in the city center, the traffic congestion is very severe and it is difficult to pass the construction vehicles during the daytime. Therefore, the transportation of segments and excavated soil has to be removed during the night time. In order to do so, securing a vast stock yard would be necessary to contain double the regular amount of the soil pit space, which could retain the soil excavated during the day. When it is difficult to secure the space, 2 layers of launching site is necessary and this could increase the cost of construction.
- Along the Kochukhet Station, which is planned for the launching site, is the area for the military residence and it is very quiet area. Therefore, it is a concerned that the construction noise could disturb the residents throughout the night for two years until the construction is completed.
- Cost of construction is increased as the number of shield machines is increased from 4 in the 2-package plan to 6 in the 3-package plan.

(2) Construction Speed of TBM Machine

Average speed of TBM machine is generally planned as 35 mm/mim. However, in this study, average speed is assumed as 30 mm/min considering unknown factors. And, segment length is 1.5m per each segment.

Table 4.6.1 Construction Items and Duration of TBM Machine

Construction Item		Duration (min)
Preparation		15
Mobilization (Entry)		20
Adjustment of Machine		15
Ring No1	Excavation: 1500mm (30mm/min)	50
	Segment Assembling: 6piece (6min/piece)	36
Ring No2	Excavation: 1500mm (30mm/min)	50
	Segment Assembling: 6piece (6min/piece)	36
Break		60
Ring No3	Excavation: 1500mm (30mm/min)	50
	Segment Assembling: 6piece (6min/piece)	36
Ring No4	Excavation: 1500mm (30mm/min)	50
	Segment Assembling: 6piece (6min/piece)	36
Cleanup / Maintenance		20
Demobilization (Exit)		20
Total		494

Source: JICA Study Team

Based on above conditions, construction time of 4 rings is calculated as 8.5 hours (494 min). If construction is carried out in day and night (2 shifts) and 8 rings can be constructed per day, construction speed is 1.5m x 4 rings x 2 (day and night) x 25 days = 300m/month.

(3) Construction Methods for Underground Stations

The construction of the underground section largely affects the whole construction schedule and it is desired to shorten the construction period as much as possible for the underground section. Shield tunneling method is to be applied for the construction method for the underground tunnel and, by shortening the shield tunnel excavation, the whole construction schedule can be shortened.

In particular, construction of the floor in stations on which the shield machine passes through has to be completed, and the schedule for the station construction and excavation schedule has to be planned so that the preparation for accepting the shield machine at the station is ready when the machine arrives at the station.

(a) Points of Concerns for the Schedule Plan

The first station which the shield machine passes through from the launching shaft located on the west side is Gabtoli Station. This station, with two platforms that serve four tracks, is the junction station for the north and south routes on MRT Line 5 and link line are placed on the both end of the station. The length of the station is about 615 m and the width of the station is about 38 m. The size of the station is extremely large as well as the depth of the station. Therefore, construction of the station is expected to be required a long period of time. On the other hand, excavation schedule has to comply with the completion of Gabtoli Station, and being able to shorten the period of the station construction is a key to shortening the whole construction schedule.

The first station which the shield machine passes through from the launching shaft located on the east side is Notun Bazar Station. This station is planned to locate deep in the ground as MRT Line 5 runs under the Notun Bazar Station for MRT Line 1. Therefore, as scale of the construction for this station is also large, the construction period for Notun Bazar Station affects the excavation schedule for shield tunnel.

(b) Countermeasures

For the structure of the station frame, generally, Top-down method is applied utilizing RC diaphragm wall (hereinafter: RC D-wall), and in this project, if this method is considered, then for shortening the construction period the number of construction sets has to be increased.

In addition, since construction speed for RC D-wall is slow, Soil Mixing Wall method (hereinafter called “SMW”), which is a faster construction method, can be considered as an alternative method. In SMW method, temporary retaining walls are constructed and after excavating insider the wall, the frame is to be constructed with Bottom-up method.

(c) Overview of the construction

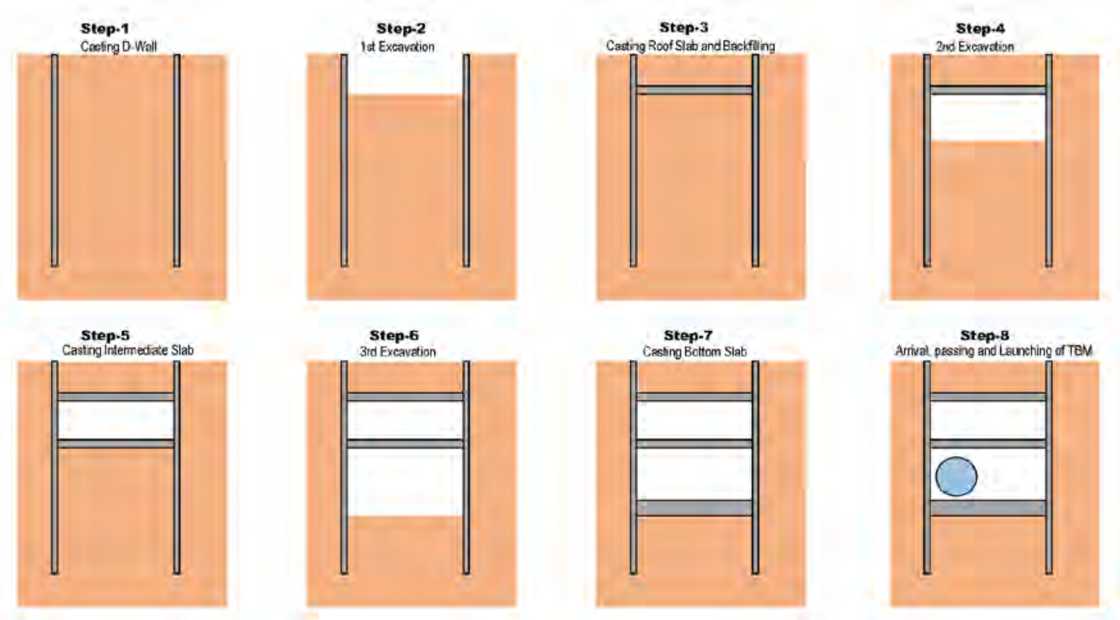
Table 4.6.2 explains the construction overview for RC D-Wall method and SMW method and **Figure 4.6.6** and **Figure 4.6.7** show the procedure for each method.

Table 4.6.2 Overview for Method for Retaining Wall

	RC D-Wall	SMW

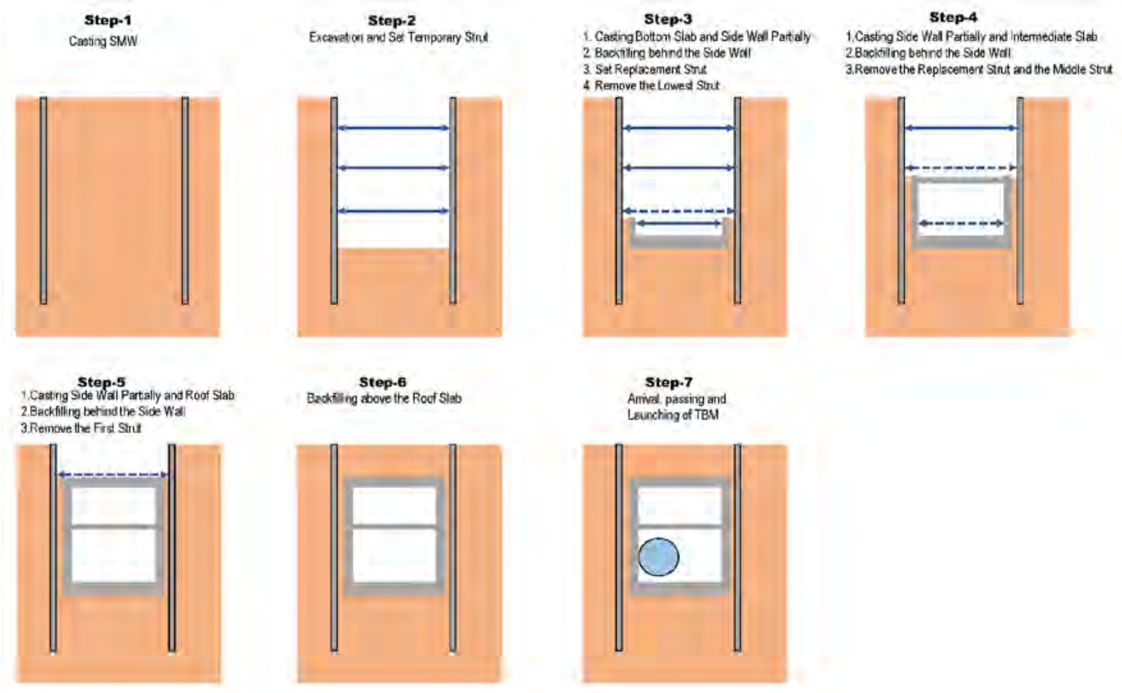
Purpose	Main frame Rigidity of the wall is high and the wall is applied as a permanent structure	Temporary Rigidity of the wall is low and the wall is not appropriate as a permanent structure.
Method	Top-down	Bottom-up
Advantage	Since the main frame is utilized, steel materials for temporary construction such as short strut and wailing are not necessary. Since temporary retaining walls are not necessary, the sufficient space for utility diversion can be secured.	Period for wall construction is relatively short. Since plant facility is simple and can be moved in accordance with the construction, separate plant yard is not necessary.
Disadvantage	Period for wall construction is relatively long. Since plant facility is large and it is difficult to move during the construction, separate plant will be necessary.	This technique is very unique and only special contractor can carry out the construction using this method.

Source: JICA Study Team



Source: JICA Study Team

Figure 4.6.6 Overview of the Procedure for the Construction of Underground Station using RC D-Wall



Source: JICA Study Team

Figure 4.6.7 Overview of the Procedure for the Construction of Underground Station using SMW Method

(d) Construction Period

Table 4.8.3 and Table 4.8.4 show the construction period in case of RC D-wall method and SMW method for each package. From Table 4.8.5 to Table 4.8.14 show the tentative schedule for each case. These documents shall be the basis of the review of package division and underground construction method.

[Conclusion]

- ➢ SMW method can be finished construction period than D-wall, it is effective for minimumaization of construction period in 3 packages.
- ➢ In case of 3 packages, some stations can be constructed at the same time and affect to existing road can be minimized.

[Issue to be considered]

- ➢ Confirm if construction machinery for RC D-wall can be procured in Bangladesh.
- ➢ Prepare the trial design for RC D-wall and SMW and compare economic efficiency after understanding the rough quantity of construction.
- ➢ Confirm if the construction noise and vibration won't be a problem in case of 3 packages and having the launching shaft at the Kochukhet Station.

Table 4.6.3 Tentative Schedule in case of 2 packages

	Method	Period		
CP-04	RC D-wall	Oct. 2022～end of Apr. 2027	4 years and 7 months	
	SMW	Oct. 2022～end of Dec. 2026	4 years and 3 months	
CP-05	RC D-wall	Oct. 2022～Mid of Aug. 2027	4 years and 10.5 months	
	SMW	Oct. 2022～end of Dec. 2026	4 years and 3 months	※1

Source: JICA Study Team

Table 4.6.4 Tentative Schedule in case of 3 packages

	Method	Period		
CP-04	RC D-wall	Oct. 2022～end of Aug. 2027	3 years and 11 months	※2
	SMW	Oct. 2022～end of Jul. 2026	3 years and 10 months	※3
CP-05	RC D-wall	Oct. 2022～mid of Feb. 2026	3 years and 4.5 months	
	SMW	Oct. 2022～end of May 2026	3 years and 8 months	
CP-06	RC D-wall	Oct. 2022～end of Jan. 2027	4 years and 4 months	
	SMW	Oct. 2022～end of Dec. 2027	4 years and 3 months	※4

Source: JICA Study Team

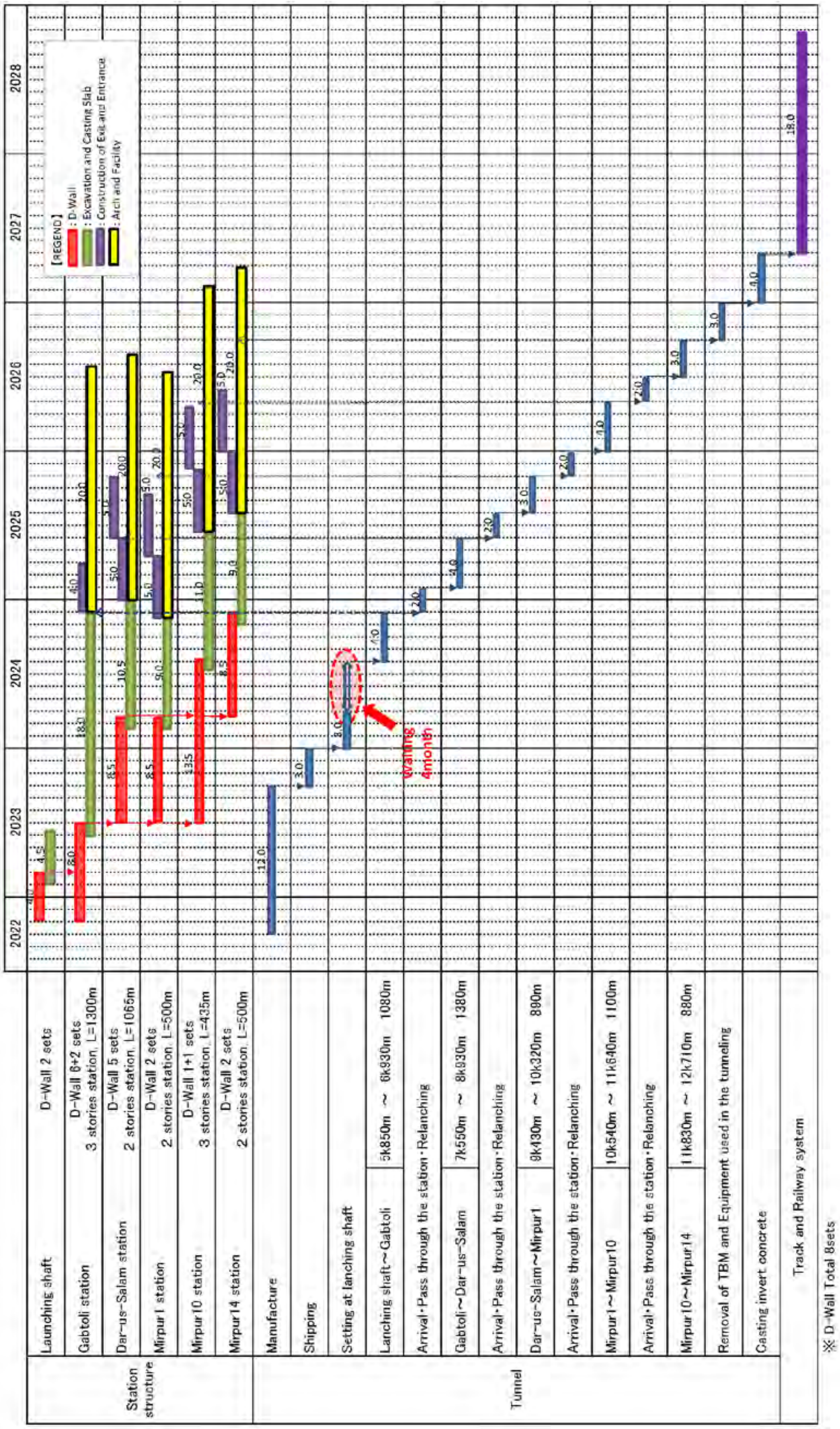
※1. Since reduction of construction period for SMW wall by adding two more sets of SMW, construction can be shortened for 1.5 months.

※2. Since reduction of construction period for D-wall by adding two more sets of RC D-wall, construction can be shortened for 1.0 months.

※3. Since reduction of construction period for SMW wall by adding two more sets of SMW, construction can be shortened for 1.5 months.

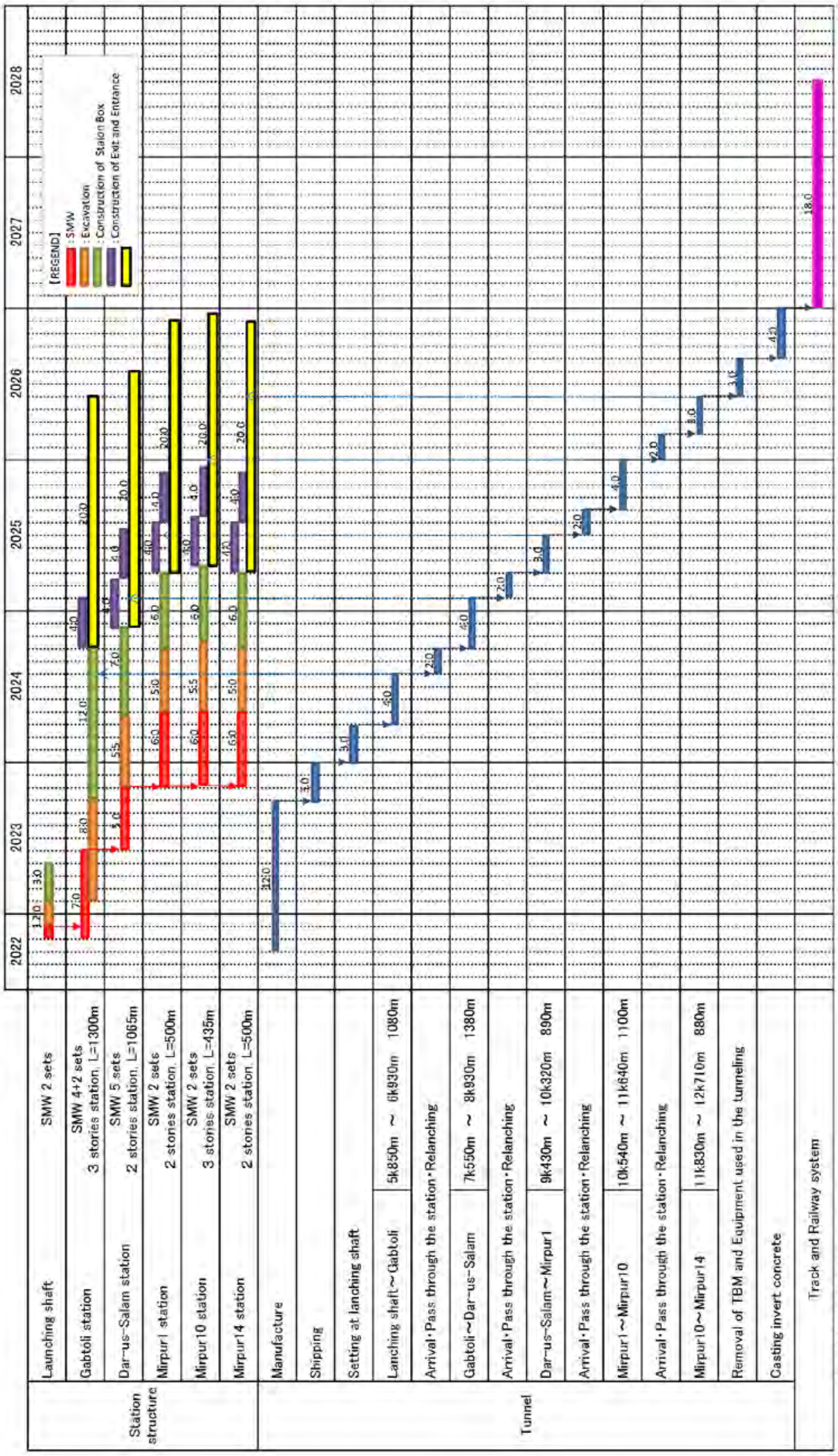
※4. Since reduction of construction period for SMW wall by adding two more sets of SMW, construction can be shortened for 2.5 months.

Table 4.6.5 Tentative Schedule for RC D-Wall in case of 2 packages (CP04)



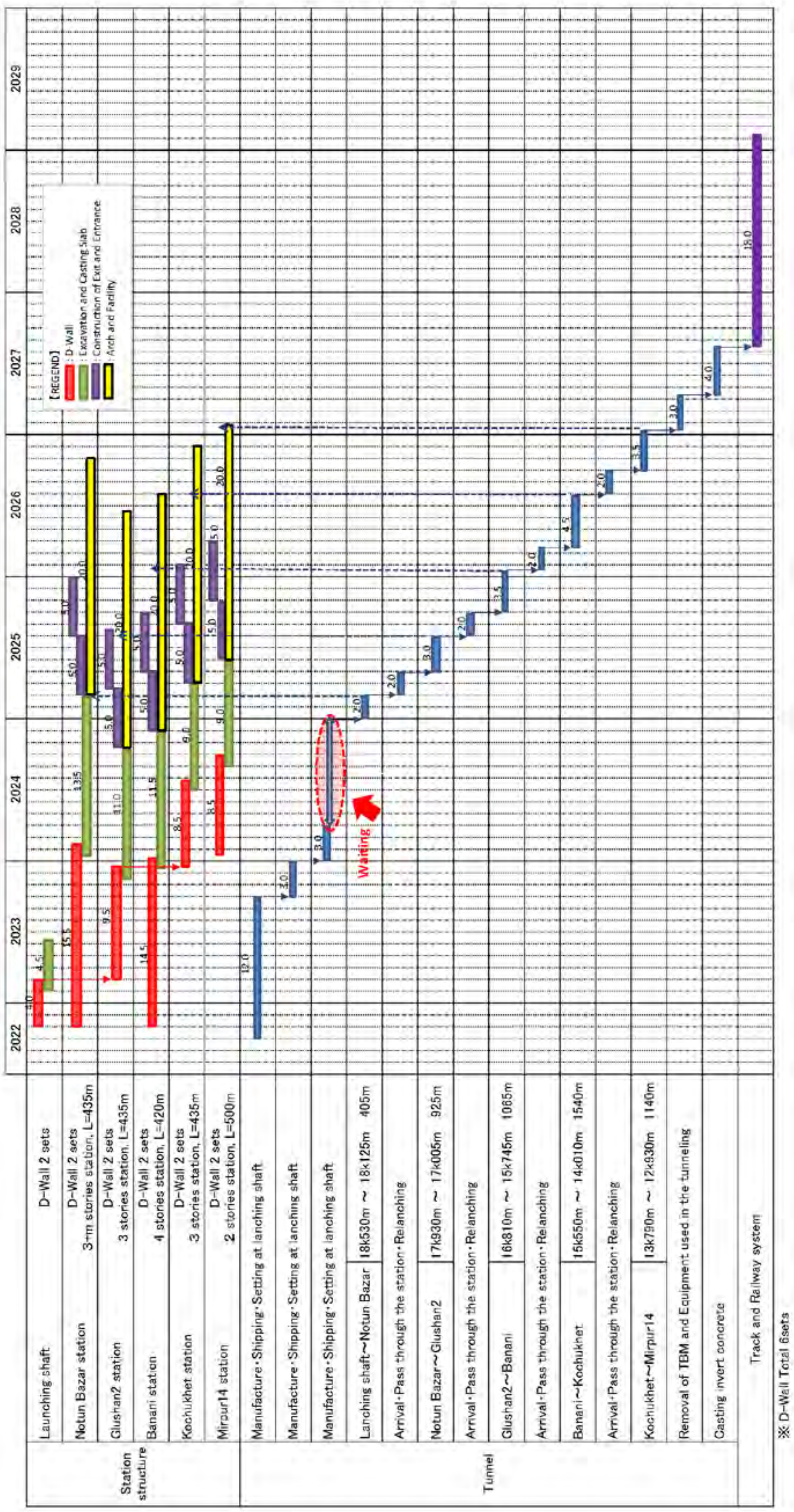
Source: JICA Study Team

Table 4.6.6 Tentative Schedule for SMW in case of 2 packages (CP04)



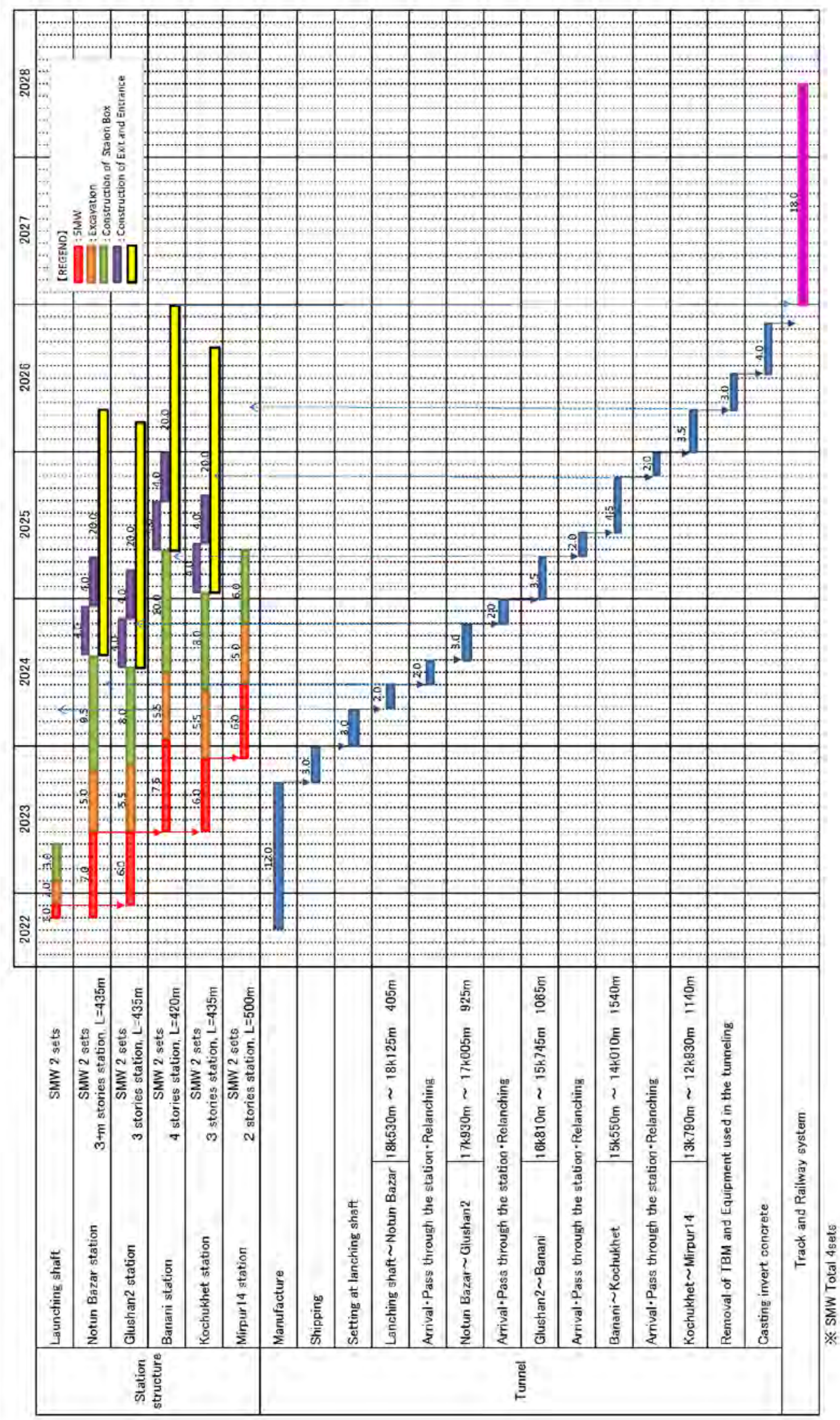
Source: JICA Study Team

Table 4.6.7 Tentative Schedule for RC D-Wall in case of 2 packages (CP05)



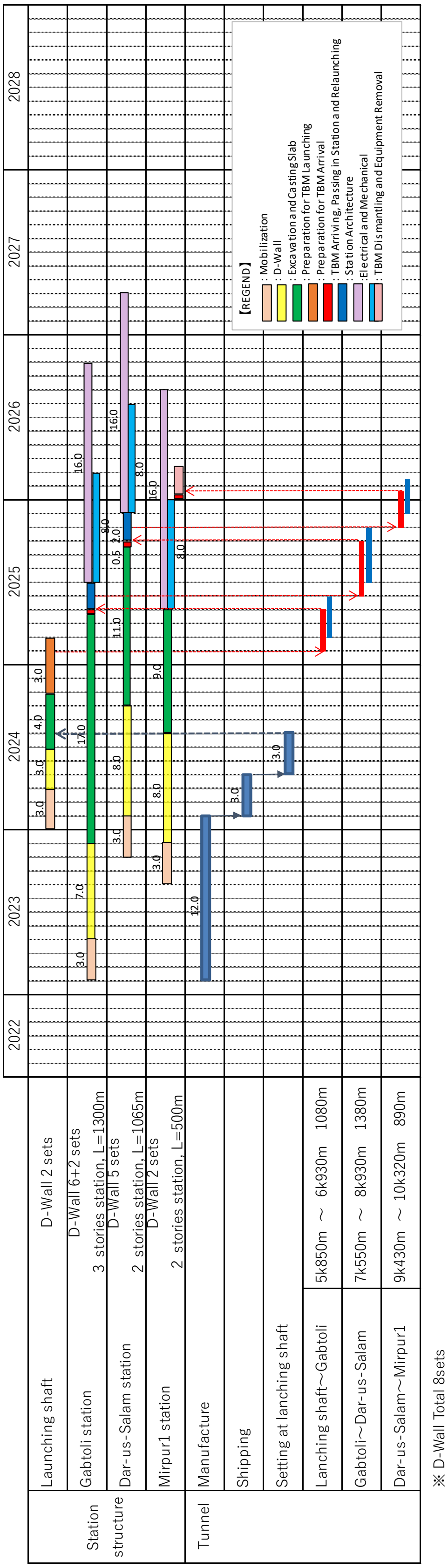
Source: JICA Study Team

Table 4.6.8 Tentative Schedule for SMW in case of 2 packages (CP05)



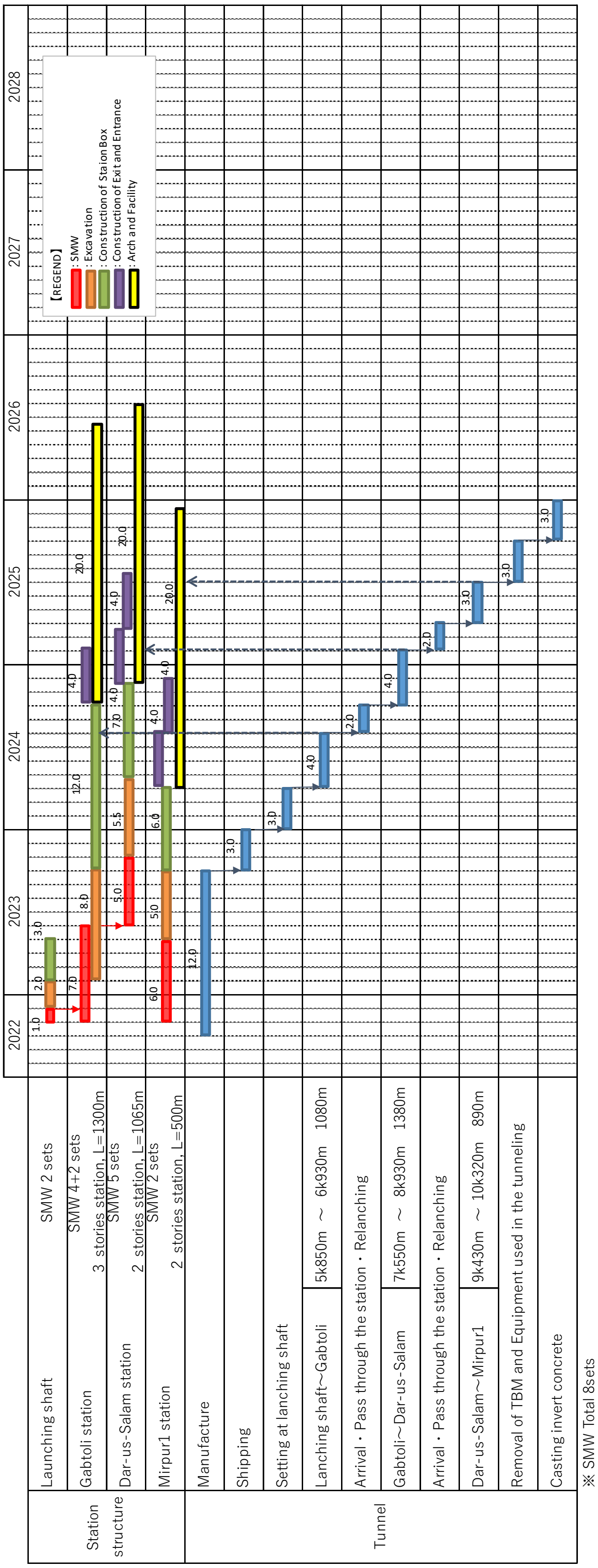
Source: JICA Study Team

Table 4.6.9 Tentative Schedule for RC D-Wall in case of 3 packages (CP04)



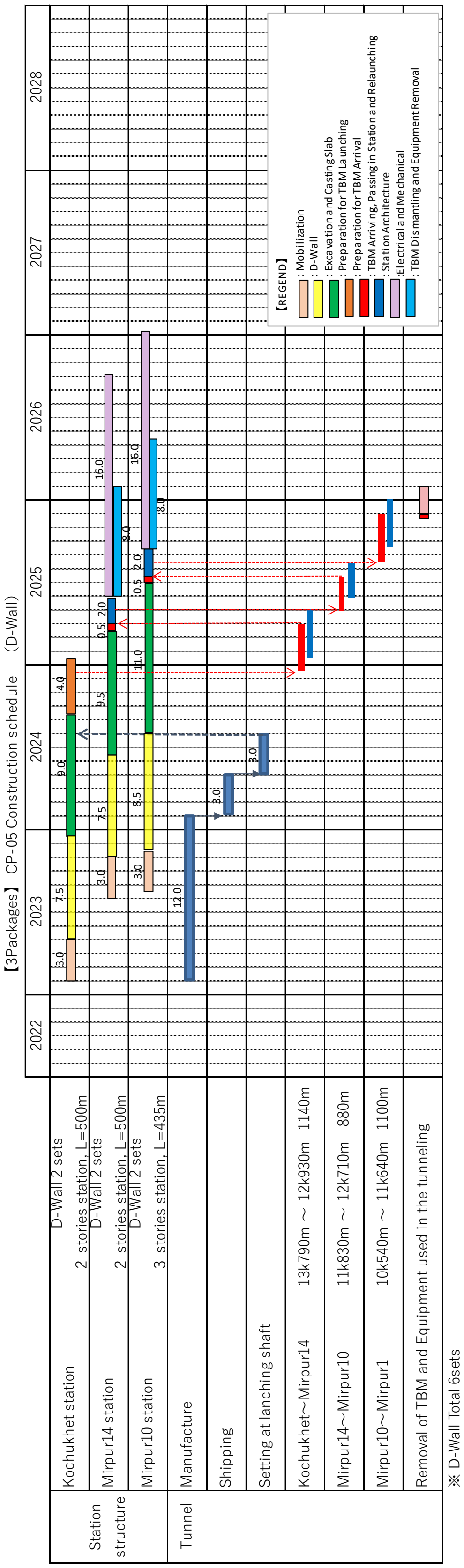
Source: JICA Study Team

Table 4.6.10 Tentative Schedule for SMW in case of 3 packages (CP04)



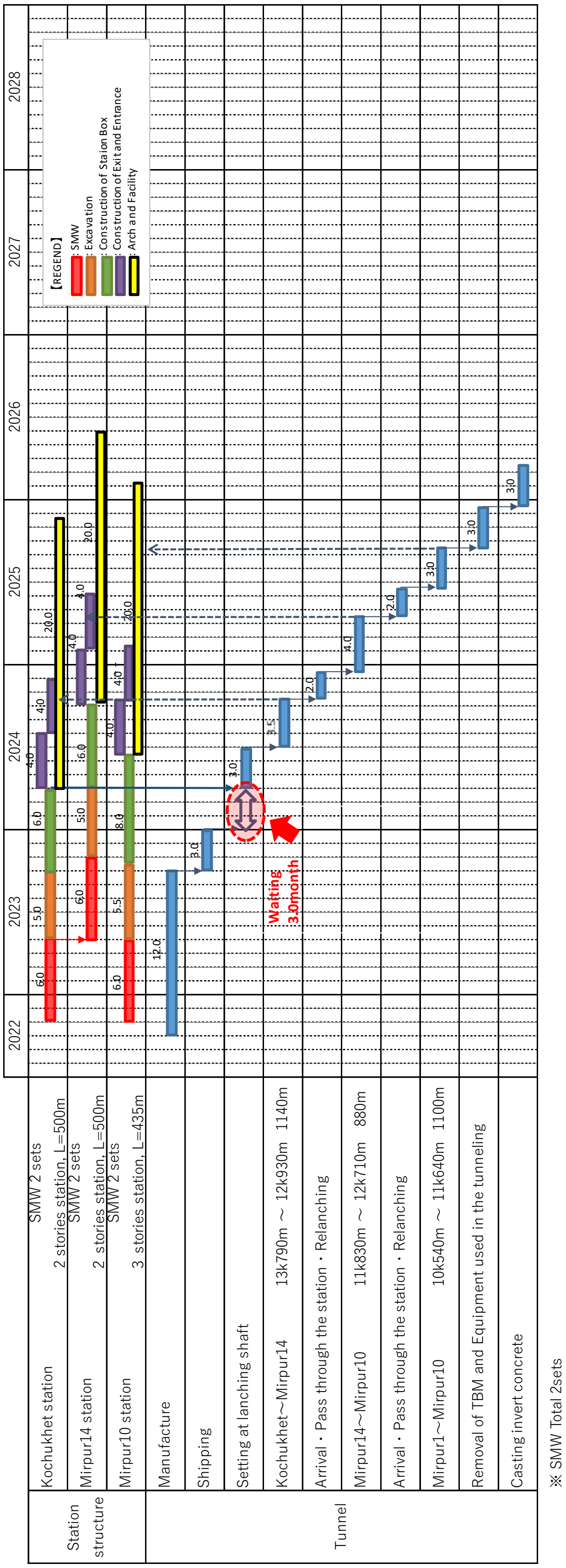
Source: JICA Study Team

Table 4.6.11 Tentative Schedule for RC D-Wall in case of 3 packages (CP05)



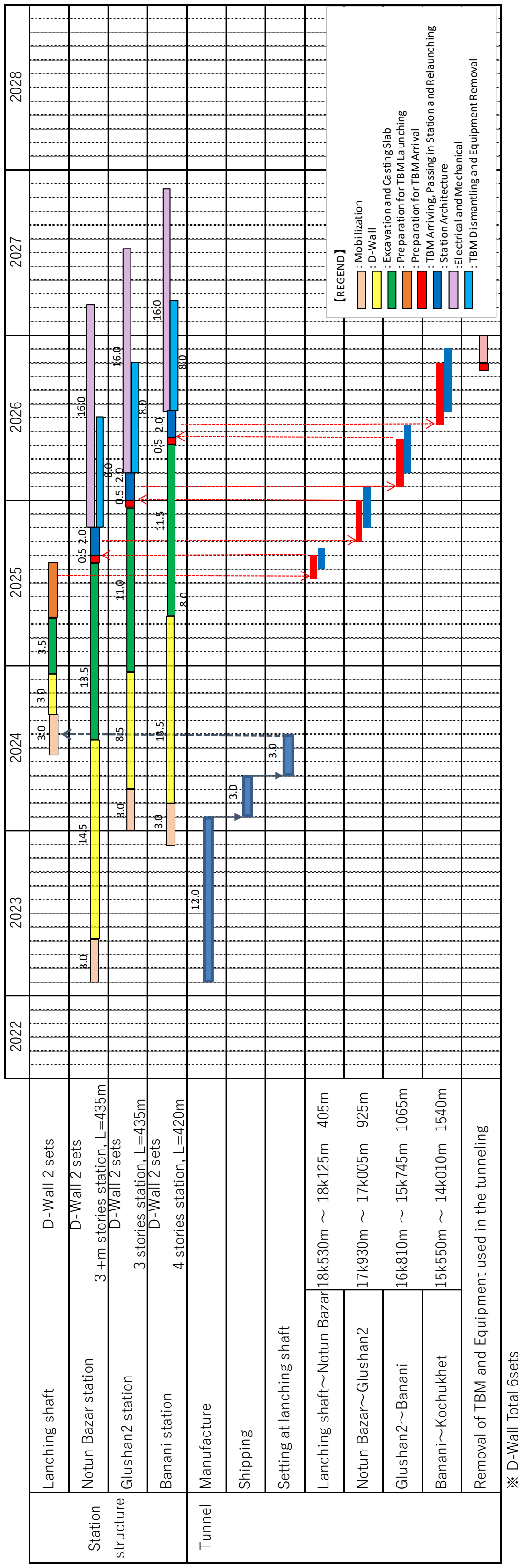
Source: JICA Study Team

Table 4.6.12 Tentative Schedule for SMW in case of 3 packages (CP05)



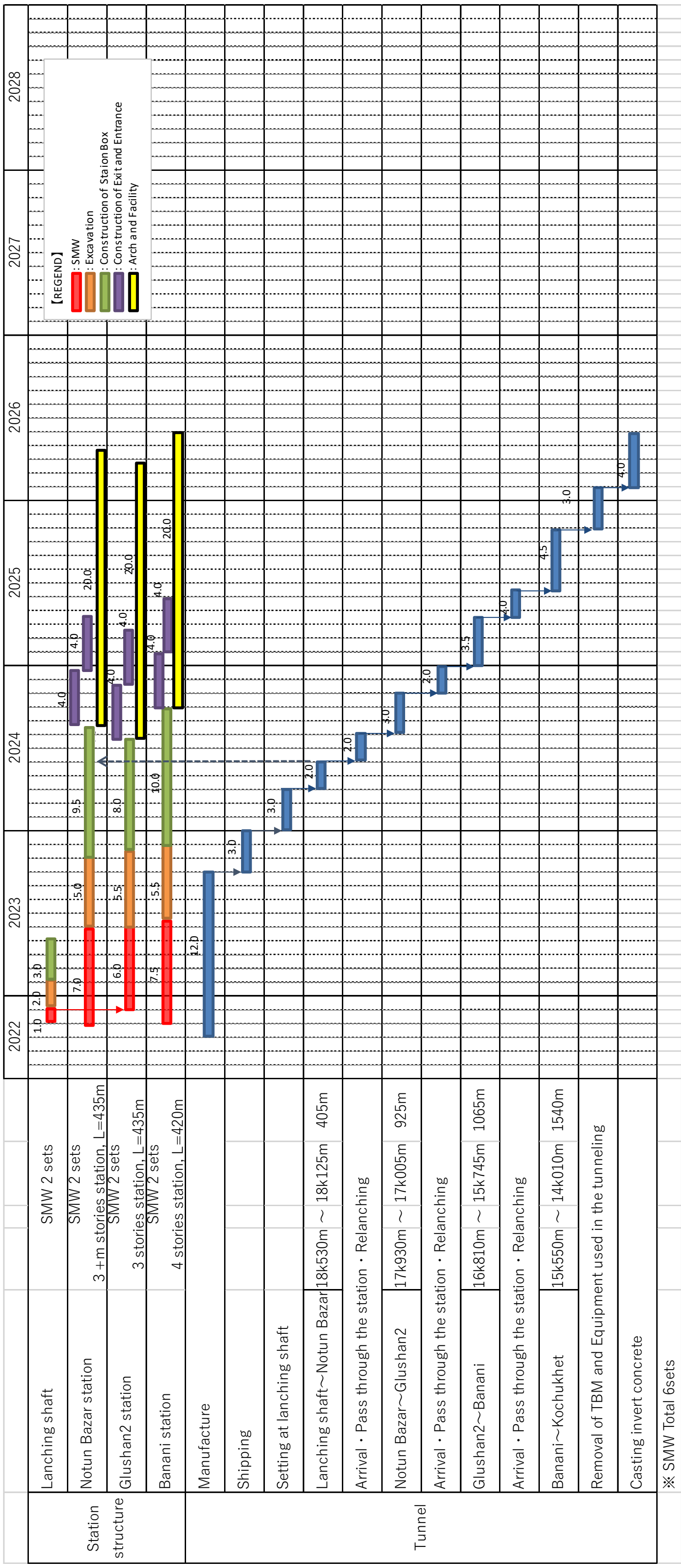
Source: JICA Study Team

Table 4.6.13 Tentative Schedule for RC D-Wall in case of 3 packages (CP06)



Source: JICA Study Team

Table 4.6.14 Tentative Schedule for SMW in case of 3 packages (CP06)



Source: JICA Study Team

4.6.2 Procurement of Materials and Products

1) Construction Materials and Machinery

(1) Basic Policy

General materials (cement / rebar) for construction work can be procured almost in Bangladesh. However, aggregate is procured by import from other countries, since Bangladesh does not have sufficient rock sources. In Dhaka City, construction work including many elevated roads is in progress. Construction machine such as pile driving machines, transporting vehicles, cranes, etc. can be procured domestically in Bangladesh. But if construction work is started at the same time with MRT Line 1, construction equipment will be limited. In that case, it is necessary to procure from a third country. Also, it is expected that procurement of equipment related to shield tunnel construction from the third country, including shield machine body as well.

And there are many construction companies in Bangladesh, and the labour force population is also about 70 million (2015, according to ILO survey). Although it is necessary to proceed with construction under the control of overseas specialized technicians such as shield construction method which is not proven in Bangladesh and large-scale station part excavation construction. However, it is possible to be carried out general civil, architecture and track work by domestic procurement.

(2) Procurement Plan

The procurement country of major construction materials required for this construction work is shown below. The following plan is assumption at the present stage, and domestic procurement situation may change by implementing MRT Line 6 and MRT Line 1 in the future. Therefore, procurement plan is necessary to re-examine based on the domestic situation at the implementation stage of MRT Line 5.

Table 4.6.15 Assumption of Procured Countries of Major Construction Materials

Work Item	Items Procured from Overseas	Items Domestically Procured
Civil/ Architecture	➢ Aggregate	➢ Cement ➢ Brick ➢ Rebar ➢ Forms ➢ Scaffolding ➢ Asphalt (Bitumen)
Construction Machinery	➢ Erection girder (Span by Spam Method) ➢ TBM machine and related facilities ➢ Earth retaining wall construction machinery (for underground station)	➢ Cranes ➢ Excavators (Back hoe etc) ➢ Transport vehicles (Dump Track etc) ➢ Piling machine
Station Facilities	➢ Air conditioning facilities ➢ Ventilation Facilities ➢ Water Supply, plumbing and drainage system ➢ Fire protection system ➢ Environment control system ➢ Elevators, Escalators	
Railway System	➢ Automatic gate ➢ Ticket vending machine ➢ Fare adjustment machine ➢ PSD (half and full) ➢ Signaling, telecommunication system	
Track Work	➢ Rail (UIC 60kg) ➢ Turnouts	➢ PC sleeper

	➢ Scissors crossing	
Depot	➢ Depot, workshop equipment	
Rolling Stock	➢ Rolling Stock	

Source: JICA Study Team

4.6.3 Project Implementation Schedule

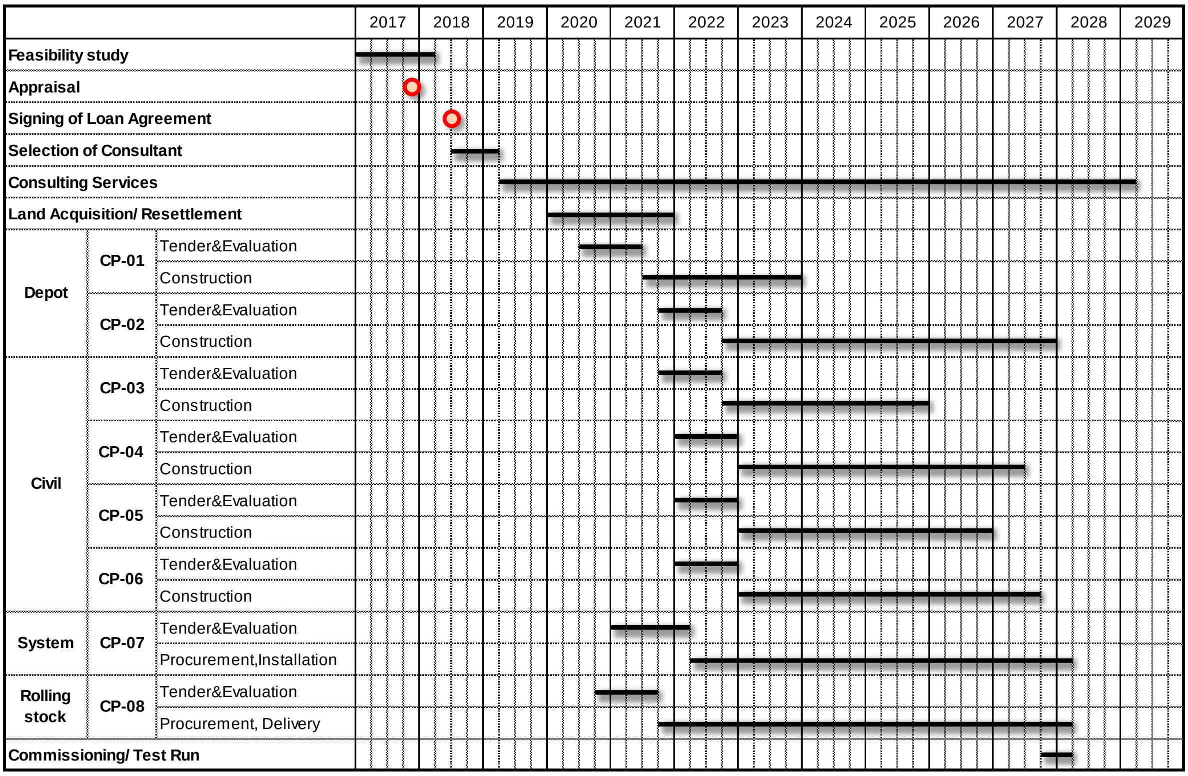
The project implementation schedule and construction schedule for civil works for MRT Line 5 are shown below.

Construction speed for implementation schedule is assumed as following table.

Table 4.6.16 Assumed Construction Speed

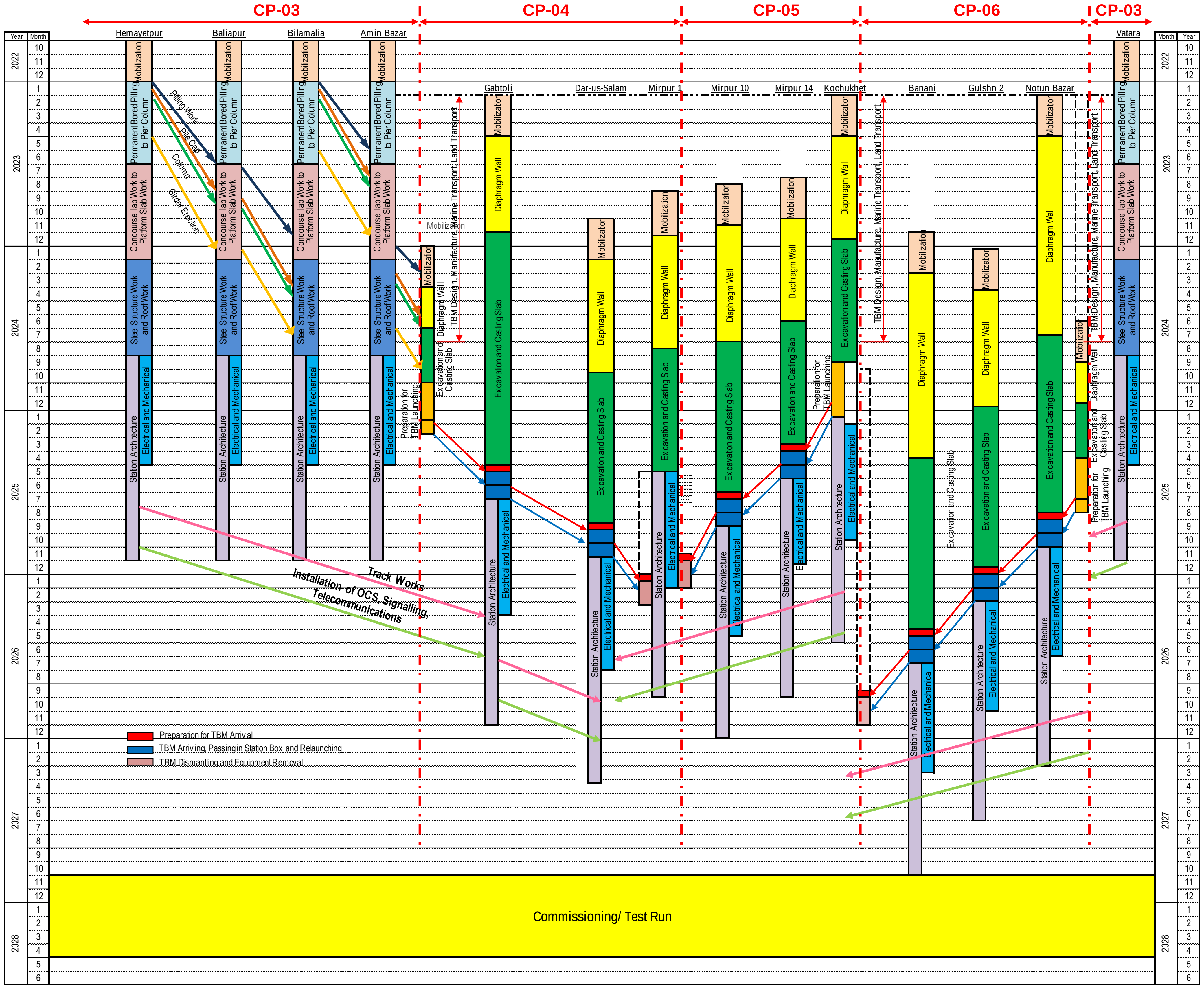
Work Item	Assumed Construction Speed	Basis of Speed
Tunneling Work (TBM)	300 m/month	Table 4.8.1
Viaduct (Span by Span Method)	200 m/month	Plan of Line 6
Track Work	900 m/month	Plan of Line 6
Telecommunication Work	900 m/month	Plan of Line 6
Signalling Work	900 m/month	Plan of Line 6
OCS Work	1,100 m/month	Plan of Line 6

Source: JICA Study Team



Source: JICA Study Team

Figure 4.6.8 Project Implementation Schedule



Source: JICA Study Team

Figure 4.6.9 Construction Schedule

4.6.4 Applicable Japanese Technology

1) Technology for Construction in Narrow Area

Japanese railway construction technology boasts the world's highest level and is highly valued overseas. In particular, various construction methods have been developed due to advanced technology development of bridge and underground structure construction technology for a narrow construction space. In the Dhaka city, it is expected that the construction space will be more limited than Japan, so it is considered that the construction technique in the narrow space of Japan can be applied.

Applicable Japanese technology is following.

(1) Screw Steel Pipe Pile

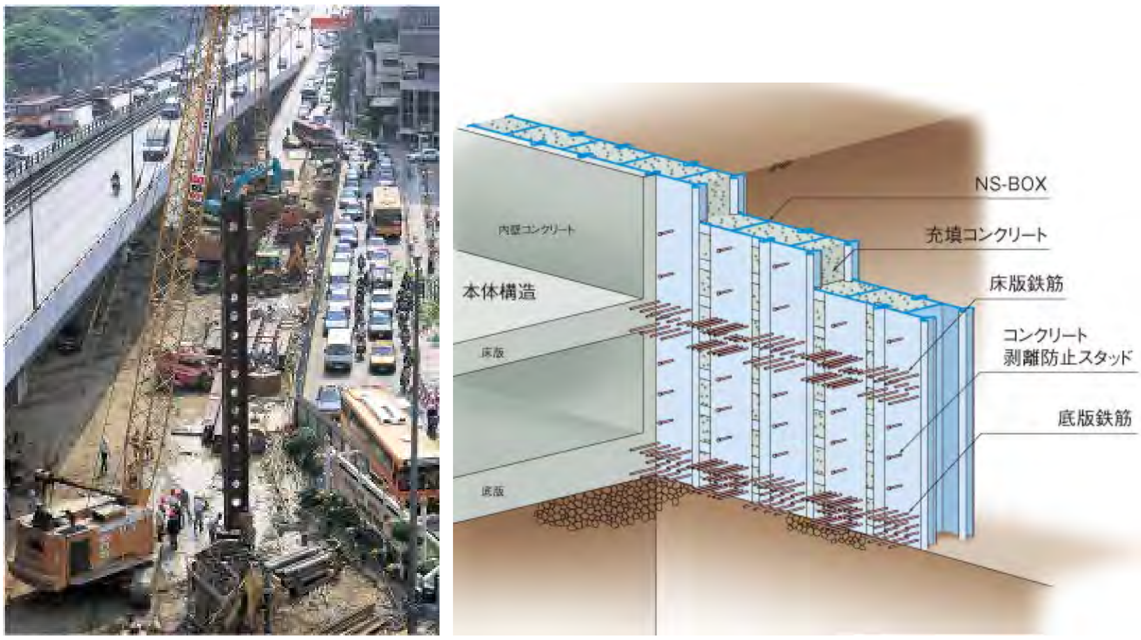
It is a method of construction for steel pipe pile with blade at tip by penetration, and it is applied in proximity construction with buildings and track in Japan. MRT Line 6 is applied this method at the station section close to the building. In the MRT Line 5, the elevated section where a pile foundation is required is a suburb, and there are no nearby buildings at the moment. However, if the situation around the station and the elevated section will change in the future, there is the possibility of application of the same construction method in the case proximity construction will be occurred.

Source: http://uedakikou.adsmart.jp/method_ok04.html

Figure 4.6.10 Screw Steel Pipe Pile

(2) Steel Diaphragm Wall

Steel diaphragm wall is construction method that earth retaining wall is constructed with connected steel diaphragm wall members. Compared with the conventional underground diaphragm wall method, it is possible to thin the wall body, and construction time and space can be minimized. It has been applied in MRT underground station construction in Japan and Thailand. Since the underground station of MRT Line 5 is located near existing buildings, there is a possibility of adoption if this construction method has advantage than conventional method.



Source: http://www1a.biglobe.ne.jp/ns-box/ns-box01.html

Figure 4.6.11 Screw Diaphragm Wall

2) Soil Improvement Method

In the MRT Line 6, Sand Compaction Pile method is applied for soil improvement at Depot for the purpose of shortening the construction period. As for MRT Line 5 as well as MRT Line 1, it is expected that soft ground counter measures will be necessary within a limited construction period, so the SCP construction method can be applied for the purpose of shortening the construction period.

3) Rolling Stock

Japanese rolling stock is highly regarded worldwide for excellent energy saving, high safety and reliability. Though European and Chinese manufacturers are developing technically equivalent to Japanese rolling stock., from the viewpoint of maintenance and operation, it is desirable to procure vehicles of similar specifications, since Japanese rolling stock will be procured at MRT Line 6.

4) Rail

Since heat-treated rails made in Japan have high quality and excellent durability, it is possible to reduce the life cycle cost in high-density routes. The UIC 60 rail, which is planned to be adopted for the MRT Line 5, is produced and exported overseas by Japanese manufacturers.

5) Railway System

Regarding railway systems such as signal, power, telecommunication, AFC, PSD, etc., MRT Line 6 will apply Japanese technology in most part of the railway system. Since it is desirable to unify the specifications of the system as far as possible from the maintenance and procurement aspects, the possibility of adopting Japanese technology is high for MRT Line 5 as well. In particular, it is desirable to unify all lines on the Japanese standard C type (ISO / IEC 18092), which is proposed for adoption for AFC for MRT Line 6, so it should be adopted also in MRT Line 5.

4.6.5 Consulting Services

1) Scope of Works of the Consultants

As for the consulting services necessary for project implementation, there are the following items according to the progress of the project.

(1) Basic Design and Detail Design

- Review of previous study
- Design work (study of design standard, alignment, station layout, civil, station, railway system, rolling stock etc.)
- Support for land acquisition and compensation activities
- Survey and Investigation (Topographic, geotechnical, hydrological, social and natural environment etc.)
- Stakeholder coordination
- Preliminary construction cost estimate
- Preparation of tender documents (Drawings, general and technical specification etc.)
- Preparation of tender evaluation criteria

(2) Tender Assistance

- Assistance for invitation of the tender (including PQ)
- Assistance for evaluation of the tender
- Preparation of evaluation report
- Assistance for negotiation of the contract with the tenderers

(3) Construction Supervision

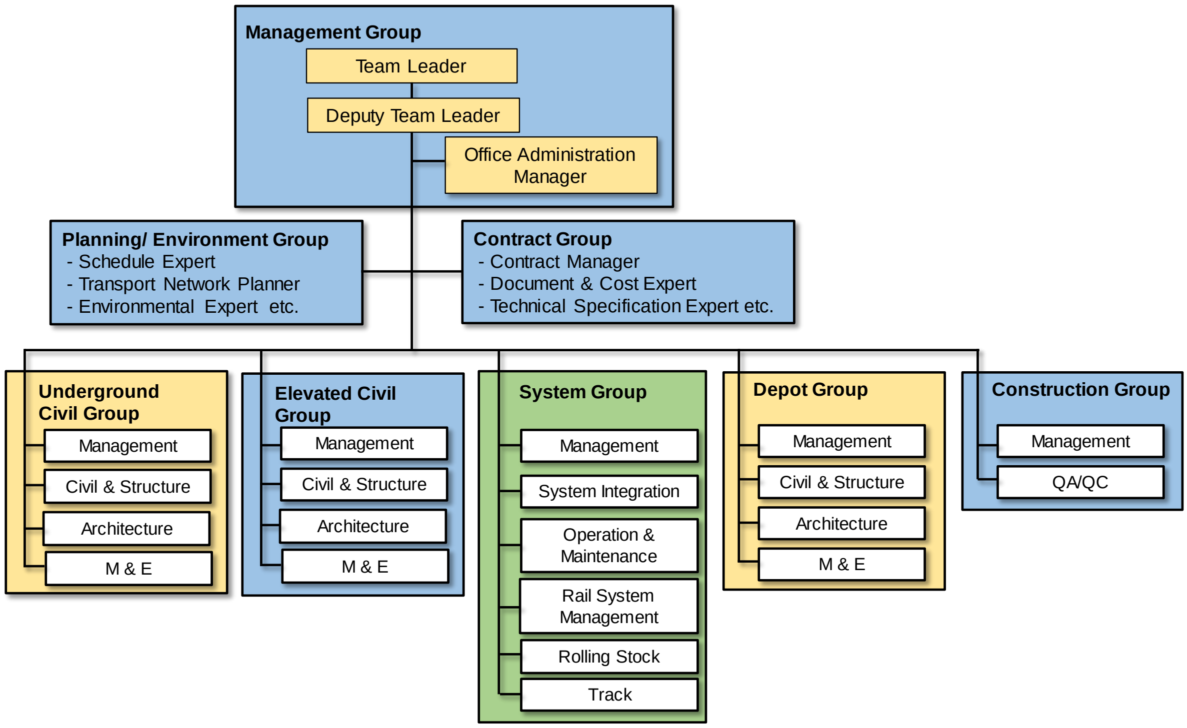
- Construction supervision (quality, schedule and safety management etc.)
- Inspection for the civil, architecture works at the necessary stages
- Delivery inspection for facilities, railway systems and rolling stock etc.
- Cost management
- Review of drawings and report made by contractors
- Monitoring for environmental protection
- Test run and commissioning before operation

(4) Operation Maintenance Support

- Support on human resource development (Training)
- Preparation of manuals for operation, management and maintenance

2) Organization of Consultants

The implementation organization is shown below.



Source: JICA Study Team

Figure 4.6.12 Implementation Organization of Consultants Services

4.7 Geotechnical Investigation

4.7.1 Overview

Geotechnical investigations through field level borehole testing and laboratory soil property testing is one of the most important requirements of the subsurface design, which includes foundation designs of elevated viaduct and stations, tunnel design and underground stations design. In this Project, the geotechnical investigation has much more importance due to underground tunnel and stations construction.

The work of geotechnical investigation was entrusted to a local sub-contractor. Because of the various reasons beyond control (like, drilling approval from road owning authorities, and prevailing security concern), the investigation took longer time than anticipated. The schedule was as follows:

- Field work start date: 27 February, 2017
- Field work finished date: 29 October, 2017
- Laboratory work start date: 15 March, 2017
- Laboratory work finished date: 11 November, 2017

This section summarizes the outcome and results of the geotechnical investigations, as well as issues to be looked into more specifically during the detail design stage. Details could be found in the final report submitted by the sub-contractor.

4.7.2 Location of Boreholes

Fifty-two (52) boreholes were drilled for the project. The borings were drilled vertically and stopped in hard/ very dense layer when SPT N-value was greater than 50 blows/ft. Borehole diameter was 100mm.

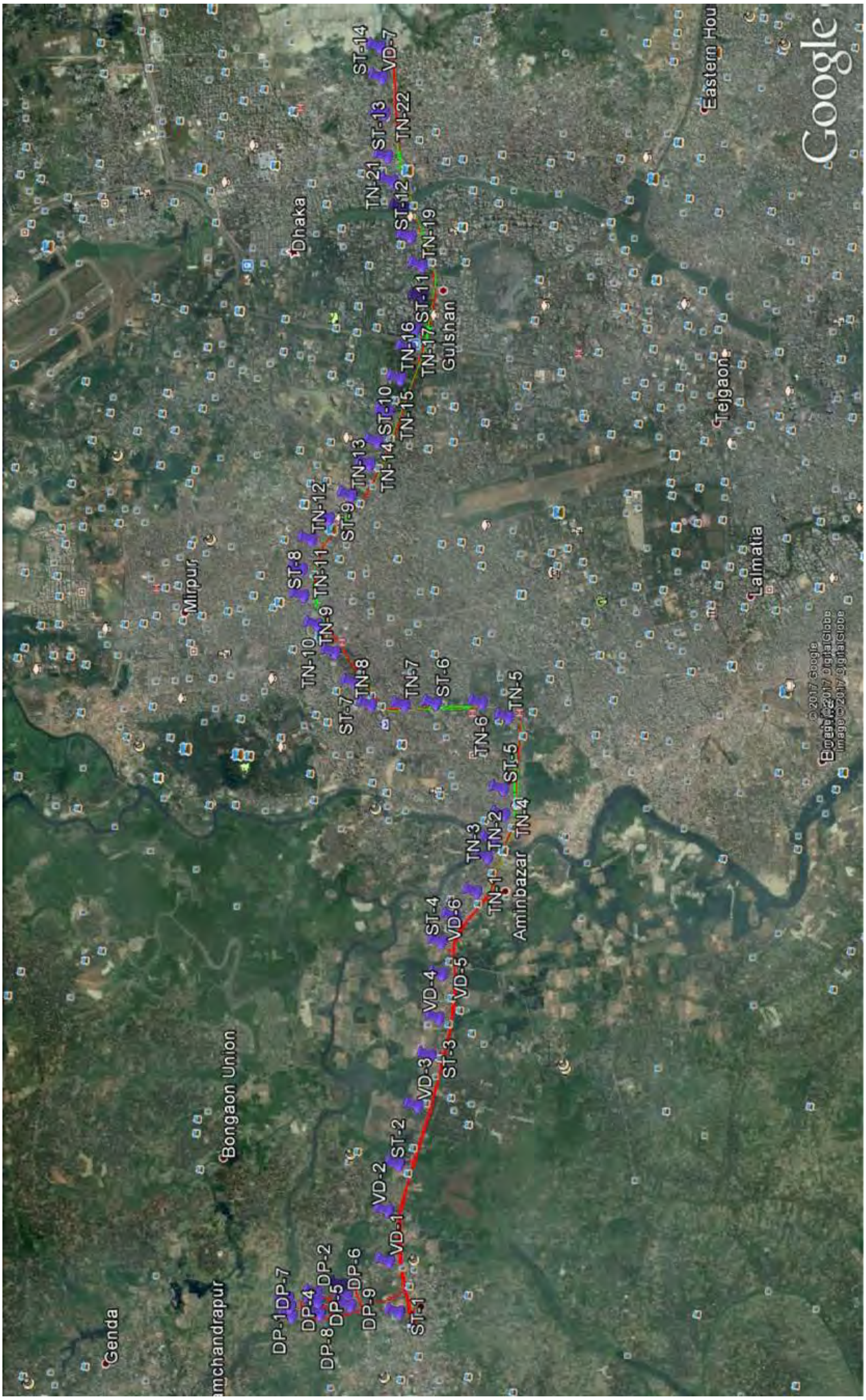
The locations were fixed based on the following general guidelines.

- At every 500m interval for elevated line(VD) 13 locations
- At every 200m interval for underground line (TN) 16 locations
- At every stations (ST) 14 locations
- At proposed depot (DP) 9 locations
    - ✧ **Total 52 locations**

The locations of the boreholes on google map is shown in Figure 4.7.1.

Depending on the land ownership of the borehole locations, it can be classified as follows:

- Local Private Land owners 9 locations
- RAJUK (Capital Development Authority) 4 locations
- Roads and Highways Dept (RHD) 12 Locations
- Dhaka North City Corporation (DNCC) 23 locations
- Bangladesh Army 2 locations
- Bangladesh Navy 1 location
- National Housing Authority (NHA) 1 location



Source: JICA Study Team

Figure 4.7.1 Locations of Boreholes

4.7.3 Test Parameters and Standards Used

The boreholes were made by the Hydraulic Rotary Drilling Method. Disturbed samples were collected during Standard Penetration Testing at 1.5 m intervals. Bentonyte slurry was used for stabilization of borehole.

The field and lab test parameters and standards used are shown in the following table.

Table 4.7.1 Field and Laboratory works Items and Standards Used

Field and Laboratory Works	ASTM Nos
Standard Penetration Test (SPT)	D 1586
Sieve Analysis Test	D 422
Atterberg Limits Test	D 4318
Natural Moisture Content Test	D 2216
Unit Weight Test	D 2937-00
Consolidation Test	D 2435
Unconfined Compression Test	D 2166
Tri-axial Test (UU)	D 2850-95

Groundwater table is required for foundation design and stability analyses. Here, instead of ground water table, bore hole water table was measured at 24 hours after completion of the borehole. Significant fluctuations of ground water table should be anticipated throughout the year, depending upon the amount of precipitation, evaporation and surface runoff.

Finally, water quality tests were also performed. Water quality tests refer to physical and chemical analysis of borehole water samples. Physical analysis covers Color and Suspended Solid. Chemical analysis includes pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Carbonate ion (CO_3), Nitrate ion (NO_3), Nitrite ion (NO_2), Sulfate ion (SO_4), Chlorine ion (Cl) and Ammonium ion (NH_4) concentration. ORION AQ3700 Colorimeter is used for these tests except BOD and COD. BOD and COD tests were performed using APHA 5210B and APHA 5220C method respectively.

4.7.4 General Geological Condition of the Site

The Dhaka City is bounded by the rivers Buriganga to the south, Turag to the west, Balu to the east and Tongi Khal to the north. Dhaka city and its surroundings are situated in the national seismic zone 2, that is, within the medium risk/ hazard zone. Neotectonic movement in and around the city has been reported widely, as all four sides of the city are bounded by faults. The high lands of Dhaka area are composed of Pleistocene Madupur clay and sand formation, whereas the low lands are recent floodplain deposits.

The MRT Line - 5 passes from Vatara to Hemayetpur through Gabtoli, Mirpur, Banani, and Gulshan - 2. The Hemayetpur end is mostly consists of high land with several river tributaries including Turag river which contributes as the active drainage system. From Hemayetpur to Gabtoli, the abundance of the Madhupur clay and sand formation decreases due to overburden recent sediments. The Banani to Vatara part comprises the same phenomena. The Mirpur area shows overburden recent sediments.

4.7.5 Summary Results of Soil Parameters

The lowest and highest values of test parameters found in this investigation are shown in the following table.

Table 4.7.2 Lowest and Highest Values of Test Parameters

		Lowest Value	Highest Value
Sieve	Sand	0.43	97.22
	Silt	1.45	89.09
	Clay	0	66.67
Limit	LL	27.55	231.03
	PL	11.25	75.37
	PI	9.03	159.16
NMC	%w	12.01	36.09
Consolidation	σ'pc	22	260
	e_i	0.42	1.41
	Cc	0.02	0.44
UCS	Cu(Undisturb)	11.74	150.61
	Cu(Remolded)	15.34	162.6
	St	0.62	0.97
Triaxial	Cuu	9	180
	ϕo	0.9	11.3
BULK DENSITY	γwt	17.13	22.98
	γd	13.52	18.59

It may be mentioned here that the depths of the boreholes were between 39.0m and 55.5m, that means support layer with N values more than 50 appeared at those levels.

4.7.6 Soil Profile

First, interpolated soil profiles were prepared for sections of alignment, which were later combined into a full length soil profile for the entire alignment. The synthetic subsurface profile from Hemayetpur to Vatara is given in Figure 4.7.2.

In this soil profile, six types of soils are designated, namely, Sand, Silt, Clay, Organic Clay, Fill Layer and Support Layer (with N value more than 50).

The N values of each layer for each borehole can be found in the sub-contractor's final report.

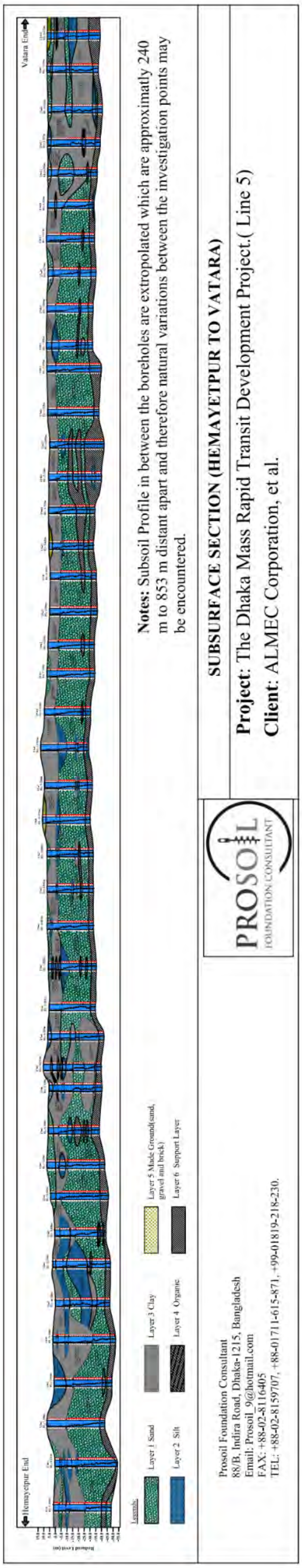


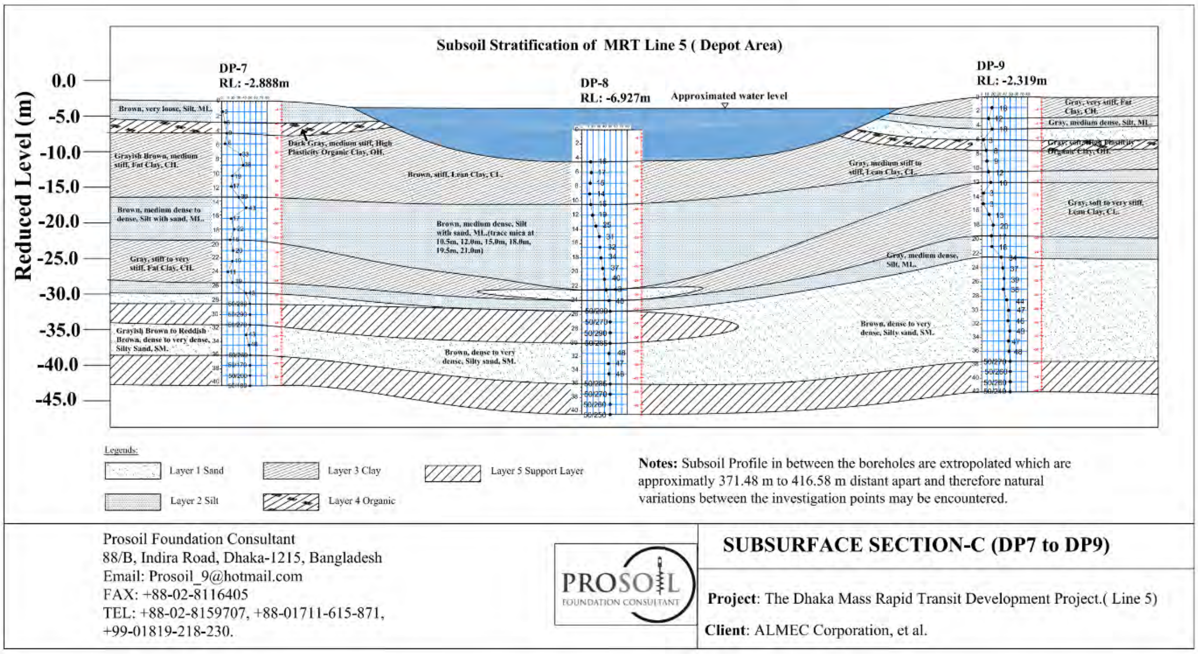
Figure 4.7.2 Subsurface Soil Profile for the Entire Alignment

4.7.7 Preliminary Analysis of Soil Profile

This sub section contains preliminary analysis of soil profile obtained from the geotechnical investigations. However, more focused analysis is needed during the detail design stage based on more closely spaced additional boreholes.

1) Depot Area

There are 9 boreholes in the proposed depot area. One cross section profile with 3 boreholes are shown below.



Major points to be considered are,

- There are clay layers up to (–) 30 m with low N value.
- This layer can cause consolidation. Final settlement should be calculated during the detail design stage. Based on that, soil improvement measures may be planned.
- There is a thin layer of organic clay near top. Risk of liquefaction may be low, but needs further investigation.
- There is a bearing layer after at around (–) 30 m. However, the layer is not continuous, so more investigation is needed before considering the layer as pile end layer.
- On the other hand, the bearing layer at (–) 40 m can be safely used as pile end layer.

2) West Side Viaduct Area

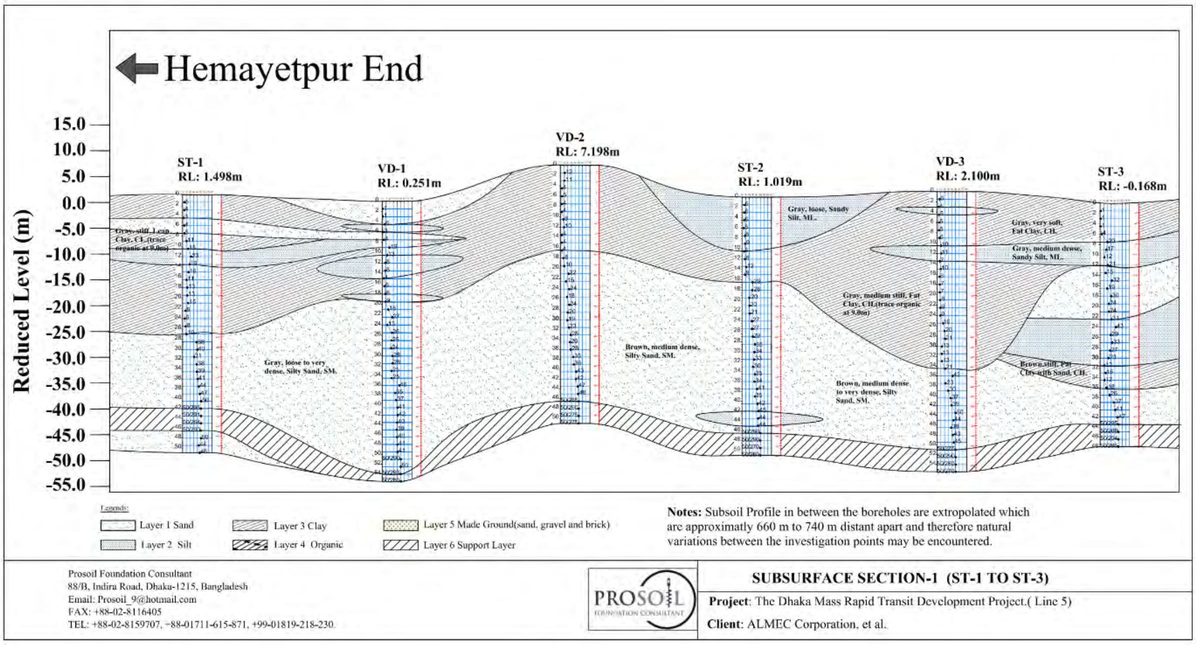
The following figure shows the soil profile between ST-1 (Hemayetpur) and ST-3 (Bilamalia). It contains 6 boreholes.

Major points to be considered are,

- As the SPT-N values of the bearing layer are over 50, that layer is the first option as a “Bearing Layer for the Viaduct”. This layer varies in depth between 40 to 55 m. Thus, the depth of the bearing layer must be determined at each borehole based on site specific geotechnical investigation during detail design stage.
- At VD-1 site, the thickness of bearing level is less than 5 m. During DD, the thickness

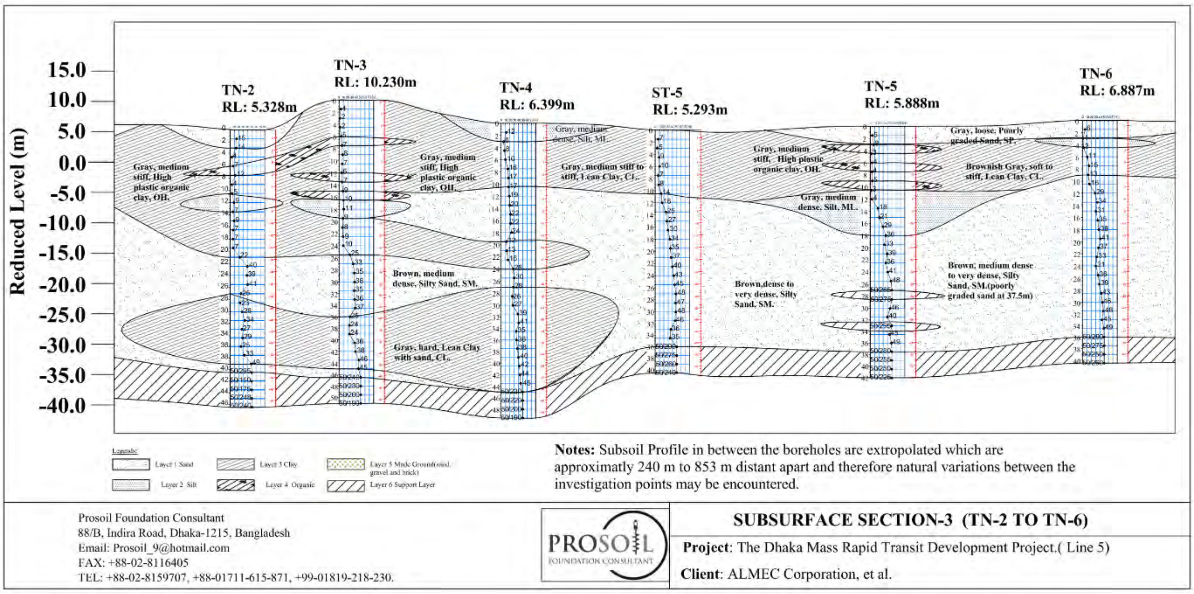
of the layer must be rechecked to confirm if the layer is adequate to serve as the bearing layer.

- Because of the rather deeper bearing layer location, longer pile length may be required compared to Line 6 project.
- Though there are rather thick clay layer, which might cause consolidation (like VD-3); it may not cause any adverse impact for viaduct piles.



3) Tunnel section crossing Turag River

The following soil profile section shows the tunnel section where it crosses the Turag River (between ST-4 and ST-5).



Major points to be considered are,

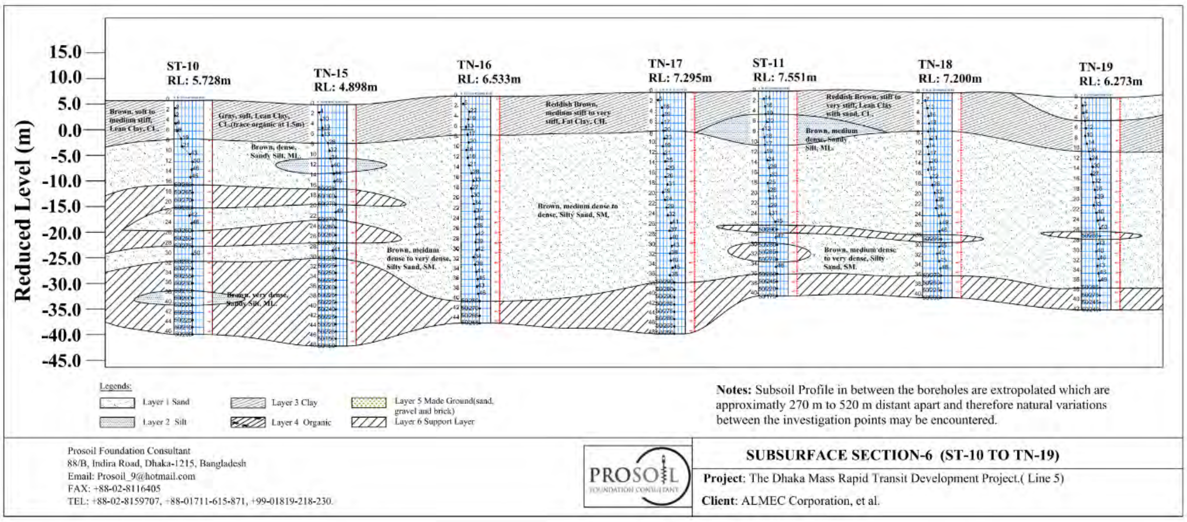
- The tentative tunnel levels (top and bottom) under the river is (-) 16 to (-) 23 m (based on the Figure 4.1.17 Plan and Profile). There are sand layers around that depth, so no difficulty is expected.
- At Gabtoli station (ST-5), tunnel top and bottom level are expected at (-) 11 m and (-) 18 m. The profile shows that at those depths, there are dense silt and sand layers. So, no difficulty is expected.
- For the bottom tunnel after Gabtoli station, the tunnel is expected to be placed between (-) 20m and (-) 27 m. That layer is also sandy. So, no difficulty is expected.

4) Typical Tunnel Section

After Gabtoli, the tunnel placement locations are tentatively between (-) 14 and (+) 2 m, except around Banani area (Refer to Figure 4.1.17 Plan and Profile). It was found that in general, the tunnels will encounter sand and silt layers, but a small portion of the tunnel section may be placed within the clay layer. For those cases, proper design of tunnel outer ring should be done.

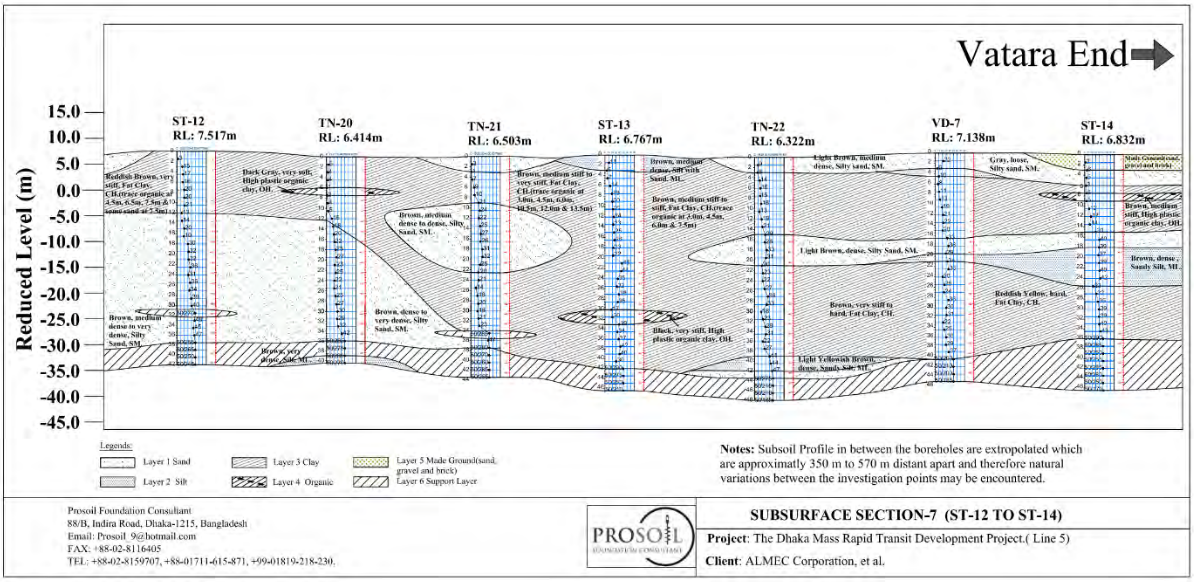
5) Tunnel section around Banani Station

The tunnel around Banani station (ST-11) will be the deepest in the project. The up and down tunnels will be vertically stacked. The proposed locations of the two tunnels will be between (-) 20m to (-) 40m. According to soil profile shown below, there are sand and bearing layers at those layers. So, no difficult is expected.



6) Western part after Gulshan 2 station

The following figure shows the soil profile section from Gulshan 2 station (ST-12) till Vatara station (ST-14). There are 7 boreholes shown in the figure. It can be seen that after Gulshan 2 station, soil profile rapidly changes and at Notun Bazar station, the clay layer reaches up to (-) 30 m, and there is no distinct sand layer. Very detail investigation is recommended during the detail design stage to encounter any anticipated adverse effect.



4.7.8 Borehole Groundwater Quality Tests

Out of 52 boreholes, the sublet firm was instructed to conduct borehole groundwater quality tests from 30 boreholes for the parameters mentioned in Sec 4.7.3. A typical test result from Gabtoli Station is shown below. All results are available in Sublet firm's final report.

PROSOIL

Water Quality Test

Project: The Dhaka Mass Rapid Transit Development Project. (Line 5)
Client: ALMEC Corporation, et al.
Apparatus: ORION AQ3700 Colorimeter
Location: Gabtoli Bus Terminal. **BH No.** ST-5

Test Results

Color (TCU)	pH	Biochemical Oxygen Demand, BOD5 (mg/L)	Chemical Oxygen Demand, COD (mg/L)	Suspended Solid, SS (mg/L)	Carbonate ion (CO_3^{2-}) (mg/L)	Nitrate ion (NO_3^{2-}) (mg/L)	Nitrite ion (NO_2^{2-}) (mg/L)	Sulfate ion (SO_4^{2-}) (mg/L)	Chlorine ion (Cl^-) (mg/L)	Ammonium ion (NH_4^-) (mg/L)
132	8.1	15.90	39.9	3700	44	< 0.35	0.07	< 5	143.35	0.71

4.7.9 Field Permeability Tests

In this investigation, field permeability tests were conducted for 10 borehole locations. Usually, the test is applicable to sandy soil.

The degree to which soils are permeable depends on a number of factors, such as soil type, grain size distribution, water content, degree of compaction and stress history. The ability to transmit water is characterized by the coefficient of permeability (or hydraulic conductivity).

The selected borehole locations and test depths are shown below

No	Boring	Chainage	RL	GL	Test Depth (GL-)
1	TN2	6km300	-20.118	5.328	**25.446**
2	TN5	8km100	-19.272	5.888	**25.160**
3	TN8	10km000	-6.553	11.132	**17.685**
4	TN10	11km280	-10.947	9.438	**20.385**
5	TN12	12km500	-9.892	4.946	**14.838**
6	TN14	13km700	-10.710	5.723	**16.433**
7	TN15	14km480	-17.734	4.898	**22.632**
8	TN19	16km500	-22.913	6.273	**29.186**
9	TN20	17km300	-17.050	6.414	**23.464**
10	TN22	18km600	-8.288	6.322	**14.610**

The results are shown below.

BH NO.	Test Depth	Hydraulic Conductivity	Relative Permeability	Soil Type	Particle Distribution		
					Sand	Silt	Clay
	(m)	(cm/sec)			(%)	(%)	(%)
TN-2	25.446	$9.20\text{x}10^{-5}$	Medium to Low	Silty Sand, SM	76.35	23.65	0.0
TN-5	25.160	$7.60\text{x}10^{-5}$	Medium to Low	Silty Sand, SM	66.28	33.72	0.0
TN-8	17.685	$4.50\text{x}10^{-4}$	Medium to Low	Silty Sand, SM	80.58	19.42	0.0
TN-10	20.385	$6.30\text{x}10^{-3}$	Medium to Low	Silty Sand, SM	86.28	13.72	0.0
TN-12	14.838	$4.94\text{x}10^{-4}$	Medium to Low	Silty Sand, SM	79.70	20.29	0.0
TN-14	16.433	$7.80\text{x}10^{-4}$	Medium to Low	Silty Sand, SM	76.41	13.59	10.2
TN-15	22.632	$6.30\text{x}10^{-3}$	Medium to Low	Silty Sand, SM	78.80	21.20	0.0
TN-19	29.186	$2.82\text{x}10^{-3}$	Medium to Low	Silty Sand, SM	83.41	16.59	0.0
TN-20	23.464	$3.93\text{x}10^{-4}$	Medium to Low	Silty Sand, SM	79.26	20.79	0.0
TN-22	14.610	$8.48\text{x}10^{-5}$	Medium to Low	Silty Sand, SM	76.16	23.84	0.0

As there is no permeability level lower than 10^{-5}, it can be said that the test layers were basically sandy.

4.7.10 Liquefaction Analysis

In this investigation, liquefaction analysis was conducted for 33 borehole locations, out of which analysis of 30 boreholes on the alignment was given in the sublet firm's final report (Nov, 2017), while the analysis of 3 depot boreholes was given in the sublet firm's supplementary report (Jan, 2018).

For an alluvial sandy layer having all of the following three conditions, liquefaction assessment should be conducted (Part V, Japan Highway Bridge Code, 2002).

1) Saturated soil layer having ground water level higher than 10 m below the ground surface and located at a depth less than 20 m below the present ground surface.
2) Soil layer containing a fine content (FC) of 35% or less or soil layer having a higher FC and plasticity index IP less than 15.
3) Soil layer with a mean grain diameter (D_{50}) less than 10 mm and a grain diameter at 10% pass (on the accumulation curve) (D_{10}) less than 1 mm.

For a soil layer requiring liquefaction assessment, liquefaction resistance factor FL shall be calculated and if the result turns out to be less than 1.0, the layer shall be regarded to have liquefaction potential. FL is a factor depending on Dynamic Shear Strength Ratio R to Seismic Shear Stress Ratio L.

Of the 33 locations for which liquefaction analysis was conducted, only few locations show any possibility of liquefaction. The results are shown in the following table.

Table 4.7.3 Identified Layers with Liquefaction Potential (Main Line)

Borehole ID No	Depth of layer with Liquefaction potential	Total depth of layer with Liquefaction potential	Remarks
ST-01	4.5m, 6.0m	3 m	Not so thick layer
VD-01	3m, 19.5m, 21.0m	4.5 m	Upper layer is thin
ST-02	8.0m	1.5 m	Thin layer
VD-05	16.5m, 18.0m	3 m	Not so thick layer
VD-06	4.5m, 6.0m	3 m	Not so thick layer
TN-16	10.5m	1.5 m	Thin layer
TN-18	10.5m, 15.0m	3 m	Thin layers
TN-20	12.0m, 13.5m	3 m	Not so thick layer
ST-14	4.5m	1.5 m	Thin layer

The effect and impact of liquefaction is more for the depot area than the main line. Liquefaction analysis was conducted for the 3 boreholes at proposed depot area along the larger longitudinal axis. The results are shown in the following table.

Table 4.7.4 Identified Layers with Liquefaction Potential (Depot Site)

Borehole ID No	Depth of layer with Liquefaction potential	Total depth of layer with Liquefaction potential	Remarks
DP-04	1.5m, 3.0m	3 m	Not so thick layer
DP-05	4.5m, 7.5m, 9m	4.5 m	May cause risk, Needs further investigation
DP-06	15m, 19.5m, 21m, 22.5m	6 m	Liquefaction potential, needs countermeasure

From the above results, risk of liquefaction cannot be overruled. Further geotechnical investigations should be carried out during the detail design stage. Since the depot site soil results also indicate consolidation risks, proper soil improvement measures like Sand Compaction Pile (SCP), Dynamic Compaction (DC), Perforated Vertical Drain (PVD), Surcharge Loading, etc., may be considered.

4.7.11 Concluding Remarks

Because of the long approval process from the road owning agencies and prevailing security situation (as mentioned in Sec 4.7.2), geotechnical investigations could not be completed in timely manner. All field works completed in October, 2017, while lab testing were completed in November 2017. As such, complete synchronization between substructure design and geotechnical results were not matured. However, practicality level cross checking was conducted which is sufficient for this feasibility level study.

The results of this geotechnical study will serve as an important tool during detail design stage. The current investigation will help in defining the scope of the detail design level geotechnical investigation and also help to identify the locations and aspects for which concentrated focus should be made.

5 Environmental and Social Considerations

5.1 Project Component which Affects Environmental and Social Considerations

This project is a railway project in Dhaka Metropolitan Area (DMA). The objective of the project is to satisfy the traffic demand in DMA, to contribute an economic development, and to mitigate air pollution.

The project was proposed as a priority project in RSTP assisted by JICA. In RSTP, based on a strategic environmental assessment, the project was selected from some traffic projects. From the result of the RSTP, BOG and JICA agreed a development of MRT Line5 and Line1 and are carrying out this survey as a feasibility study.

Table 5.1.1 Project Components

Construction of alignment	Viaduct and substructure	19.5km (Hemayetpur Station ~ Vatara Station)
Construction of stations	Underground structure and viaduct structure including entrance and exit, elevator and ventilation facility	14 stations
Depot	Ground leveling, construction of depot and maintenance facility, and approach	22 ha (Vicinity of Hemayetpur station)
Others	Construction yard	Unfixed

Source: JICA study team

Source: JICA Study Team prepared based on Google Maps

Figure 5.1.1 Route of MRT Line5

Construction works and the existence and operation of the project may cause negative impact on the environment and social matters and would require land acquisition and involuntary resettlement in Right of Way (ROW).

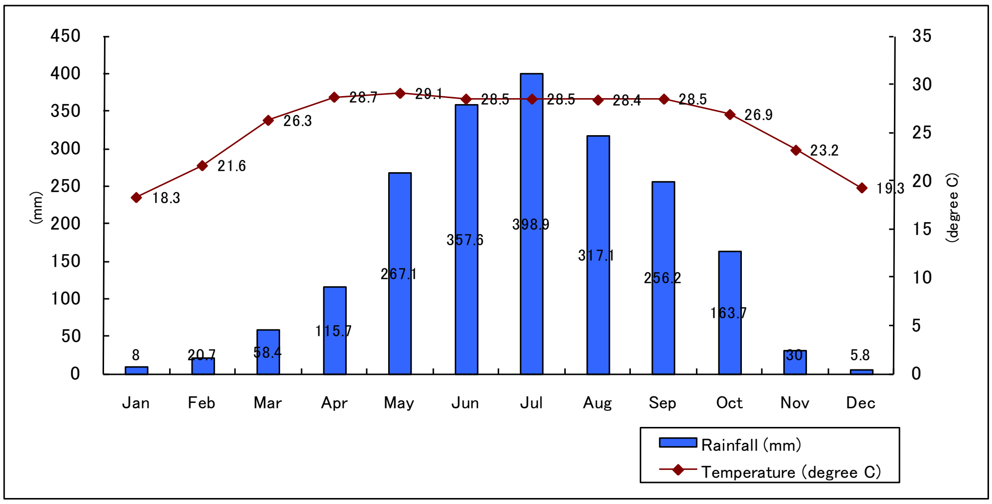
Accompanied with the project. It is expected that the vicinity of stations will be developed. However, since it is due to private developers, as of now, prediction and evaluation of the environment is difficult. Therefore, the evaluation of the development of the surroundings is out of the environmental and social considerations of the project.

As cumulative impacts caused by the project, some traffic projects planned in Dhaka may cause negative impacts. The cumulative impacts are examined on 6.6.2. Operation of borrow pits, quarry sites and construction yards have potential negative impacts, however as of now the location of the facilities are unfixed. Therefore, the mitigation policies of negative impacts are examined in this study.

5.2 Environmental and Social Baseline

5.2.1 Location and Climate

The climate of Dhaka is categorised as tropical monsoon of Keppen climate classification. The annual average temperature is 25 degrees Celsius; the annual precipitation is approximately 2,000mm. Seasons are divided to hot and rainy season (May to October), cool and dry season (November to February), and hot and dry season (March to April). Eighty percent of the annual precipitation is observed during May to September (see Figure 5.2.1). Because water levels of rivers rise in the rainy season, high intensity rain often causes inundation in Dhaka city.



Source: http://www.worldclimate.com/

Figure 5.2.1 Monthly average precipitation and temperature

5.2.2 Topography and Geology

RAJUK area including the project area is formed with an alluvial plain including highland swamp, lowland and natural bank. Swamp and wetland distribute in urban Dhaka and the vicinity.

Low lying swamps and marshes located in and around the city are other major topographic features. The elevation of DCC area varies from 2 to 13 m above the mean sea level. Most of the developed areas in RAJUK area are at an elevation of 6 to 8 meters above the mean sea level.

Part of the RAJUK area is covered by Pleistocene Madhupur Clay and Holocene sediments of the Ganges- Brahmaputra floodplain. The Madhupur Clay is situated in north-west part and lies elongated from the middle of the north to south of the project area and these are oxidized Pleistocene sediments. In the east, south and western half of the

RAJUK area are covered by the Ganges-Brahmaputra floodplain sediments.

Regarding the seismology, the National Seismic Zoning Map (Geological Survey of Bangladesh (GSB)) divides the country into three regions (see Figure 5.2.2). The city of Dhaka falls within the medium-risk zone (zone 2). In the medium risk zone, shocks of moderate intensity are possible, with a probable maximum magnitude of 6-7 on the Richter scale.

Source: Ministry of Power, Energy & Mineral Resources Division

Figure 5.2.2 National Seismic Zoning Map of Bangladesh

5.2.3 Hydrology

1) Hydrology in/around Dhaka city

Dhaka is surrounded with tributary rivers of three major rivers (Ganges River, Brahmaputra River and Meghna River). The water levels of rivers around of Dhaka city are linked to those of the major rivers, and rise up to 5.0~6.0m during rainy seasons, 1.0~2.0m during dry seasons.

2) Current condition of groundwater in Dhaka city

The groundwater extraction from groundwater table is an important water source in Dhaka city. Since most of the water resource in Dhaka depends on the extraction of groundwater, this extraction causes a drop of groundwater level. In addition, developments such as roads, buildings and embankment by rapid expansion of urban area are hampering groundwater cultivation from rainfall and rivers*. Water network formed by lakes, canals and small rivers have not only function of urban drainage against flood but also cultivation of underground water. However, recent disordered developments had these water bodies dropped sharply, and caused to deteriorate the function of groundwater cultivation.

* Dhaka Structure Plan 2016-2035 (draft) 11.3.4 Ground Water Depletion

3) Depletion of groundwater in Dhaka city

In Dhaka city, groundwater is pumped up from approximately 100m to 300m below the ground level. The level of the groundwater tends to decline year by year. In future, a lot of well may become to be unable to use, and cost of water supply may raise.

5.2.4 Wetland characteristics

1) Function of wetland

The wetland distributed on the low land around Dhaka city plays important roles of control and environment protection.

(a) Water retention for flood water
(b) Drainage of rain water from urban district
(c) Recharge of groundwater
(d) Preservation of ecological system and biodiversity
(e) Contribution to local economy: it is utilized as fertile rice paddies in dry seasons, or fishing ground in rainy seasons.
(f) Field of recreation activities

2) Wetland loss

In 1960, the area of the open water body was about 2,952 ha, which became about 1,991 ha in the year 2008. The amount of the open water body reduction is 961 ha. From 2005 to 2011 in just six years, the wetlands adjacent to Dhaka shrank from 5.85 km2 to 3.95 km2 when local water bodies and lowlands were converted to commercial, industrial and residential zones. If the current trend continues, experts said, by the year 2037 all wetland of Dhaka will disappear, posing a serious threat to the city's existence.

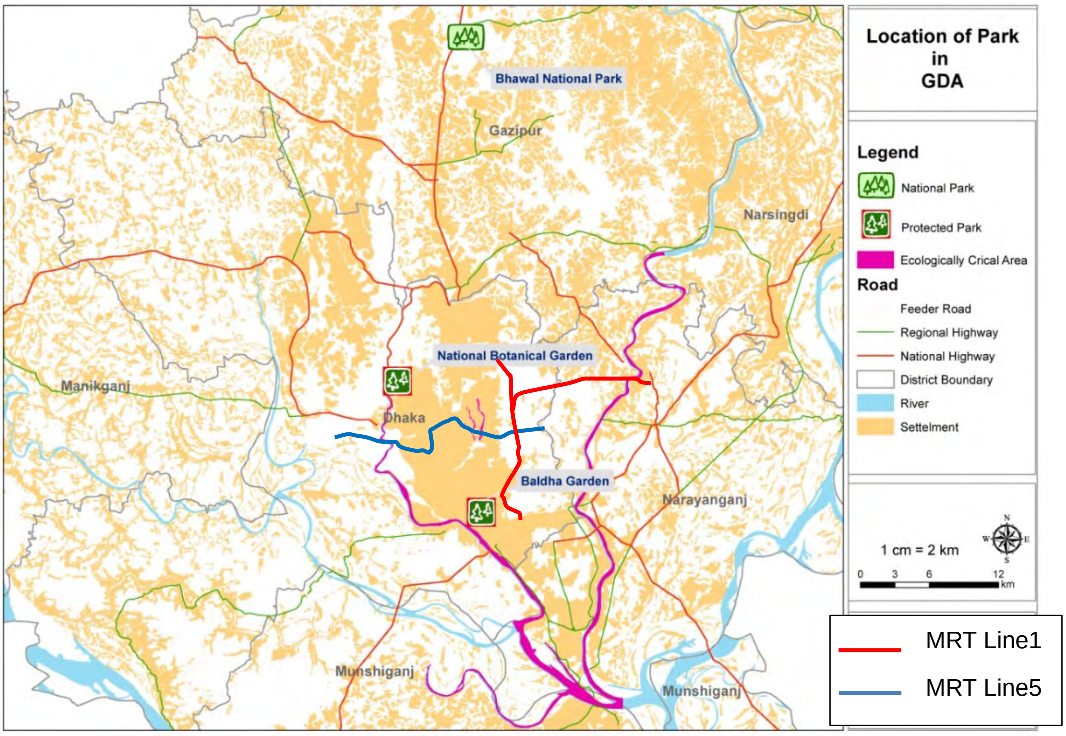
5.2.5 Natural park, sanctuaries and other conservation sites

Based on Bangladesh Wildlife Preservation Order 1973, Protected Areas (PAs) is classified into national parks, wildlife sanctuaries, game reserves and private game reserves. The protected areas in GDA are shown on Figure 5.2.3. In GDA, there is Bhawal National Park which is the only national park in GDA. In/around the project sites, there is no protected area such as natural park, sanctuary and conservation site. National Botanical Garden and Baldha Garden is botanical gardens which are located on over 2km from the project sites.

5.2.6 Environmentally critical area

The 1995 Bangladesh Environment Conservation Act includes provision for Ecologically Critical Area (ECA) declarations by the director general of the Department of the Environment in certain cases where the ecosystem is considered to be in danger of reaching a critical state. ECA is an area that “has been already quite polluted, and should prevent more pollution”, and does not prohibit development. Wild reserves and cultural heritage reserves are designated under Bangladesh Wildlife Preservation Order and Forest Act. In ECA, GOB restricts activities and process of manufacture in the view of preventing deterioration of the environment. In RAJUK, there are five ECA including one lake (Gulshan Banani-Baridhara Lake) and four rivers (Buriganga, Turag, Balu and Shitalakshya). (see Figure 5.2.3) In line with the project, the underground structure of MRT Line5 crosses Gulshan Banani-Baridhara Lake, which is designated ECA in 2001. After that, RAJUK is implementing an environmental improvement project (Gulshan – Banani - Baridhara Lake Development Project). MRT Line5 crosses Buriganga river and

Gulshan-Banani-Baridhara Lake under the ground.



Source: The Project on the Revision and Updating of the Strategic Transport Plan for Dhaka, 2nd Draft Final Report, February 2016, JICA

Figure 5.2.3 Natural Preservation Areas in GDA

5.2.7 Ecosystem

1) Ecosystem

The ecosystem of Bangladesh is categorised territorial ecosystem and aquatic ecosystem. The territorial ecosystem includes forest and hill ecosystems, agro-ecosystem and homestead ecosystem; while seasonal and perennial wetlands, rivers, lakes, coastal mangroves, coastal mudflats and chars, and marine ecosystem fall into the aquatic category. In RAJUK area, there are Moist Deciduous Forest (Sal Forest ecosystem), Agro-ecosystem and Homestead ecosystem.

In the project sites which are urbanized, the only Agro-ecosystem, Homestead ecosystem and wetland ecosystem are still existed in the west of Amin Bazar.

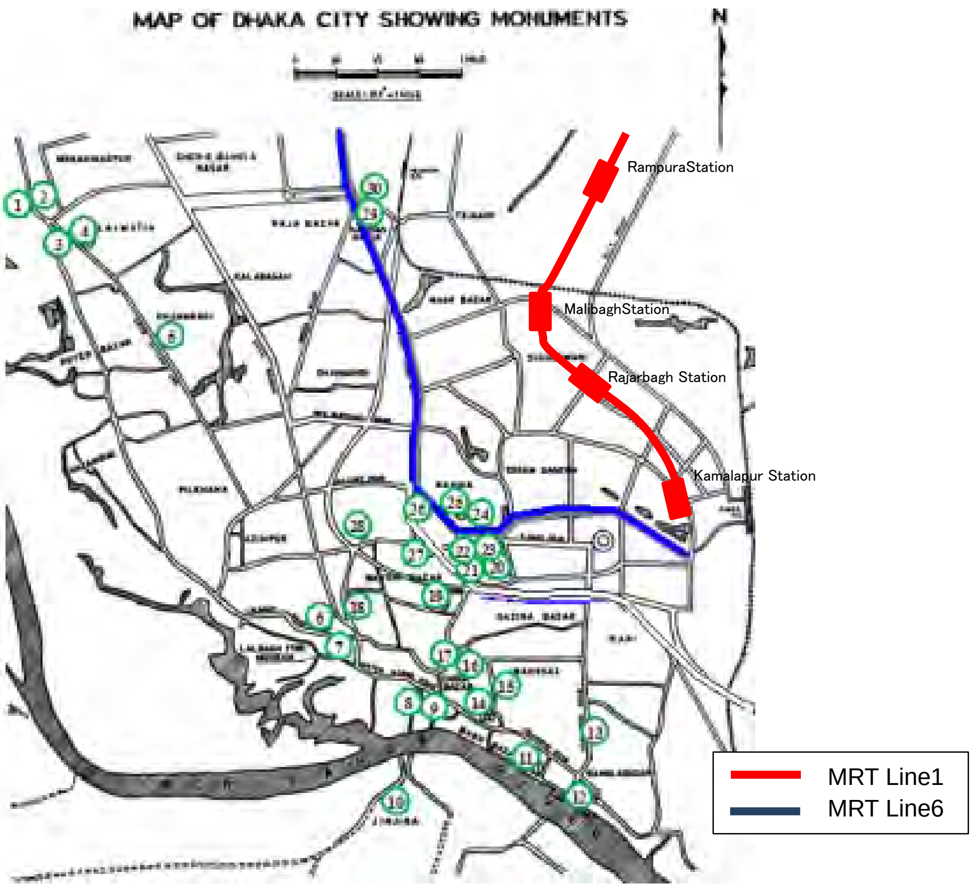
2) Endangered species

Bangladesh possesses extremely various species. As of July 2014, International Union for Conservation of Nature designates 106 animal species and 16 plant species as Critically Endangered(CR), Endangered(EN) and Vulnerable(VU).

5.2.8 Cultural Heritage

In RAJUK area, seventy four archaeological heritages including the followings are preserved. Major archaeological heritages in Dhaka city are shown below.

1. Sat Gumbad Mosque
2. Unknown Tomb near Sat Gumbad Mosque
3. Alakuris Mosque
4. Dara Begum's Tomb
5. Old Eidgah
6. Khan Muhammad Mridha Mosque
7. Lalbagh Fort
8. Bara Katra
9. Chhoto Katra
10. Kadamtali Circle
11. Ahsan Manzil
12. Northbrook Hall
13. St. Mary's Cathedral
14. The American Church
15. Sitara Mosque
16. Baoli
17. Kartalab Khan Mosque
18. Dhakeswari Temple
19. Hussaini Dalan
20. Fazlul Huq Hall
21. Curzon Hall
22. Dhaka City Corporation
23. Musa Khan Mosque
24. Greek Memorial
25. Tomb and Mosques of Haji Khawaja Shahbaz
26. Salimullah Hall
27. Dara Begum's Tomb
28. BUET
29. Khwaja Ambar Mosque
30. St. Augustin Church



Source: Department of Archaeology、Bangladesh

Figure 5.2.4 Archaeological Heritage in Dhaka city

Since the archaeological heritages concentrate on the south of the city, it seems that there are no heritages affected directly in/along the project. In this survey, cultural heritage in/around the project site is confirmed.

5.2.9 Pollution Control

1) Air Pollution

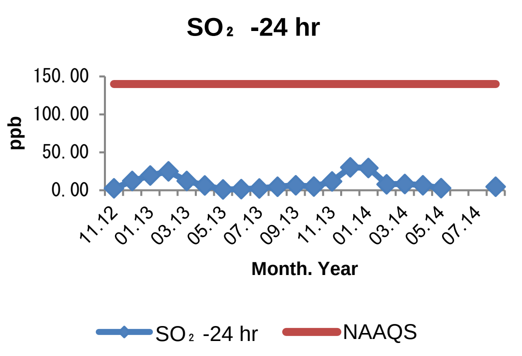
Deterioration of the air quality is one of the major environmental issues in Dhaka. Major pollutants are NOx, SO2, PM, PM10 PM2.5 CO, O3 and Lead. Major origins of air pollutants are vehicles and traditional brick manufacturers. A lot of the brick manufactures around Dhaka city operates during dry season (November to April). The emissions including SO2, NOx and organic hydrogen worsen the air quality. Table 5.2.1 shows National Ambient Air Quality Standards (NAAQ) in Bangladesh with WHO Guidelines.

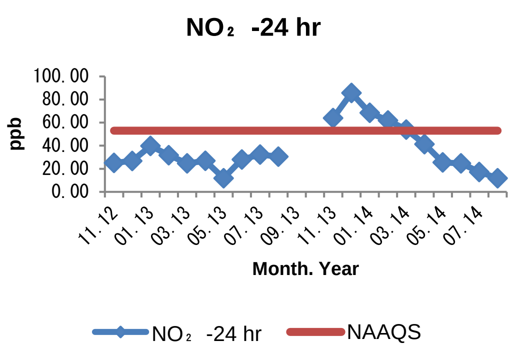
Table 5.2.1 National Ambient Air Quality Standards (NAAQ) in Bangladesh

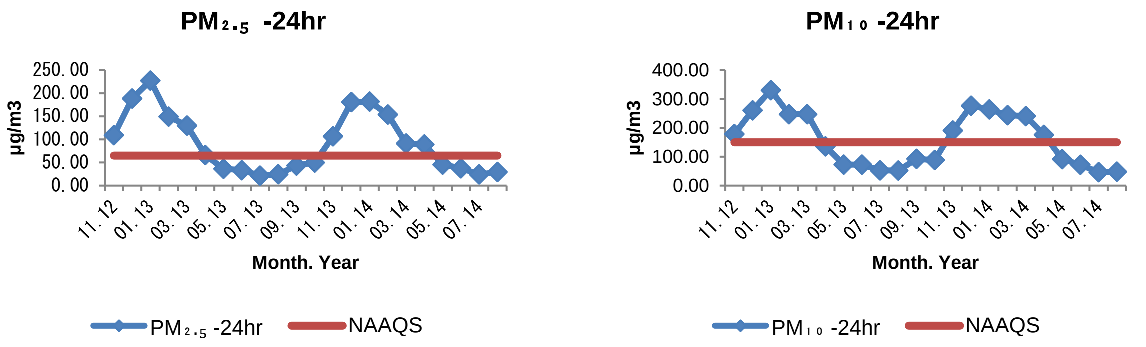
Air Pllutants	Unit	Measurement Time	Standards	WHO Guidelines
CO	mg/m^3	8 hours(a)	10 (9 ppm)	10
	mg/m^3	1 hour(a)	40 (35 ppm)	30
Pb	$\mu g/m^3$	Annual	0.5	0.5
NO_x	$\mu g/m^3$	Annual	100 (0.053 ppm)	40 (as NO_2)
PM_{10}	$\mu g/m^3$	Annual (b)	50	20
	$\mu g/m^3$	24 hours (c)	150	50
$PM_{2.5}$	$\mu g/m^3$	Annual	15	10
	$\mu g/m^3$	24 hours	65	25
O_3	$\mu g/m^3$	1 hour (d)	235 (0.12 ppm)	-
	$\mu g/m^3$	8 hours	157 (0.08 ppm)	100
SO_2	$\mu g/m^3$	Annual	80 (0.03 ppm)	-
	$\mu g/m^3$	24 hours (a)	365 (0.14 ppm)	20

Source: Statutory Rules and Order No. 220、 GOB (2005); Air Quality Guidelines for Europe、 2nd ed.、 WHO (2005);.and Air Quality Guidelines for Particulate Matter、 Ozone、 Nitrogen Dioxide and Sulfur Dioxide、 WHO (2006).

Figure 5.2.5 shows concentrations of the air pollutants on the vicinity of the project site by Clean Air and Sustainable Environment Project. The concentrations of the air pollutants change seasonally. The concentration rises during the dry season (December to February) and declines during the rainy season (May to September). Particularly the concentration of PM is high.







Source: The Project on the Revision and Updating of the Strategic Transport Plan for Dhaka, 2nd Draft Final Report, February 2016, JICA

Figure 5.2.5 Concentrations of Air Pollutants measured on November 2012 to August 2014（Darus-Salam）

2) Noise

Noise level is high in Dhaka city. This is a major issue for citizens. In most area of the city noise level exceeds standards. Table 5.2.2 shows the noise standard of Bangladesh and WHO Guidelines.

Table 5.2.2 Noise Standard of Bangladesh and WHO Guidelines

Category of Area	Noise Standard of Bangladesh *1 (LAeq: dBA)		Guidelines of Community Noise (WHO, 1999)	
	Daytime (6:00-21:00)	Night (21:00-6:00)	Daytime (7:00-22:00)	Night (22:00-2:00)
Silent zone	45	35	-	-
Residential area	50	40	55	45
Mixed area	60	50	-	-
Commercial area	70	60	70	70
Industrial area	75	70	70	70

Source: Study Team

Note: 1)noise standards of ECR, 1997

Table 5.2.3 shows noise levels which were measured around the project site. Totally the noise levels are high. Particularly in areas except residential area high noise exceeding 80dB(A) were observed. The high noise is originated by horn of vehicles, demonstration parade and audio player.

Table 5.2.3 Noise Levels around the Project Site

Locations		Noise Level (dBA)
Gabtuli	Vicinity of Gabutli Station	102
Mirpur-1	Vicinity of Mirpur-1	97
Mirpur-10	Vicinity of Mirpur-10 Station	86
Gulshan Residential Area	Vicinity of Gulshan2 Station	70
Banani and Baridhara Residential Area	Vicinity of Banani Station	68

Source: Dey, A. R., N. Kabir and D. Efroymson, 2010, Noise Pollution in Dhaka: Current Situation and Suggestions for Action.

3) Water Quality

There are lots of rivers, canals and wetlands which contribute formation of water environment. On the other hand, recent rapid increase of population makes water pollution severe.

Table 5.2.4 shows results of water quality survey around the project area and standards of water quality of Bangladesh. No.2 and No.3 which are small river and drainage in urban area are highly polluted.

Table 5.2.4 Results of water quality survey around the project site (2010)

No.	Location	Date	pH	Dissolved Oxygen (DO) ppm	Chemical Oxygen Demand (COD) ppm	Total Suspended Solid (TSS) g/l	Total Coliform number/100ml
1	Pond in Northern Pallabi	2 Oct.	7.5	5.8	45.6	288	500,000
2	Mirpur Khal	2 Oct.	7.3	0.6	164.0	636.4	500,000
3	Begunbari Drain	2 Oct.	7.6	1.4	141.6	502.1	1,100,000
1	Pond in Northern Pallabi	12 Dec.	7.6	7.2	64	149	1,000
2	Mirpur Khal	12 Dec.	7.7	Under DL*	480	392	910,000
3	Begunbari Drain	12 Dec.	7.7	Under DL*	448	367	960,000
Bangladesh Standard for Inland Surface Water Quality (Water usable by various process)			6.5-8.5	5 or more	Not yet set	Not yet set	5,000 or less

*: Detection Limit

Source: Preparatory Survey on Dhaka Urban Transport Network Development Project – Phase II

4) Ground Water

Bangladesh had used surface water including lake and river and drinking water. However, because water pollution created difficulty to utilize, utilization of groundwater has been developed since 1970. Meanwhile, arsenic pollution for groundwater has become a serial problem since 1990. A cause of the pollution still has not been clear. Now 270 districts are arsenic contaminated areas. Approximately 30 million persons has been affected by arsenic contaminated water.

GOB has taken emergency measures for arsenic mitigation, and adopted National Policy for Arsenic Mitigation and the implementation plan in 2004. However, since alternative water sources are limited safety supply of drinking water is still significant issues. There are lot of unresolved issues including care for arsenic poisoning and negative impacts to foods.

There are no standards of underground water quality in Bangladesh.

5.2.10 Basic Information on Social Economy

1) Population and Social Economy

Though issues are arisen due to so many population in Bangladesh (according to the World Development Index of World Bank it is reported that the census shows 142.5 million in 2011 and expected to increase 156.6 million in 2015), the country is persisting a development which aims at building a prosperity and pluralistic society. According to WB, though the income per capita is 1,096 UDS (actual achievement in 2014), however, annual economic growth rate is more than 6% in a past decade and Gross Domestic Product (GDP) has achieved 195.1 billion USD (reported by WB in 2015). Considering it was 65.1 billion USD in 2004, it has rapidly grown up four times in a decade.

The prime of economic development is export industry. Specially, export of texture is ranked second, subsequently to China. The break down presents 21.6 billion USD owed to the production of knitwear and ready-made clothes which occupies 80% of total export amount. Other industries are pharmaceutical, shipbuilding, chinaware, leather goods and home electric appliances. In addition, Bangladesh has extremely fertile soil in terms of the primary industry, and rice, jute, tea, cotton and sugar cane are cultivated as cash crop. The fishery and marine products is ranked fifth in the world. Last, overseas remittances by migrant workers are brought up 14 billion USD (actual achievement in 2014). Economic share by sectors are agriculture: 16%, industry: 28% and services: 56% (WB's report in 2013), respectively.

The GDA which includes target area of the Study is the most developed area and its Gross Regional Domestic Product (GRDP) is approximately 25% of GDP. From sector point of view, the weight of agriculture is decreasing however industry is increasing. Furthermore, from census point of view, population in GDA is 23,459,577 which occupy 16.29% of Bangladesh.

Table 5.2.5 District Based Population and Area

District	Area（km^2）	Population		Annual Average growth rate
		2001	2011	
Dhaka	1,463.6	9,036,647	12,043,977	2.91%
Gazipur	1,806.4	2,143,200	3,403,912	4.73%
Mnikganj	1,383.7	1,343,749	1,392,867	0.35%
Mushiganj	1,004.3	1,353,483	1,445,660	0.66%
Narayanganj	684.4	2,300,514	2,948,217	2.51%
Narsingdi	1,150.1	1,983,449	2,224,944	1.15%
Total	7,492.5	18,161,042	23,459,577	2.59%

Source: Census（2011）、Area:STATISTICAL YEAR BOOK BANGLADESH 2015

As described above, in GDA it is assumed that the population is 23.48 million in 2011 will increase 32.59 million in 2025. Rapid increase makes Dhaka disordered and high-density city which is one of the fragile against disaster due to low quality buildings. In addition, influx from rural district to urban area is in progress which increase low income (6,000 taka per year) group, expansion of slum area, traffic congestion, insufficient power supply and expansion of environmental pollution.

The present urban transport significantly depends on traffic transport. Traffic volume exceeds its capacity and severe traffic congestion arises because the various kinds of transportation system are running together such as, automobile, bus, rickshaw etc. Accordingly, many problems such as, increase of trip hour, deterioration of transport efficiency, increase of traffic accidents, increase of fuel consumption and public nuisance by air pollution/health hazard are arisen.

Poverty rate shows those who are living under poverty line against whole population. According to Bangladesh Bureau of Statistic in 2011, poverty rate was 31.5% which consist of 35.2% in rural district and 21.3% in urban. On the other hand, poverty rate in 2005 was 40.0% which consist of 43.8% in rural district and 28.4% in urban. That is to say between 2005 and 2015, poverty rate decreased 8.5% in Bangladesh which consist of 8.6% in rural and 7.1% in urban. Considering the poverty rate was 56.7% between 1991 to 1992, it decreased 25.2% in the past decade.

Table 5.2.6 GRDA in GDA

	Nominal GRDP (million USD)						Average Annual Growth Rate	
	1995		1999		2005		1995-1999	1999-2005
	million USD	Percent (%)	million USD	Percent (%)	million USD	Percent (%)	AAGR (%)	AAGR (%)
Bangladesh	39,065	100.0	45,447	100.0	59,748	100.0	3.1	5.6
GDA	9,206	23.6	10,762	23.7	15,004	25.1	3.2	6.9
Dhaka	5,714	14.6	6,742	14.8	9,497	15.9	3.4	7.1
Gazipur	1,132	2.9	1,309	2.9	1,850	3.1	2.9	7.2
Manikganji	342	0.9	401	0.9	503	0.8	3.2	4.6
Munshiganji	325	0.8	372	0.8	465	0.8	2.7	4.6
Narayanganji	1,097	2.8	1,246	2.7	1,751	2.9	2.6	7.0
Narsinghdi	596	1.5	692	1.5	938	1.6	3.0	6.3

Source: Growth, Income Inequality and Poverty Trends in Bangladesh: Implications for Development Strategy by Center for Policy Dialogue (CPD)

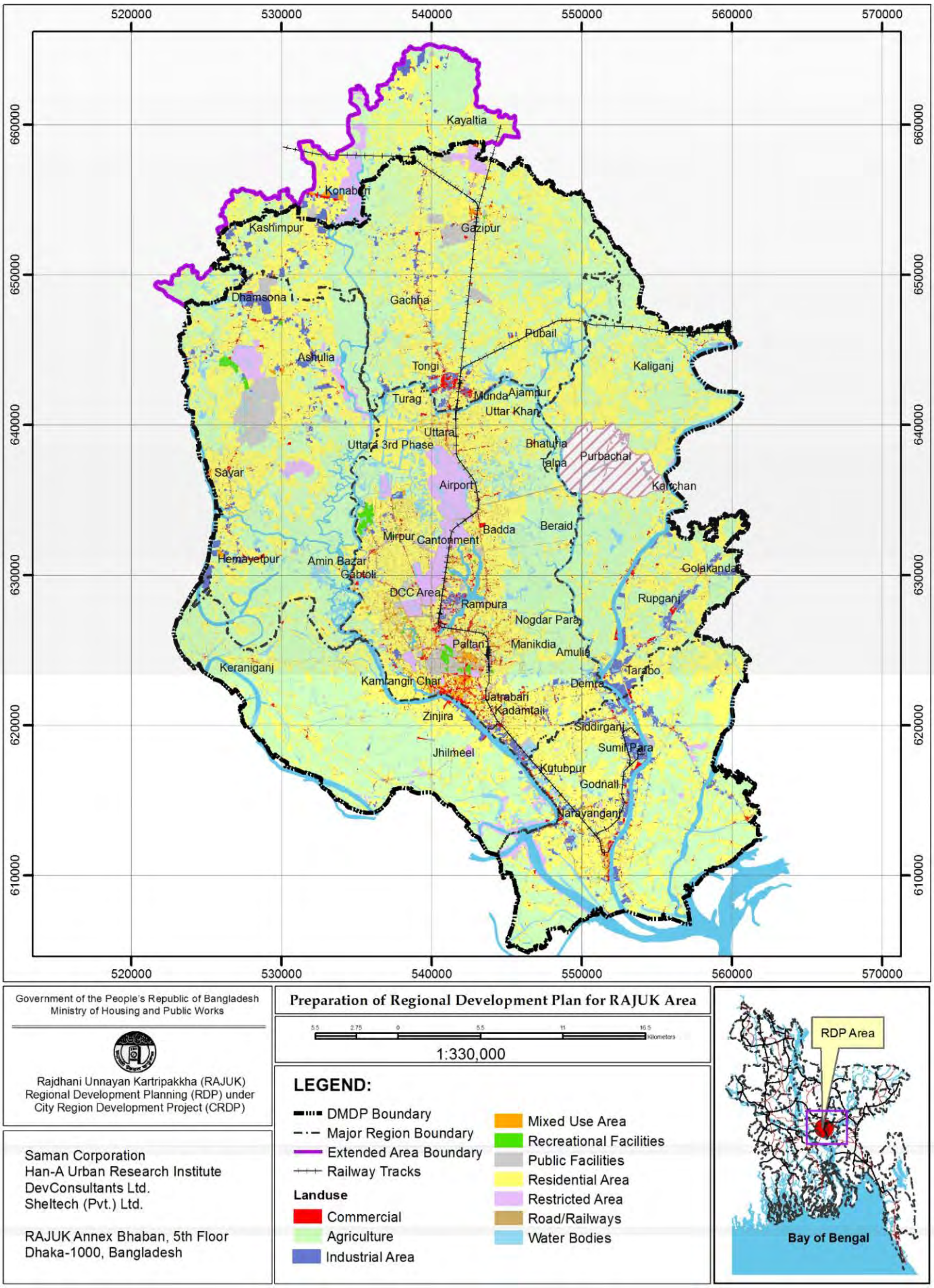
According to Rushidan I. Rahman and Rizwanul Islam (2013), Female labour force participation in Bangladesh: trends, drivers and barriers, ILO Asia-Pacific Working Paper Series, thanks to the economic development female participation rate in urban was 20.5% in 1995/96, then increased 27.4% in 2005/06 and 34.5% in 2010/11. Female participation rate in Dhaka was 36.4% in 2010/11. In this country, there had been a custom called Purda which requires female group “to stay within home and do not go to work outside home”, however, because of increase of female participation and extension of educational opportunity, this custom has changed in urban especially, and liberalization of movement of female is expected to increase more in future.

The detail on female participation will be studied at project area, however, according to the site reconnaissance and opinion by executing agency, the trend will basically be same as in whole country.

2) Land-use

In the jurisdiction of RAJUK, the land-use has changed related to the progress of urbanization of Dhaka. Especially, the 209,969 hectare of water body in 1967 decreased 5,520 hectare, approximately one fourth of year 2010. These conversions were happened due to the absence of land-use management, incomplete urban planning which cause the expansion of urban poor and flood disaster. Same urbanization is extending to the north: Savar Ashulia and Uttra, specifically.

RAJUK is divided in Dhaka Central, North, East, West, South and South-West areas and out of 152,000 hectare North occupy 23%, Dhaka Central occupy 20% and West occupy 17%. From land-use point of view, agricultural land is 40% and extended to North and West. Residential land is second rank which occupy 37% and extended to Dhaka central and North. Commercial land and mixed land-use have same tendency like residential land. On the other hand, many Industry lands are situated in North and South. The land-use map under jurisdiction of RAJUK is attached in Figure 5.2.6.



Source: Regional Development Planning (RDP) Survey Report (RAJUK, 2014)

Figure 5.2.6 Land-use Map Prepared by RAJUK

3) Assumed Land Acquisition and Resettlement

Land acquisition and Resettlement on MRT Line 5 are assumed in Table 5.2.7.

Table 5.2.7 Assumed Land Acquisition and Resettlement

MRT	Elevated・Tunnel Section	Station	Depot	Access to Depot	Construc-tion Yard
Line 5	Elevated section : Structure of metro will be built within the ROW which belong to Road and Highway Department (RHD). Therefore, further land acquisition will not be required.	Land acquisition on private land and resettlement related to the station and ancillary facilities are assumed as follows. Land acquisition: 1.57 hectare Resettlement: 1,107 households	Some are private land and others are waste land. RAJUK own some land. Land acquisition: 21.99 hectare Resettlement: Nil (however, approximately sixty local families are engaged in cultivation)	Assumed Land acquisition: Included in Depot Assumed resettlement: Two HHs	Review on proposed site and size are on-going.

Source: JICA Study Team

5.2.11 Environmental Conditions of the Project Site

MRT Line5 connects east-west corridor in Dhaka city. Total length is 19.7km. The section between Amin Bazar Station and Hemayetpur Station goes under the existing roads. A part of the sections between Gobtoli station and Dar-Us-Salam station and the section between Kochunkhet station and Banani station is out of the existing ROW. There is no facility which is source of pollution such as factories within the ROW.

Source: JICA Study Team prepared based on Google Maps

Figure 5.2.7 Route of MRT Line5

The section of Hemayetpur station and Amin Bazar station goes within the ROW of Dhaka-Aricha Highway. The vicinity is wetlands, lakes, agricultural lands where brick factories scatter. A depot site is planned on the north of Hemayetpur station. The vicinity is mixed areas of wetlands, agricultural lands. (see Figure 5.2.8)

Source: JICA Study Team

Figure 5.2.8 Section between Hemayetpur station and Modhunmati station

Source: JICA Study Team

Figure 5.2.9 Surrounding of Depot Site of Line 5

The section of Amin Bazar station and Notun Bazar station is located in the centre of Dhaka city. The area where Gabtoli station (see Figure 5.2.10) is located has a bus terminal, and much congested by arrival and departure of buses. The section between here and Mirpur-1 station goes under Principal Abul Kashem Road. The vicinity is mainly occupied by medium high-rise housing. (see Figure 5.2.11)

Source: JICA Study Team

Figure 5.2.10 Surroundings of Gabtoli Station

Source: JICA Study Team

Figure 5.2.11 Surroundings of Dar-Us-Salam Station

The section between Mirpur-1 station (see Figure 5.2.12) and Kochunkhet station goes under Mirpur Road. There are lot of educational facilities in Mirpur area. The intersection of Mirpur Road where Mirpur 10 station is located and Begum Rokeya Avenue is extremely congested. The section between Kochunkhet station and Banani station (see Figure 5.2.13) goes under restricted area (cantonment) out of the existing roads. The east of Banani station is a business district where high rise office buildings, hotels, commercial facilities stand. Guldhan -Baridhara Lake and Banani Lake which are located on the alignment are designated to ECA. The alignment connects to MRT Line1 at Notun Bazar station (see Figure 5.2.14)

Source: JICA Study Team

Figure 5.2.12 Surroundings of Mirpur1 Station

Source: JICA Study Team

Figure 5.2.13 Surroundings of Banani Station

The vicinity between Notun Bazar station and Vatara station (see Figure 5.2.15) which is the east end point is an area where low medium-rise shops stand.

Source: JICA Study Team

Figure 5.2.14 Surroundings of Notun Bazar Station

Source: JICA Study Team

Figure 5.2.15 Surroundings of Vatara Station

5.3 Legal and Institutional Framework Regarding Environmental Consideration

5.3.1 Legal Framework

1) Relevant Laws on Environmental Protection

Table 5.3.1 shows major environmental laws and legislations of Bangladesh.

Table 5.3.1 Relevant Laws on the Environment

Law, Policy	Outlines
Environmental Policy 1992	Basic policy of the environment in Bangladesh. The policy is formed by environmental policy, legal framework in 15 sectors. This policy shows a basis of EIA implementation.
Environmental Action Plan	It was established in 1992. The plan shows a tangible action plan of Environmental Policy 1992, and designates relevant agencies. The publication of white paper on the environment is stipulated on this plan.
National Environment	It was established in assistance with UNEP in 1995. Purposes of the plan are: understanding of

Management Action Plan	important environmental issues relevant to Bangladesh, mitigation of environmental deterioration, protection of biodiversity, promotion of sustainable development and action of improving life quality. Not only government agencies NPO and residents proceeded the formulation of the plan.
Bangladesh Environment Conservation Act	It was established by Ministry of Environment and Forests in 1995 as substitute of Environment Preservation Act. The act covers fundamental domains of environmental preservation.
The Environmental Conservation Rules	The rule stipulates the environmental standards including air quality, water quality, industrial waste water, exhaust gas, noise and odor. Submission of project plan, EIA, and environmental management plan is stipulated in the rule.
Environmental Court Law	It was established in 2000. The law stipulates a legal procedure on pollution.

Source: METI, MRI (2012)

2) Policy on Climate Change

Bangladesh is one of vulnerable areas on flood. Rise of sea level caused by climate change becomes factor that expands flood damage. Moreover, the increase of drought and cyclone may become significant issues on social and economic activities in Bangladesh.

Bangladesh is a party of United Nations Framework Convention on Climate Change (UNFCC). Under the framework of UNFCC, Bangladesh formulated Bangladesh Climate Change Strategy and Action Plan. The action plan which consists of 6 items builds adaptation and durability against climate change aiming action during 10 years (2009-2018).

- Security of food, social security and health control
- Comprehensive disaster control
- Fundamental facility management
- Study relevant to climate change, and improvement of knowledge
- Mitigation of GHG emission, and low carbon development
- Capacity building, expansion of relevant facilities

As tackling reduction of greenhouse gasses, GOB signed Joint Crediting Mechanism (JCM) which is a promoting mechanism of low carbon technique by Japan in 2013. Under the mechanism, Bangladesh is introducing energy saving and technique and renewable energy technique of Japan.

In Intended Nationally Determined Contributions, GOB is aiming to 20% reduction of GHG emission of energy, traffic and industrial sectors by 2030. Since the MRT Line1 and Line5 projects will reduce the emission of GHG by modal shift from vehicles to railway, the projects contribute the policy of climate change of Bangladesh.

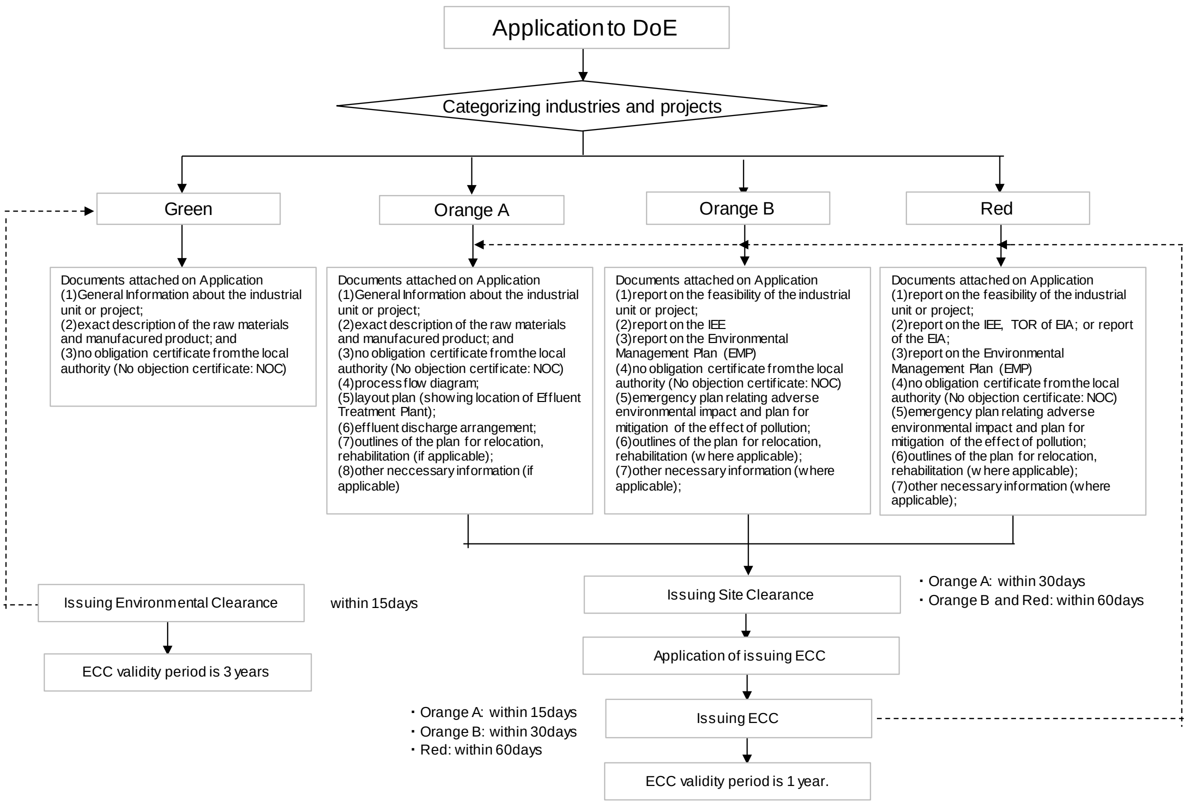
5.3.2 Institution of EIA

Bangladesh stipulates EIA system on the Environmental Conservation Act (ECA: 1995) and Environmental Conservation Rules (ECR: 1997). GOB has promoted a lot of industrial policy to solve poverty and employment issues. However, developments without an environmental consideration caused deterioration of the environment. Under this lesson, the said legislations were established for the purpose of environmental conservation.

5.3.3 EIA Procedure

Implementation of whole industries and projects needs Environmental Clearance Certificate (ECC) issued by DoE. (ECA, Section12) Industries, activities and projects are categorized Green, Orange A, Orange B and Red with magnitudes of negative impacts and location, and needs procedure along each activity. Projects categorized Green are small scale and environmentally insignificant. Orange A, Orange B and Red categories include large and environmentally significant project. Red projects are the most environmentally significant project.

Green and Orange A projects require submission of summary report of the project and approval of local government. Orange B and Red projects require Initial Environmental Examination (IEE) and Environmental Management Plan (EMP) in addition to above.



Source: Environmental Profile of Bangladesh (11,2016, Japan Bank International Cooperation)

Figure 5.3.1 Flow of ECC acquisition

5.3.4 EIA Projects and Report

Red category projects require EIA. The Red projects are shown on Table 5.3.2.

Table 5.3.2 Red Category Projects

1. Leather processing (tannery)	26. Asbestos	51. Hospitals
2. Formaldehyde	27. Fibreglass	52. Ship manufacturing
3. Urea fertiliser	28. Pesticides, fungicides and herbicides	53. Tobacco (processing/cigarette/bin-making)
4. T.S.P. fertiliser	29. Phosphorus and its compounds/derivatives	54. Metallic boat manufacturing
5. Chemical dyes, polishes, varnishes and enamels	30. Chlorine, fluorine, bromine, iodine and their compounds/derivatives	55. Wooden boat manufacturing
6. Power plants	31. Industrial gases (excluding nitrogen, oxygen and carbon dioxide)	56. Refrigerator, air conditioner/air cooler manufacturing
7. All mining projects (coal, limestone, hard rock, natural gas, mineral oil, etc.)	32. Waste incinerators	57. Tyres and tubes
8. Cement	33. Other chemicals	58. Board mills
9. Fuels (oil refineries)	34. Ordinance factory	59. Carpets
10. Artificial rubber		60. Engineering works (capital above 10 hundred thousand
11. Paper and pulp		

12. Sugar 13. Distillery 14. Fabric dyeing and chemical processing 15. Caustic soda, potash 16. Other alkalis 17. Iron and steel manufacturing 18. Raw materials for medicine and basic drugs 19. Electroplating 20. Photo films, photo paper and photo chemicals 21. Chemicals derived from petroleum or coal 22. Explosives 23. Acids and their salts (organic and inorganic) 24. Nitrogen compounds (cyanide, cyanamide, etc.) 25. Production of plastic raw materials (PVC, PP/iron, polystyrene, etc.)	35. Nuclear power 36. Alcoholic beverages 37. Non-metallic chemicals not listed elsewhere 38. Non-metals not listed elsewhere 39. Industrial estate 40. Basic industrial chemicals 41. Non-iron basic metals 42. Detergent 43. Landfilling by household/industrial/commercial waste 44. Sewage treatment plants 45. Lifesaving drugs 46. Animal glue 47. Rodenticide 48. Refractories 49. Industrial gas (nitrogen, oxygen, carbon dioxide) 50. Batteries	taka) 61. Repairing of motor vehicles (capital above 10 hundred thousand taka) 62. Water treatment plants 63. Laying down/replacement/expansion of sewerage pipelines 64. Laying down/replacement/expansion of water, power and gas distribution lines 65.Exploration/extraction/distribution of mineral resources 66.Construction/reconstruction/expansion of flood control embankment, polder, dike, etc. 67.Construction/reconstruction/expansion of roads (regional, national and international) 68.Construction/reconstruction/expansion of bridge (length 200 m or more) 69. Muriate of potash (manufacturing

Source: Schedule-I, Rule7(2) of Environment Conservation Rules 1997

In infrastructure projects, construction of flood control embankment, polder, road and bridge (length is 200m and more than). Although a railway project is not included in the table, MRT Line1 and Line5 projects fall into Red category because the project has viaduct which length is more than 200m.

Project proponents submit required documents to a Division Office of DoE. The red category projects are required the following documents.

(1) Feasibility study of the project

(2) IEE, TOR of EIA, flow of EIA and EIA report

(3) EMP report

(4) No objection certificate of local governments

(5) Emergency plan against significant negative impacts, and mitigation plan

(6) Outlines of involuntary resettlement and rehabilitation plan

(7) Others

5.3.5 Stakeholder Meetings and Disclosure of Information

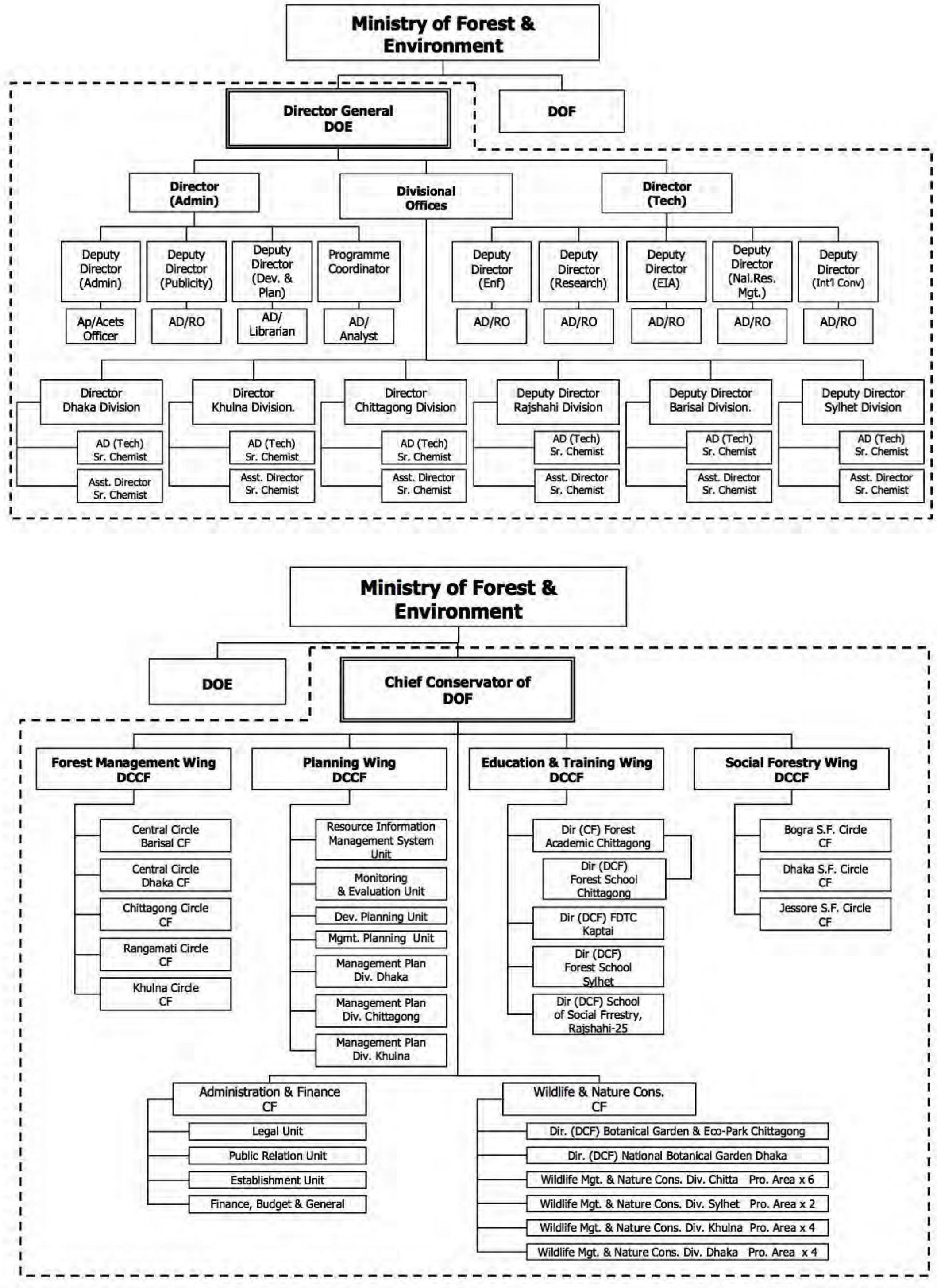
The matters of stakeholder meetings and disclosure of information have not been described in relevant legislations. These should be coordinated to JICA Guidelines.

5.3.6 Relevant Authorities of EIA

DoE completely involves the process to ECC issue. Project proponents requires to acquire No-objection certificate (NOC) of local governments and submit with an ECC application.

An ECC application is submitted to a Division Office of DoE who is responsible for the project location. After receiving the application, the Division Office appraises the application. As needed, central office of DoE can appraise.

Environmental administration in Bangladesh is handled by DoE and Department of Forest (DoF) under MoEF. DoE mainly handles the procedure of EIA: MoF handles forest reservation and biodiversity.



Source: Profile on Environmental and Social Considerations in Bangladesh (July 2012, JICA)

Figure 5.3.2 Organogram of DOE and DOF

5.3.7 Comparison of JICA Guidelines and EIA System of Bangladesh

Table 5.3.3 shows the comparison of policies of JICA Guidelines and EIA system of Bangladesh, gaps and policies of gap filling.

Table 5.3.3 Comparison of JICA Guidelines and EIA System of Bangladesh

	Policies of JICA Guidelines	EIA System of Bangladesh	Policies of Gap Filing
Basic Matters	Environmental impacts that may be caused by projects must be assessed and examined in the earliest possible planning stage. Alternatives or mitigation measures to avoid or minimize adverse impacts must be examined and incorporated into the project plan. (JICA Guidelines Appendix1 1.1)	Regarding selection of project site, comparison of alternatives is recommended. (EIA Guidelines for Industries, DoE, 1997)	Institution of Bangladesh does not obligate the comparison of alternatives. Based on the policy of JICA Guidelines, alternatives and mitigation measures that minimize negative impacts are examined and reflect to the project.
Disclosure	EIA reports must be written in the official language or in a language widely used in the country in which the project is to be implemented. When explaining projects to local residents, written materials must be provided in a language and form understandable to them; EIA reports are required to be made available to the local residents of the country in which the project is o be implemented. The EIA reports are required to be available at all times for perpetual by project stakeholders such as local residents and copying must be permitted. (JICA Guidelines Appendix1, 2)	There is no description on written language of EIA report. There is no description of disclosure of EIA report.	Explanation is done by language which is available to local persons (Bengal). That the EIA report is available at all times is proposed to the counter parts.
Social Acceptability	For projects with a potentially large environmental impact, sufficient consultations with local stakeholders, such as local residents, must be conducted via disclosure of information at an early stage, at which time alternatives for project plans may be examined. The outcome of such consultations must be incorporated into the contents of the project plans. (JICA Guidelines, Appendix1. 5.Social acceptability) In preparing EIA reports, consultations with stakeholders, such as local residents, must take place after sufficient information has been disclosed. Consultations with relevant stakeholders, such as local residents, should take place if necessary throughout the preparation and implementation stages of a project. Holding consultations is highly desirable, especially when the items to be considered in the EIA are being selected, and when the draft report is being prepared. (JICA Guidelines, Appendix 2) Multiple alternatives must be examined in order to avoid or minimize adverse impacts and to choose better project options in terms of environmental and social considerations.	There is no description about public participation on the EIA system in Bangladesh.	On the explanation before the EIA survey, draft scoping and DFR stage, stakeholder meetings are held. Result of the meetings are incorporated in EIA report.

Items of Impact Assessment	The impacts to be assessed with regard to environmental and social considerations include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, including trans-boundary or global scale impacts. These also include social impacts, including migration of population and involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor and indigenous peoples, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety. (JICA Guidelines, Appendix 1, Scope of Impacts to Be Assessed)	There is no tangible description of survey items in the EIA report. DoE presents TOR to each project. Based on the TOR, EIA study is conducted.	Based on the survey items on JICA Guidelines, scoping is conducted and survey items are decided.
	In addition to the direct and immediate impacts of projects, their derivative, secondary, and cumulative impacts as well as the impacts of projects that are indivisible from the project are also to be examined and assessed to a reasonable extent. It is also desirable that the impacts that can occur at any time throughout the project cycle should be considered throughout the life cycle of the project.	In the EIA system of Bangladesh, there is no description about derivative, secondary, and cumulative impacts.	As needed, derivative, secondary, and cumulative impacts with other projects are examined.
Monitoring / Grievance Redress Mechanism	Project proponents etc. should make efforts to make the results of the monitoring process available to local project stakeholders. (JICA Guidelines, Appendix 1, Monitoring 3) When third parties point out, in concrete terms, that environmental and social considerations are not being fully undertaken, forums for discussion and examination of countermeasures are established based on sufficient information disclosure, including stakeholders' participation in relevant projects. Project proponents etc. should make efforts to reach an agreement on procedures to be adopted with a view to resolving problems. (JICA Guidelines, Appendix 1, Monitoring 4)	On ECC acquisition, EMP report is required. However, there are no obligation of report and no penalty for violation.	There is no description about monitoring. On the EIA study, environmental management plan is formulated, and implementation of monitoring is proposed and agreed with the counterpart.
Ecosystem and Biota	Projects must not involve significant conversion or significant degradation of critical natural habitats and critical forests.	In Bangladesh, significant habitats are protected as reserves and activities in the reserves are restricted.	There may be no wild habitat in / around the project site.
Indigenous Peoples	Any adverse impacts that a project may have on indigenous peoples are to be avoided when feasible by exploring all viable alternatives. When, after such an examination, avoidance is proved unfeasible, effective measures must be taken to minimize impacts and to compensate indigenous peoples for their losses.	There is no ordinance on indigenous people.	In case that affected indigenous people are confirmed in this survey, effective measurements for protection of the indigenous people are examined in RAP study.

Source: JICA Study team

5.4 Comparisons on Alternatives

5.4.1 Comparisons of public transportation projects on RSTP

The RSTP proposed traffic development policy in the view of future of Dhaka. One of the traffic policy is strength of public transportation including 5 MRTs and 2 BRTs. And based on results of demand forecast and conformity with urban development, MRT Line1 and Line5 were recommended as prioritised projects.

For these public transportation projects, in the view of the environmental and social considerations, comparisons of IEE level were examined based on a strategic environment assessment. (see Table 5.4.1)

MRT Line5 may cause negative impacts to swamp in the east expansion section, however has less impacts next to MRT Line1. Therefore MRT Line5 was selected as a priority project. (Since the original route of Line5 was revised, the east extension section which affects low swamp is not included in the project.)

Table 5.4.1 Comparisons of public transportation projects on RSTP

<table>
<tr><th>Impact Items</th><th colspan="2">MRT Line1</th><th>MRT Line 2</th><th>MRT Line 4</th><th colspan="2">MRT Line 5</th><th>BRT Line 7</th></tr>
<tr><td>Social Environment</td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td>Land acquisition and Involuntary Resettlement</td><td colspan="2">[All Elevated]
In order to pass over Kuril Flyover and Moghbazar - Mouchak Link Flyover with elevated structure, a massive resettlement of affected persons due to additional ROW acquisition will be unavoidable.

[Partial Underground]
The tracks go partially underground in Kuril area and from Maribag to Kamulapur BR station and further Buriganga River.</td><td>[All Elevated]
The route goes the narrow existing roads from Gabtali to Dhaka University. A large number of structures might be affected. The existing highway in Western Fringe area can accommodate the viaduct.</td><td>[All Elevated]
The elevated structure will be built within the BR ROW. There are hundreds of informal settlers and illegal vendors in BR ROW. If the BR line will be double tracked, there might be no more informal settlers.</td><td colspan="2">[All Elevated]
The line 5 covers the center portion of Dhaka, congested area. Thus a large number of affected structures are expected. Eastern Fringe Area is not heavily populated.

[Partial Underground]
The tracks go partially underground at the section from Kachukhet to Notun Bazar (under cantonment), and from Dhanmondi to Bashundahara City.</td><td>[At Grade]
Since there is no existing roads. The 60m width of ROW acquisition will be needed.</td></tr>
<tr><td rowspan="2">Number of Affected Households</td><td>Elevated</td><td>Underground</td><td rowspan="2">1,100</td><td rowspan="2">500</td><td>Elevated</td><td>Underground</td><td rowspan="2">1,000</td></tr>
<tr><td>500</td><td>100</td><td>620</td><td>120</td></tr>
<tr><td rowspan="2">Number of Affected Persons*1</td><td>Elevated</td><td>Underground</td><td rowspan="2">5,500</td><td rowspan="2">2,500</td><td>Elevated</td><td>Underground</td><td rowspan="2">5,000</td></tr>
<tr><td>2,500</td><td>500</td><td>3,100</td><td>600</td></tr>
<tr><td>Natural Environment</td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td>Protected Area</td><td colspan="2">The line will not go through any protected area.</td><td>The line will not go through any protected area.</td><td>The line will not go through any protected area.</td><td colspan="2">The line will not go through any protected area.</td><td>The line will not go through any protected area.</td></tr>
<tr><td>Biodiversity (wetland)</td><td colspan="2">Because the line will go through the existing road and BR ROW in the built-up area, wetlands will not be directly affected. There are some small swamps along the track around Tongi to Gazipur and Purbachar areas.</td><td>The line will go through the existing road in the built-up area from Gabtali to Kamalapur. From Gabtali to Hemayetpur the highway is surrounded by wetland. The wetland might be affected during construction.</td><td>The line will go through the existing BR ROW in the built-up area. There will be no impacts on wetlands.</td><td colspan="2">Because the line will go through the existing road in the built-up area, there will be no direct impacts on wetlands. The route will extend to the Eastern Fringe area, therefore, wetland and agricultural land will be reclaimed.</td><td>Since the route will go through the wetland and agricultural land in Eastern Fringe area, a significant impact on biodiversity will be expected.</td></tr>
<tr><td>Flood Risk</td><td colspan="2">The line will go through the existing road. The risk of flooding is low.</td><td>The line will pass through the flood flow zone in the western side of Dhaka city. There will</td><td>The line will go through the existing BR ROW. The risk</td><td colspan="2">The route will extend to the Eastern Fringe water retention area. There will be a high risk of</td><td>Since the route will go through the flood flow zone and</td></tr>
</table>

Impact Items	MRT Line1	MRT Line 2	MRT Line 4	MRT Line 5	BRT Line 7
		be a high risk of inundation.	of flooding is very low.	inundation.	water retention area in Eastern Fringe, there will be a high risk of flooding.
Pollution Control					
Noise and vibration	Because the line will go through the existing road and BR ROW in the built-up area, mitigation measures to abate the noise and vibration levels should be considered especially for sensitive receptors at the elevated section.	The line will go through the existing road in the built-up area of Dhaka CBD and Savar, mitigation measures to abate the noise and vibration levels should be considered especially for sensitive receptors.	Because the line will go through the BR ROW in the built-up area, the mitigation measures to abate the noise and vibration levels should be considered especially for sensitive receptors.	The line will go through the existing road in the built-up area, mitigation measures to abate the noise and vibration levels should be considered especially for sensitive receptors at the elevated section. There might be lesser impacts in the Eastern Fringe area.	There are a few communities in the Eastern Fringe area. Noise and vibration will not cause a significant impact.
Air Pollution	Because the line will go through the built-up area, dust generated during construction will cause a nuisance along the route, especially for residential areas.	The line will go through the built-up area of Dhaka CBD and Savar, dust generated during construction will cause a nuisance along the route, especially for residential areas.	Because the line will go through the BR ROW in the built-up area, dust generated during construction will cause a nuisance along the route, especially for residential areas.	The line will go through the built-up area dust generated during construction will cause a nuisance along the route, especially for residential areas. There might be fewer impacts in the Eastern Fringe area.	There are a few communities in the Eastern Fringe area generated during construction will not cause a significant impact.
Water pollution	Since the route will not pass though the wetland, turbid water will not directly deteriorate water quality of the wetland.	Water quality of wetland will be likely to be deteriorated by suspended solids discharged from construction sites.	Since the route will not pass though the wetland, turbid water will not directly deteriorate water quality of the wetland.	Water quality of wetland in the Eastern Fringe area will be likely to be deteriorated by suspended solids discharged from construction sites.	Water quality of wetland in the Eastern Fringe area will be likely to be deteriorated by suspended solids discharged from construction sites.
Overall Assessment	O: The lowest number of affected households both all elevated case and partial underground case O: Less impact on protected area and biodiversity O: Low risk of flooding X: Impact due to noise and vibration at the elevated section. The smallest number of affected households and fewer impacts on natural environment.	X: The largest number of affected households X: Impact on biodiversity in the wetland X:Risk of flooding X:Impact due to noise and vibration The largest number of affected households and moderate impacts on natural environment. The BRT should be considered for the short to midterm term plan in CBD.	△: A large number of informal settlers occupy the BR ROW. O: Less impact on protected area and biodiversity O: Low risk of flooding X: Impact due to noise and vibration A large number of informal	O: The second lowest number of affected households in the partial underground case. X: Impact on biodiversity in the wetland X:Risk of flooding X:Impact due to noise and vibration The second lowest number of affected households. The extension to the Eastern Fringe will cause a significant impact on natural environment and increase the risk of	X: The second largest number of affected households X: Impact on biodiversity in the wetland X:Risk of flooding O:Impact due to noise and vibration The large number of affected households. A

Impact Items	MRT Line1	MRT Line 2	MRT Line 4	MRT Line 5	BRT Line 7
	Recommended as a priority project from the viewpoints of environmental and social considerations.		settlers occupy the BR ROW. If the BR line will be double tracked, then the plan has to be reconsidered. Fewer impacts on natural environment.	flooding.	significant impact on natural environment. The risk of flooding is very high. The eastern fringe road should be carefully planned to minimize the environmental impacts.

Source: The Project on the Revision and Updating of the Strategic Transport Plan for Dhaka, 2nd Draft Final Report, February 2016, JICA

5.4.2 Comparison of Alternatives on MRT Line 5

Comparisons on alternatives of MRT Line 5 are described as the followings.

1) No Action Option

No action plan is a case that MRT Line5 is not implemented. In DMA, expansion and unipolarization of the city cause chronic traffic congestion, and it has become significant problem.

Expected population increase and economic growth will cause expansion of traffic congestion, deterioration of environment and economic loss.

In case that MRT Line5 are not implemented, no land acquisition and involuntary resettlement are expected. However sustainable growth of local industry will be hampered. The environment of the area will deteriorate further by the traffic congestion and air pollution.

2) Comparison of Structure Types

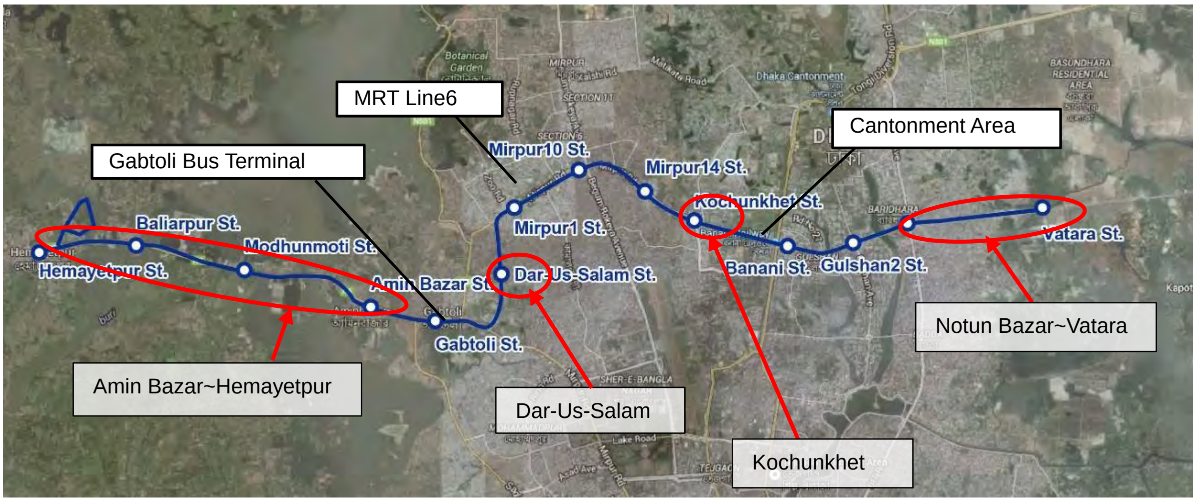
As structures of urban railway, there are (1)at grade, (2)viaduct, (3)underground (tunnel). Because the project runs in a density area, at grade structure is excluded. To decide structure on each section, the study team proposed the following 3 plans (Figure 5.4.2) and examined.

(1) Section between Kochunkhet and Notun Bazar

(2) Section between Dar-Us-Salam and Notun Bazar

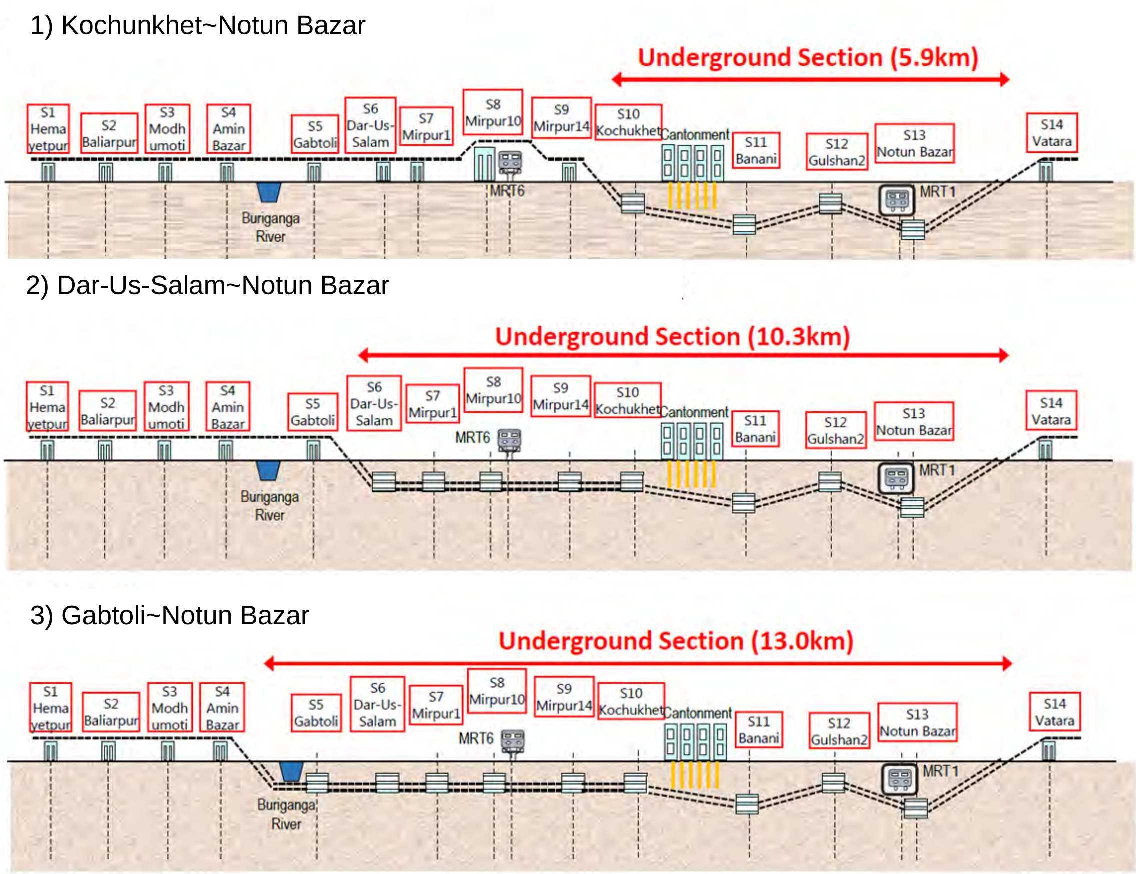
(3) Section between Gabtoli and Notun Bazar

Since the project is a railway which passes through the urban area of Dhaka city, major criteria are avoidance or minimization of living environment of local resident, pollution control and social environment including land acquisition and involuntary resettlement.



Source: JICA Study Team prepared based on Google Maps

Figure 5.4.1 Location of Underground Section of Alternative Routes



Source: JICA Study Team

Figure 5.4.2 Underground Section of Alternative Route

Since the project is a railway runs through urban area in Dhaka city, main evaluation items are deterioration of residential environment, pollution, and land acquisition/involuntary resettlement.

The results of the comparison are shown on Table 5.4.2.

(1) option has following merits; cheapest construction cost, the least inundation risk, and the least excavation soil. On the other hand, since the viaduct expands to the center of the city, there is demerits such as the most land acquisition/resettlement, noise and impacts on landscape. Moreover, construction work in the center of the city can cause traffic congestion and risk on safety.

(3) option that has long underground section has following merits; the least land acquisition/resettlement, noise and impacts on landscape. Issues on construction work are also superior to the other options. On the other hand, demerits are the most expensive construction cost, the most inundation risk and the most excavation soil. Although there is an ECA river (Briganga river) between Gabtoli and Amin Bazar, there is no direct impact because the alignment runs under the ground.

Considering various factors such as priority including resettlement, land acquisition and environment and negative factor of construction cost, (3) option was recommended as structure type of the project.

Table 5.4.2 Comparisons of Underground Sections of MRT Line5

Items \ Options	1) Section between Kochunkhet and Notun Bazar	2) Section between Dar-Us-Salam and Notun Bazar	3) Section between Gabtoli and Notun Bazar
Construction/Project			
Length	20.0km (Viaduct 14.1km, Underground 5.9km)	20.0km (Viaduct 9.7km, Underground 10.3km)	20.0km (Viaduct 6.5km, Underground 13.5km)
Stations	14 (Viaduct 10, Underground 4)	14 (Viaduct 6, Underground 8)	14 (Viaduct 5, Underground 9)
Social Environment			
Land Acquisition and Involuntary Resettlement	△: On the underground section, land acquisition and involuntary resettlement are expected at the entrance and exit of stations and construction site. Moreover, on the centre of Dhaka, land acquisition and involuntary resettlement is expected at stations and viaduct. Therefore negative impacts is most among three options.	○: On the underground section, land acquisition and involuntary resettlement are expected at the entrance and exit of stations and construction site. Land acquisition on viaduct sections is easy because the area is within ROW of RHD. About the section around Gabtoli station, land acquisition is needed.	◎: On the underground section, land acquisition and involuntary resettlement are expected at the entrance and exit of stations and construction site. Land acquisition on viaduct sections is easy because the area is within ROW of RHD.
Affected Households	△801	○771	◎721
Dividing of local community	◎: Underground structure does not divide local communities.	◎: Underground and viaduct structures do not divide local communities.	◎: Underground and viaduct structures do not divide local communities.
Natural Environment			
Preservation Area	○: The alignment does not run in preservation areas.	○: The alignment does not run in preservation areas.	○: The alignment does not run in preservation areas.
Biodiversity (Wetland)	○: On the west viaduct section, the structure is constructed in ROW. Therefore negative impacts to wetland is less. On the east viaduct section, the structure is constructed in the center of an existing road. Therefore no negative impacts to wetland is expected.	○: On the west viaduct section, the structure is constructed in ROW. Therefore negative impacts to wetland is less. On the east viaduct section, the structure is constructed in the center of an existing road. Therefore no negative impacts to wetland is expected.	○: On the west viaduct section, the structure is constructed in ROW. Therefore negative impacts to wetland is less. On the east viaduct section, the structure is constructed in the center of an existing road. Therefore no negative impacts to wetland is expected.
Damage to the project by inundation	◎: No inundation on viaduct structures expected. Because there is a possibility of inundation from an entrance and exit, appropriate measures are required. This option has least negative impacts comparing the other options.	○: No inundation on viaduct structures expected. Because there is a possibility of inundation from an entrance and exit, appropriate measures are required.	○: No inundation on viaduct structures expected. Because there is a possibility of inundation from an entrance and exit, appropriate measures are required.
Landscape	△: Negative impacts to landscape is most among the options because viaducts are installed on density areas.	○: There is no impact to landscape because structure in the centre of Dhaka is underground. In case that Gabtoli station takes viaduct structure, large structure of the	◎: There is no impact to landscape because structure in the centre of Dhaka is underground. Although viaduct sections may affect landscape, it will be insignificant because

Items \ Options	1) Section between Kochunkhet and Notun Bazar	2) Section between Dar-Us-Salam and Notun Bazar	3) Section between Gabtoli and Notun Bazar
		station may affect the landscape.	the areas are not density areas.
Ecologically Critical Area (ECA)	△: Construction of viaduct may affect water quality of Trug river which is designated as ECA.	△: Construction of viaduct may affect water quality of Trug river which is designated as ECA.	◎: Underground tunnel will not affect may affect water quality of Trug river which is designated as ECA.
Pollution Control			
Noise and Vibration	△: Construction noise of stations and viaducts is expected. Negative impacts are wider than the other options. Railway operation causes noise along viaduct sections.	○: Although construction noise of stations and viaducts is expected, negative impacts are small. Although railway operation causes noise along viaduct sections, negative impacts are limited.	○: Although construction noise of stations and viaducts is expected, negative impacts are small. Although railway operation causes noise along viaduct sections, negative impacts are limited.
Air Pollution	△: Negative impacts to air pollution is most among three options because construction area is very wide.	◎: Negative impacts to air pollution is less than (1) because viaducts are constructed on suburb.	◎: Negative impacts to air pollution is less than (1) because viaducts are constructed on suburb.
Water Quality (Groundwater)	○: Negative impacts to underground water are expected. However it is expected that negative impacts are small because the length of underground section is shorter than the other options.	△: Negative impacts to underground water are most among three options because the length of underground sections is long.	△: Negative impacts to underground water are significant because the length of underground sections is long.
Waste	◎: Volume of excavation soil is least.	△: Volume of excavation soil is large.	△: Volume of excavation soil is most.
Engineering			
Construction Cost	◎: 280 billion Yen	○: 330 billion Yen	△: 360 billion Yen
Feature of Structure	△: Length of underground section is shortest. The viaduct at the intersection with MRT Line 6 needs high rise structure exceeding 20m.	○: The centre of Dhaka except Gabtoli takes a tunnel structure. Suburb takes a viaduct structure.	◎: The centre of Dhaka takes a tunnel structure. Suburb takes a viaduct structure.
Difficulty of Construction	△: The section of underground needs construction spaces at stations alone. Viaduct section is long and needs a lot of construction space.	○: The section of underground needs construction spaces at stations alone. Because Gabtoli and the vicinity is crowded, construction of viaduct is difficult.	◎: The section of underground needs construction spaces at stations alone. On the viaduct section, construction spaces are kept easily because it is located on suburb.
Traffic	△: During construction, negative impacts to traffic is most because road lanes by viaduct construction are regulated widely.	○: Lane control by construction of viaduct causes traffic congestion around Gabtoli.	◎: Construction of viaduct needs lane control. However, negative impacts to traffic is small because the area of construction is located on suburb.

Options / Items	1) Section between Kochunkhet and Notun Bazar	2) Section between Dar-Us-Salam and Notun Bazar	3) Section between Gabtoli and Notun Bazar
Liquefaction by earthquake	△: Less damage by liquefaction is expected on underground structures. Liquefaction may damage footings of viaduct installed on long section.	○: Less damage by liquefaction is expected on underground structures. Liquefaction may damage footings of viaduct.	○: Less damage by liquefaction is expected on underground structures. Liquefaction may damage footings of viaduct.
Safety	○: Because there is no railroad crossing, traffic accident is not expected. A Fire of a station building is expected.	○: Because there is no railroad crossing, traffic accident is not expected. A seismic disaster of viaduct is expected.	○: Because there is no railroad crossing, traffic accident is not expected. A seismic disaster of viaduct and a fire of a station building are expected.
Total Evaluation	◎: Because construction cost is cheapest and negative impacts to environment are less, it is most suitable. Although negative impacts on inundation are expected, appropriate measures can avoid the risk of the inundation.	△: Construction cost is cheaper, however negative impacts of resettlement and environment is quite significant. Therefore this option has less priority than option 3).	○: The shortest viaduct section has priority in the view of mitigation for environment. This option has a priority to option 2) on the construction cost and social environment, but less priority than option 1).

Note ◎: most suitable ○: suitable △: required more considerations

Source: JICA Study Team

3) Comparisons of Alternative Routes on Cantonment Area

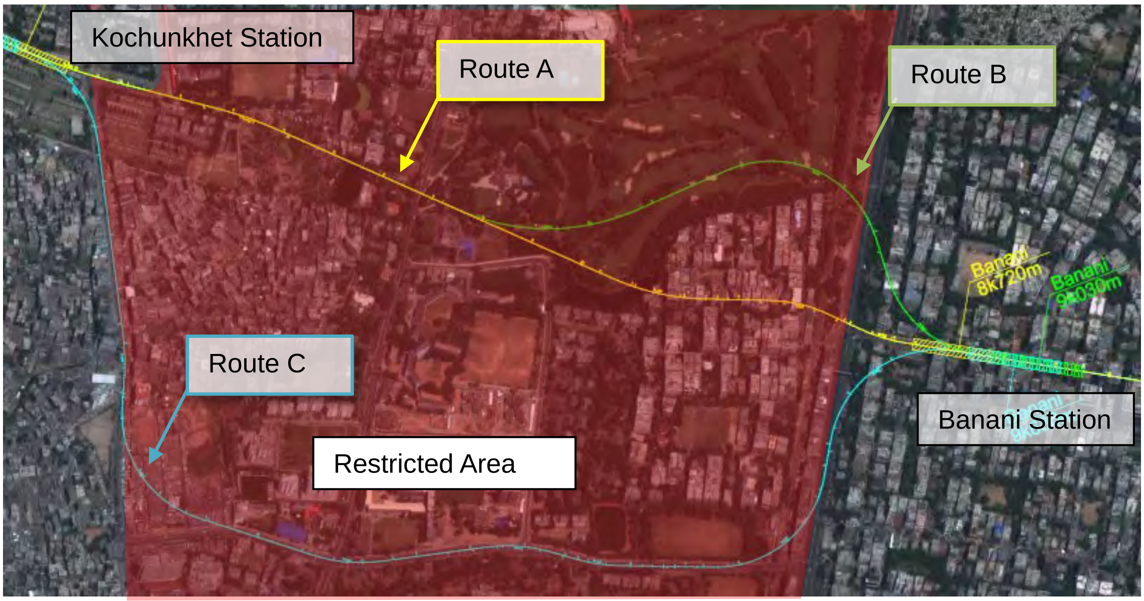
There is a restricted aria (cantonment area) between Banani Station and Kochunkhet Station on the route of MRT Line5. (Figure 5.4.3) Three route options were examined on this section. The route options include viaduct plan and underground plan. On the underground plan, only the shortest plan is examined to apply fully the merit of underground. Therefore 3 viaduct options and 1 underground option were compared.

Route A is the shortest route connecting Banani Station and Kochunkhet Station. The rout e A secures running performance, however, interferes a lot of building in the area. Therefore, it is hard to adopt viaduct plan.

Route B which mitigates interference with the buildings comparing the route A has minor curves.

Route C does not interfere with the buildings. However, since the route have more curves than other routes and longer alignment, running performance and comfort is inferior to the other routes.

From stated above, the route B as viaduct plan is recommended because the route B has less interference with the buildings than the other plans and better running performance. The route A as underground plan is recommended because the route A has no interference with the buildings and better running performance. Finally the study team recommended the underground route A considering magnitude of involuntary resettlement.



Source: JICA Study Team prepared based on Google Maps

Figure 5.4.3　Comparisons of Alternative Routes on Cantonment Area

Table 5.4.3 Comparisons of Alternative Routes on Cantonment Area

		Viaduct			Underground
		Route A	Route B	Route C	Route A
Alignment		Good	Detour Continuous small curve	Large detour Continuous small curve	Good
		○	△	×	○
Length of the route		1.2km	1.35km	2.0km	1.2km
		○	△	×	○
Obstruction		(Significant) Banani DOHS Residences for public workers (Insignificant) Few	(Significant) Golf course Residences for public workers (Insignificant) A lot of private building	(Significant) Nothing (Insignificant) A lot of private building	There is no direct obstacle.
		△	△	○	◎
Social/Environment		Least resettlement (Underground) No resettlement	Less resettlement volume than route C (Underground) No resettlement	Resettlement as same as B route (Underground) No resettlement	There is no resettlement.
		○	△	△	◎
Natural Environment		Railway operation may cause negative impacts to noise and landscape.	The Least negative impacts are expected because it passes through golf course.	(Viaduct) Negative impacts such as noise and landscape is expected because it passes through residents Most negative impacts because length is longest.	There are no negative impacts such noise and obstruction to landscape. The volume of excavation soil is most.
		○	△	×	○
Recommendation		○	△	△	◎
Project Cost (case of viaduct)	Construction	2.2 billion Yen	2.3 billion Yen	3.3 billion Yen	-
	Land Acquisition/Compensation	13.3 billion Yen	9.9 billion Yen	9.2 billion Yen	-
	Total	15.5 billion Yen	12.2 billion Yen	12.5 billion Yen	

Source: JICA Study Team

5.5 Scoping of EIA

5.5.1 Scoping Matrix

Based on the comparisons of the alternatives, scoping of the project is carried out.

The study team confirmed current situation of the environment and social matters in/around the project site by field reconnaissance, and developed a draft scoping of the selected option including pollution control, natural environment and social environment. A draft scoping is shown on Table 5.5.1.

Table 5.5.1 Draft Scoping (MRT Line5)

No	Items	Evaluation		Reason of evaluation
		Before/ under construction	Operation	
Pollution Control				
1	Air Pollution	B-	B+	Construction Phase: ･Construction works and operation of construction equipment will generate dust and exhaust gas. Operation Phase: ･Air pollution will be mitigated by reducing traffic congestion.
2	Water pollution	B-	B-	Construction Phase: ･Turbid water derived from construction sites may deteriorate water quality of rivers. Operation Phase: ･Waste water from stations and maintenance facility may deteriorate water quality of rivers.
3	Soil pollution	B-	B-	Construction Phase: ･Bad maintenance construction machinery and vehicles may cause soil contamination by leak of oil. Operation Phase: ･Maintenance facility of depot may cause soil contamination by leak of oil.
4	Waste	B-	B-	Construction Phase: ･Construction works will cause waste including excavated soil. Operation Phase: ･Illegal dumping from stations and depot may cause negative impacts on the environment.
5	Noise and Vibration	B-	B-	Construction Phase: ･Construction works will cause noise and vibration. Operation Phase: ･Driving of trains may cause noise around viaduct sections.
6	Ground subsidence	C	C	Construction /Operation Phase: ･Appropriate methods should be selected to avoid ground subsidence in case of soft soil.
7	Offensive odors	D	D	Construction / Operation Phase: ･In terms of the project character (railway), offensive odors are unlikely to occur.
8	Bottom sediment	B-	D	Construction Phase: ･Turbid water from the construction activity may deteriorate bottom sediment of rivers.
Natural Environment				
9	Protected areas	D	D	Construction / Operation Phase: ･ The Project site and the vicinity include no protected areas.

No	Items	Evaluation		Reason of evaluation
		Before/ under construction	Operation	
10	Ecosystem	B-	B-	Construction Phase: ･Vegetation and wetland may be lost by construction works. ･Agricultural ecosystem will be lost or disturbed by construction activity. Operation Phase: ･Activity of depot may have negative impacts on the ecosystem.
11	Hydrology	C	C	Construction / Operation Phase: ･Piers in river may cause negative impacts on a flow of the river.
12	Groundwater	B-	D	Construction / Operation Phase: ･Excavation and installation of underground structure may cause negative impacts on groundwater level and quality.
13	Geographical features	B-	D	Construction Phase: ･Excavation and installation of underground structure may cause collapse of ground.
Social Environment				
14	Resettlement/ Land Acquisition	A-	D	Pre-Construction Phase: ･Large scale land acquisition and resettlement is anticipated (721 households including 39 residents). Operation Phase: ･Additional physical resettlement and land acquisition will not be required for this Project.
15	Poor people	A-	A-	Construction Phase: ･Poor who are living in the project sites may be affected. Operation Phase: ･In case of no mitigation measures, poverty may Poverty of poor who are resettled involuntarily may become severe.
16	Ethnic minorities and indigenous peoples	C	C	Construction / Operation Phase: ･Impacts is unclear as of now.
17	Local economies, such as employment, livelihood, etc.	B-/B+	C	Construction Phase: ･Involuntary resettlement may cause negative impacts on Rikisya or taxi. On the other hand, construction work will increase employment. Operation Phase: ･Rikisya and taxi will be used as para transit from stations.
18	Land use and utilization of local resources	B-/B+	B+	Construction Phase: ･Development of the depot will change current land use. Operation Phase: ･Effective use of land will accelerate undeveloped suburb.
19	Water usage	C	C	Construction / Operation Phase: ･Impacts is unclear as of now.
20	Existing social infrastructures and services	C	C	Construction / Operation Phase: ･Impacts is unclear as of now.
21	Social structure such as social capital and local decision-making institutions	C	C	Construction / Operation Phase: ･Impacts is unclear as of now.
22	Misdistribution of benefits and damages	B-	B-	Construction Phase: ･There may be misdistribution between affected households and no-affected households. Operation Phase: ･Since the vicinity of stations has convenience, misdistribution of benefits and damages is expected.

No	Items	Evaluation		Reason of evaluation
		Before/ under construction	Operation	
23	Local conflicts of interest	B-	B-	Construction Phase: ・Implementation of land acquisition and payment of compensation may cause local conflicts of interest Operation Phase: ・Since the vicinity of stations has convenience, local conflicts of interest.
24	Cultural heritage	C	C	Construction / Operation Phase: ・Impacts is unclear as of now.
25	Landscape	B-	B-	Construction Phase: ・Small scale and short duration impacts are expected. Operation Phase: ・In case that viaduct exceeds other structures, the viaduct may cause negative impacts on landscape
26	Gender	C	C	Construction / Operation Phase: ・Impacts is unclear as of now.
27	Children's rights	C	C	Construction / Operation Phase: ・Impacts is unclear as of now.
28	Infectious diseases such as HIV/AIDS	B-	D	Construction Phase: ・Infection risks of HIV/AIDS may be increased among construction workers. Operation Phase: ・Since the Project aims improvement of urban traffic, the project will not directly concern spread of infection risks of HIV/AIDS.
29	Working conditions (including occupational safety)	B-	B-	Construction Phase: ・Inappropriate safety measures of contractor will deteriorate occupational safety. Operation Phase: ・Inappropriate safety measures of railway operator will deteriorate occupational safety.
Others				
30	Trans-boundary impacts or climate change	B-	B+/-	Construction Phase: ・Operation of construction machinery and vehicles will occur greenhouse gas (CO_2). Operation Phase: ・Modal shift to from vehicles to railway will reduce greenhouse gas.
31	Accidents	B-	B-	Construction Phase: ・There is a risk of accident on construction activity. Operation Phase: ・Collision of vehicle and viaduct, and accident in depot are expected.
32	Risk of flood	B-	B-	Construction / Operation Phase: ・Because the project site includes flood prone area, risk increasing flood should be confirmed.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected
* Impact Items refer to "JICA Guidelines for Environmental and Social Considerations April 2010"
Source: JICA Study Team

5.5.2 TOR of EIA

Based on the draft scoping, the study team prepared TORs of EIA of MRT Line 5 which are shown on Table 5.5.2.

Table 5.5.2 TOR of EIA of MRT Line5

Category	Items	Before/during Construction	Operation	Survey Items and Methods of Survey and Forecast	Methods of Evaluation
Pollution Control	Air Pollution	B-	B＋	Current condition of air quality by field survey Outlines of construction works Air quality estimation on construction	Comparison with air quality standards of Bangladesh Considerations on vulnerable facilities including school and hospital (PM2.5 and PM10)
	Water pollution	B-	B-	Current condition of water quality of rivers and lakes in/around the project site by review of existing materials and field survey Review of plan of the project and past examples of other projects	Comparison with water quality standards of Bangladesh, and evaluation of turbid water derived from the implementation of the project
	Soil pollution	B-	B-	Outlines of construction works Review of past examples of other projects Review of depot plan of the project in the view of possibility of oil leak	Evaluation of the possibility of oil leak, and study of mitigation plan
	Waste	B-	B-	Review of estimated volume of excavation soil and construction waste Review of operation plan of the project and other project Review of disposal measures	Evaluation of possibility of pollution by excavation soil and construction waste Study of mitigation plan in case that high pollution is expected comparing other projects
	Noise and Vibration	B-	B-	Current condition of noise by field survey Review of construction works Estimation of construction noise by noise transmission models Estimation of railway noise on viaduct sections by noise estimation model of railway	Comparison with noise standards of Bangladesh or other countries Study of mitigation plan if needed
	Ground subsidence	C	C	Review of construction plan and geological survey	Confirmation of taking appropriate measures to avoid ground subsidence on soft ground
	Bottom sediment	B-	D	Review of construction works Estimation of an influx of turbid water and oil leak	Study of mitigation plan in case that an influx of turbid water and oil leak
Natural Environment	Ecosystem	B-	B-	Current condition of fauna and flora in/around the depot site by existing materials and field survey Estimation of area where trees and vegetation are cleared based on construction plan	Estimation of environmental impacts Study of mitigation plan if needed
	Hydrology	C	C	Review of the project plan Confirmation of structures installed in crossing rivers	Confirmation of appropriate measures for river flow in case that structure is installed in rivers
	Groundwater	B-	D	Current condition of groundwater level and quality around the project site by existing geological survey Review of the project plan and construction plan Estimation of impacts on groundwater level	Comparison with water quality standard of Bangladesh Study of mitigation plan if needed

Category	Items	Before/during Construction	Operation	Survey Items and Methods of Survey and Forecast	Methods of Evaluation
	Geographical features	B-	D	Review of existing geological survey Review of construction plan of the project Estimation of negative impacts on geographical features	Study of mitigation plan if structures around the project site is expected to affect
Social Environment	Resettlement/ Land Acquisition	A-	D	Current condition of PAPs by census and socio-economic survey Collecting opinions of the PAPs by consultation meetings, focus group discussion and interviews Estimation of negative impacts on the PAPs Discussion with counterparts and review of other countries examples on property rights	Development of policies of land acquisition and resettlement Preparation of RAP
	Poor people	A-	A-	Estimation of negative impacts on poor people (below 60,000 BT a year) included in the PAPs	Study of mitigation measures for the poor people included in the PAPs
	Ethnic minorities and indigenous peoples	C	C	Existence of ethnic minorities and indigenous peoples by RAP survey	Study of mitigation measures if needed
	Local economies, such as employment, livelihood, etc.	B-/B+	C	Current condition of livelihoods of the PAPs Estimation of negative impacts to employment and livelihoods of the PAPs Collecting opinions of rikisha and taxi drivers by stakeholder meetings	Preparation of entitlement, compensation policy
	Land use and utilization of local resources	B-/B+	B+	Review of existing materials including land use plan Collecting information by field reconnaissance	Estimation of impacts based on review of the project plan and opinions on the public consultation meetings
	Water usage	C	C	Review of existing materials on ground water usage around the project site Field survey on ground water usage around the project site Review of construction plan and project plan	Study of mitigation measures if significant negative impacts are expected
	Existing social infrastructures and services	C	C	Review of existing materials on existing social infrastructures and services Review of the project plan	Evaluation of impacts on existing social infrastructures and services based on current condition of existing social infrastructures and services
	Social structure such as social capital and local decision-making institutions	C	C	Review of existing materials and hearing on social structure such as social capital and local decision-making institutions Review of the project plan	Comparison with current condition of social structure and the project plan
	Misdistribution of benefits and damages	B-	B-	Review of the project plan	Evaluation on misdistribution of benefits and damages by project implementation
	Local conflicts of interest	B-	B-	Economic status of PAPs by the RAP study Confirmation of local conflicts of interest by hearing	Consideration avoiding significant gaps between PAPs and non PAPs on the preparation of RAP Comparison of PAPs income before/after resettlement
	Cultural heritage	C	C	Existence of cultural heritage in/around the project site by review of maps and existing materials Field reconnaissance	Evaluation of negative impacts and study of mitigation measures in case that there is a cultural heritage in/around the project site

Category	Items	Before/during Construction	Operation	Survey Items and Methods of Survey and Forecast	Methods of Evaluation
	Gender	C	C	Ratio of widow households in poor households Necessity of special assistance on the widow households Review of the gender action plan which is developed in this preparation survey	Considerations on women and traffic disadvantaged on the project plan
	Children's rights	C	C	Existence of school around the project site by review of maps Review of the project plan in terms of blocking school-commuting roads	Evaluation of negative impacts on school-commuting roads
	Infectious diseases such as HIV/AIDS	B-	D	Current condition of prevalence of infectious diseases such as HIV/AIDS in Bangladesh by review of existing materials Review of other projects on prevalence of HIV/AIDS by influx of construction workers	Evaluation of the prevalence of HIV/AIDS on the construction stage of the project
	Working conditions (including occupational safety)	B-	B-	Safety measures on the project by review of the project plan	Evaluation of safety on construction work in the light of other projects Evaluation of safety on the operation of the project in the light of other projects
	Trans-boundary impacts or climate change	B-	B+/-	Construction machinery which discharges greenhouse gas on the construction activities Estimation of greenhouse gas reduction by the implementation of the project	Confirmation of the reduction measures on the construction plan Evaluation of reduction effects of greenhouse gas on the project
Others	Risk of flood	B-	B-	Review of existing materials relevant to flood around the project site Review of the project plan	Confirmation of appropriate measures in case that there is food risk

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected
* Impact Items refer to "JICA Guidelines for Environmental and Social Considerations April 2010"
Source: JICA Study Team

5.6 The Results of the EIA Survey

5.6.1 Results of the Survey of Each Item

Regarding the raised items on the TOR of EIA, the results of the EIA survey are shown below.

1) Air Pollution

Air quality survey was conducted on the locations along the Line 5. Five survey points were allocated along the Line 5 alignment. Table 5.6.1 and Figure 5.6.1 show the survey points.

Table 5.6.1 Air Quality Sampling Location of MRT Line 5

No.	Location	Geographic Coordinate
AQ5-1	Depot Site of Line 5	23°48'1.79"N 90°16'44.04"E
AQ5-2	Gabtoli Station	23°47'0.29"N 90°20'36.07"E
AQ5-3	Mirpur 10 Station	23°48'26.44"N 90°22'13.12"E
AQ5-4	Gulshan 2 Station	23°47'40.79"N 90°24'46.65"E
AQ5-5	Vatara Station	23°47'57.44"N 90°26'23.25"E

Source: JICA Study Team

Source: JICA Study Team

Figure 5.6.1 Air Quality Sampling Location of MRT Line 5

The subjects of survey are seven parameters (PM10, PM2.5, SO_2, NO_2, CO, Pb and O_3) including national ambient air quality standards (NAAQS) of Bangladesh.

Results of the survey are shown in Table 5.6.2. The PM10 and PM2.5 concentration exceed the NAAQS in the Gabtoli, Mirpur 10 and Gulshan 2 stations of MRT line 5. The

NO_2 concentration exceeds the NAAQS in the Gabtoli and Mirpur 10 station. Rest of the parameters (SO2, CO, Pb and O_3) concentrations was present well within the NAAQS in all stations of MRT line 5.

WHO Guidelines recommends lower concentration of contaminants. Comparing the WHO Guidelines, concentrations of PM10 and PM2.5 exceed on the whole locations.

Air pollutions of survey points are dominated by PM10 and PM2.5. Because on major roads in Dhaka city, a lot of construction work is being conducting, even paved roads are very muddy. Considering low concentrations of other pollutants, the high concentration of PMs is estimated to be derived from road dust.

Table 5.6.2 Ambient Air Quality of MRT Line5

Location	Present Concentration in μg/m^3						CO (ppm)
	PM10	PM2.5	NO_2	SO_2	O_3	Pb	
Depot Site of Line 5	68.2	33.8	33.6	5.5	2.4	BDL	0.2
Gabtoli Station	345.5	145.6	120.5	24.6	23.2	0.1	5.1
Mirpur 10 Station	318.4	134.9	101.7	13.7	15	0.07	1.6
Gulshan 2 Station	268.5	88.4	87.9	12.0	12.8	BDL	0.5
Vatara Station	72.4	36.8	46.7	6.4	3.2	BDL	0.1
NAAQS (ECR1997)	150	65	100	365	157	0.5	9
WHO Guideline	50	25	40	20	100	0.5	10

Source: JICA Study Team, EQMS Laboratory Analysis, Sampling Date: 28th February to 5th March, Analysis date: 1st-15th March

Note: BDL- Below Detection Limit

Exceeding Standard Level

As the results of the baseline survey show, concentrations of PM2.5 and PM10 along the project area are high comparing the national standard of Bangladesh. Main cause of the air pollution can be dust of road surface. Some construction works including earth work may cause dust. However, mitigation measures against the dust such as water spray on the construction works should be introduced.

(1) Negative Impact of Dust caused by Construction Work

As mentioned above, main factor of air pollution in Dhaka is dust. On stakeholder meetings, some concerns about dust of construction work were raised. On the project, operation of construction machinery will generate dust. Based on simple prediction method of dust generation, study team examined negative impacts of dust falling around the project sites. As a prediction method, the prediction method by National Institute for Land and Infrastructure Management (NILIM), Japan was referred. On some typical construction work, volume of falling dust is estimated as Table 5.6.3 and meets criteria. The criteria is to secure living environment against spike tire dust in Japan.

Table 5.6.3 Estimated falling dust on typical construction work

Construction Work	Unit of falling dust near construction work (t/km2/8h)	Working day per month	Falling dust per month (t/km2/month)	Criteria (t/km2/month)
Embankment	0.04	30	1.2	20
Slope forming	0.07	30	2.1	
Piling (Earth Drill)	0.02	30	0.6	

Note: criteria: guideline on spike tire dust (NILIM)

Because estimated volume of falling dust is comparatively low, it is estimated that negative impacts are not significant. However, estimation of dust caused by construction work has uncertainty. Therefore, appropriate mitigation measures are essential.

2) Water Pollution

To understand current conditions of surface water quality along the MRT Line 5, water quality survey was conducted. Surface water samples were taken from 5 locations including river, wetland and lake. The sampling points include ECA. Surface water samples were collected on 19th to 22nd March 2017. Detail Sampling Locations are provided in the following Table 5.6.4 and shown in Figure 5.6.2.

Table 5.6.4 Surface water Sampling Location of MRT Line 5

No.	Location	Geographic Coordinate
SW5-1	Depot Site of Line 5	23°48'2.20"N 90°16'33.40"E
SW 5-2	Wetland between Modhunmoti Station and Amin Bazar	23°47'25.00"N90°19'18.40"E
SW 5-3	Turag River	23°47'4.40"N 90°20'10.80"E
SW 5-4	Banani Lake	23°47'35.70"N 90°24'36.20"E
SW 5-5	Gulshan Lake	23°47'46.40"N 90°25'6.00"E

Source: JICA Study Team

Source: JICA Study Team

Figure 5.6.2 Surface and Ground Water Sampling Location of MRT Line5

Results of the survey are shown on Table 5.6.5. To summarize, surface water quality are nearly same as “water usable by various process and cooling industries” or “water usable for irrigation” of Bangladesh standard. The Bangladesh standards have no criteria of COD and TSS (SS). Comparing the Japanese standard of water quality, it is nearly same as Category D (industrial or agricultural use) or Category E (industrial use). Particularly, SW5-3, 5-4, and 5-5, which are water bodies designated to ECA, are contaminated highly. It is crucial condition for aquatic organism.

Table 5.6.5 Surface Water Quality Analysis Result

Parameter	Unit	SW5-1	SW5-2	SW5-3	SW5-4	SW5-5	Standard for Inland Surface Water*					
							a	b	c	d	e	f
Colour	Hazen	2.1	1.8	2.0	1.3	1.7	-	-	-	-	-	-
Temperature	˚C	23.2	23.1	24.5	24.4	24.0	-	-	-	-	-	-
pH	-	7.22	7.08	7.46	7.00	7.34	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
DO	mg/l	4.1	3.2	2.7	1.3	2.9	6 or above	5 or more	6 or more	5 or more	5 or more	5 or more
BOD	mg/l	13	8	12	13	10	2 or less	3 or less	6 or less	6 or less	10 or less	10 or less
COD	mg/l	48	32	44	48	36	-	-	-	-	-	-
TSS	mg/l	24	15	42	28	21						
Coliform (Faecal)	N/100ml	475	786	995	840	787	50 or less	200 or less	5000 or less	---	5000 or less	1000 or less

Source: JICA Study Team, EQMS laboratory and Department of Public Health and Engineering Lab; Analysis date: 22/03/2017- 30/04/2017 and 30/04/2-17-22/05/2017

*Note: a- Source of drinking water for supply only after disinfecting
b- Water usable for recreational activity
c- Source of drinking water for supply after conventional treatment
d- Water usable by fisheries
e- Water usable by various process and cooling industries
f- Water usable for irrigation

The alignment of the project passes through some water bodies including ECA (Buriganga river, Turag river, Gulshan Banani-Baridhara Lake). Water quality of the water bodies are level to meet industrial use. The alignment passes through the water bodies by underground. Therefore, the construction work of the project will not directly affect the water bodies.

However, in case that structures including viaduct are constructed near the water bodies, influx of turbid water is expected. According to review of detail design, appropriate mitigation measures and monitoring should be taken as needed.

On the operation phase, the operation of the depot generates drainage water including cleaner and oil by the maintenance of rolling stocks. The drainage water is treated, and reused as washing water for rolling stocks. (4.6.7) Wastewater of stations is discharged to water bodies after treatment to meet the water quality standard of Bangladesh. (4.6.2 4)) Therefore, the drainage water will cause no deterioration of water quality around the depot.

3) Soil Pollution

On construction work of the project, some construction machinery will operate. Bad maintenance machinery has a possibility of oil leak. The machinery should be maintained appropriately. Since the structure of the project is almost underground, the project will generate a lot of excavation soil. Because there is no facility discharging pollutants such as factory in the project site, there is few possibilities to spread highly polluted soil to other areas. The depot construction of the project needs a lot of soil to form embankment. In case that the filling soil is contaminated, contaminants can scatter around the depot site. Therefore, when the project receives the soil, no contamination of the soil should be confirmed.

4) Waste

(1) Excavation Soil

Since the structure of the project is almost underground, the project will generate a lot of excavation soil (approximately 1.5 million cubic meters). There are no acts and regulations on soil disposal in Bangladesh. Although Dhaka City also has no regulation of disposal of excavation soil, disposal and reuse are promoted as followings.

a. Applicants dealing soils register to Dhaka city (with desirable spec of soil).

b. Dhaka city selects receivers of soil from the registered applicants, and informs soil owners of it.

c. Soil owners disposes spoiled soils to designated dumping sites.

The study team interviewed RAJUK[*] about procedures of soil dumping. They mentioned that RAJUK does not secure soil dumping site, and the project proponents should consult with National Housing Authority, brick factory's owners[†] and developers. Moreover they informed that there is a development plan of filling soil on the east of Dhaka city to prevent flood disaster.

Regarding soil disposal, the project will require disposal to approved site by the government to contractors. Moreover, following policies are taken to reuse the excavation soil as possible. Tangible measures will be examined on construction plan of detail design.

a. Approximately filling soil of 180,000m3 is needed. A part of excavation soil will be reused as filling soil.

b. Reuse for other projects.

(2) Waste

Regarding waste disposal, to use disposal sites which are managed by Dhaka city[‡], project proponents acquire a permit from Dhaka city and pay for disposal. Private disposal sites[§] also are available under an agreement.

Construction work of the project generates wastes: the operation of the project generates wastes from stations and the depot site. Hazardous waste must not be generated. Trash box will be installed at the stations. The waste of the project is disposed and reused appropriately under consultation with Dhaka city and a permit.

5) Noise and Vibration

For the purpose of understanding noise environment along the MRT Line 5, an ambient noise survey was conducted. Nine survey points were allocated along the MRT Line 5 alignment. Table 5.6.6 and Figure 5.6.3 show the survey points.

The survey points are chosen in such a way that a representative data could be recorded all over locations.

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[*] Ashraf Islam, Project Director, Detailed Area Plan, RAJUK

[†] It is estimated that they supposed reuse as materials of brick.

[‡] Matuali (south of Dhaka city), Amin Bazar (west of Dhaka)

[§] It depends on a land use plan.

Table 5.6.6 Noise Level Sampling Location of MRT Line 5

No.	Location	Geographic Coordinate
NL5-1	Depot Site of Line 5	23°48'0.55"N 90°16'36.97"E
NL 5-2	Modhunmoti Station	23°47'27.93"N 90°18'31.56"E
NL 5-3	Gabtoli Station	23°46'57.69"N 90°20'24.27"E
NL 5-4	Dar-Us-Salam Station	23°47'31.21"N 90°21'14.54"E
NL 5-5	Mirpur 10 Station	23°48'26.35"N 90°22'12.88"E
NL 5-6	Mirpur 14 Station	23°48'15.31"N 90°22'38.85"E
NL 5-7	Banani Station	23°47'38.50"N 90°24'10.17"E
NL 5-8	Gulshan 2 Station	23°47'42.09"N 90°24'46.49"E
NL 5-9	Vatara Station	23°47'57.09"N 90°26'20.62"E

Source: JICA Study Team

Source: JICA Study Team

Figure 5.6.3 Noise Level Monitoring Location of MRT Line 5

The results of the ambient noise survey are shown on Table 5.6.7.

Table 5.6.7 Ambient Noise Level along MRT Line 5

Code	Lmax	Lmin	Leq_{day}	Leq_{night}	L90	L50	L10	Area Setting*	Standard**	
									Day	Night
NL1	65.6	43.7	54.3	50.1	47.6	50.4	56.3	Residential	50	40
NL2	84.2	58.8	69.2	63.5	60.1	64.3	70.5	Commercial	70	60
NL3	95.5	56.2	74.8	68.0	62.1	64.9	71.9	Commercial	70	60
NL4	82.7	55.1	69.3	65.7	60.7	63.7	70.1	Mixed	60	50
NL5	87.5	57.8	68.2	63.9	61.3	63.8	66.2	Commercial	70	60
NL6	84.8	53.4	67.3	62.3	59.1	61.9	69.5	Commercial	70	60
NL7	82.2	56.5	71.0	68.1	62.8	64.4	71.5	Commercial	70	60
NL8	90.3	52.7	65.9	59.7	56.1	60.5	67.3	Commercial	70	60
NL9	74.9	46.7	64.5	57.1	55.1	59.6	66.5	Commercial	70	60

Source: JICA Study Team
* Area setting (according to the ECR, 1997)
**Standard according to the ECR, 1997 and subsequent amendment in 2006
Note: The time from 0600 hrs to 2100 hrs is counted as daytime and from 2100 hrs to 0600 hrs is counted as night time
Exceeding Standard Level

Areas along the MRT Line5 are almost commercial zone. Ambient noise levels are comparatively high. Particularly 7 points between Gabtoli and Banani exceed even the standard level of night.

Since the area along the project is almost commercial zone along major roads, ambient noise level is comparatively high. However, around the Mirpur area, a lot of sensitive facility such as educational facility and hospital are concentrated. Such locations need sufficient mitigation measure.

On construction stage, some construction machinery will be operated. On the centre of Dhaka, the structure is underground, alone the locations of the station have construction work above ground. Because basically the construction work will be conducted at the centre of road, noise damping by distance will be kept. Moreover, mitigation measures such as installation of noise barrier are hoped.

In this survey, no tangible construction plan is examined. On detail design stage, construction noise should be examined again.

On operation stage, railway noise will be expected on viaduct sections. There are no regulations or guidelines of railway noise in Bangladesh. Considering the railway noise guideline of Japan, the installation of noise barrier will reduce the noise, meet the criteria of the guidelines.

Depot site and station facilities such as ventilator may generate noise. Because tangible design has not examined yet, it should be examined on the detail design stage.

Regarding vibration, it is estimated that there are no negative impacts around the project site because there is no factory generating significant vibration. Construction work of the project, especially pile driving and earth work, may cause negative impacts of vibration around the project site. MRT Line 6 project which is going in advance is examining compensation for vibration grievance around the project site. The project adopts low vibration methods on pile driving and earth work as possible, and carry out monitoring of vibration.

On the operation stage, negative impacts of tunnel vibration are expected. However, instances of Japan show that observed vibration is below the threshold (55 dB). Therefore it is expected that negative impacts is negligible.

(1) Construction Noise

Noise level along the project site will increase due to construction activities. Most of the noise will be contributed by operation of heavy equipment and machineries. On the underground sections where are dense areas, construction work of alignment is carried out underground. Therefore, there is no noise problem on the construction work of alignment. On the other hand, because construction work of station and viaduct section are carried out on ground, there are concerns of negative impacts of noise. Study team shows an estimation of construction noise below.

- Prediction model: distance damping model of sound
- Condition of prediction: Noise source locates on the centre of road. Observed point is set on a road side. (Distance between noise source and observed point is 10m.) Installation of temporally wall (h=3m) is assumed as mitigation measures.
- Noise source: Expected typical construction activities are set. (NILIM)

Results of the prediction are shown on Table 5.6.8.

Table 5.6.8 Results of Prediction of Construction Noise

Construction Work		Distance from the Edge of the ROW to Receiving Point (m)				Noise standard of Bangladesh Day time 6:00-21:00 Night: 21:00-6:00 (Leq: dBA)
Type	Power Level (dB)	0	5	10	15	
Without temporary wall						
D-wall	107	79.0	75.5	73.0	71.0	Residential area: 50/40 Mixed area: 60/50 Commercial area: 70/60
Pile drivers (earth drill)	106	78.0	74.5	72.0	70.0	
Pile drivers (hydraulic pile hammer)	135	107.0	103.5	101.0	99.0	
Excavation	119	91.0	87.5	85.0	83.0	
Asphalt pavement	108	80.0	76.5	74.0	72.0	
With temporary wall (3.0m)						
D-wall	107	60.0	57.5	55.0	53.0	Residential area: 50/40 Mixed area: 60/50 Commercial area: 70/60
Pile drivers (earth drill)	106	59.0	56.5	54.0	52.0	
Pile drivers (hydraulic pile hammer)	135	88.0	85.5	83.0	81.0	
Excavation	119	72.0	69.5	67.0	65.0	
Asphalt pavement	108	61.0	58.5	56.0	54.0	

Source: JICA Study Team

On the condition without temporary wall, generally noise levels are expected to be high. Temporary wall installed near the noise source has remarkable effect to reduce the construction noise. The temporary wall should be introduced as noise mitigation measures. It cannot be compared the prediction and the standards directly because the noise standard of Bangladesh evaluates by Leq. Leq depends on level and duration of noise. In case that the machinery operates 8 hours per day, the noise level is deducted approximately 3 dB, in case of 1 hour per day, approximately 12dB from the figure of Table 5.6.8. Therefore operation hour of machinery should be shorten as possible by rational construction management. Since the standards of night time is 10 dB lower than daytime, the impacts at night are more. On the residential area including Hemayapur and Dar-Us-Salam, night time construction work on the ground should be avoided.

(2) Railway Noise

The west section from Amin Bazar takes viaduct structure. The operation of railway may cause noise impacts along the project site. Study team examined prediction of railway noise, evaluated and proposes noise mitigation measures based on a result of the prediction.

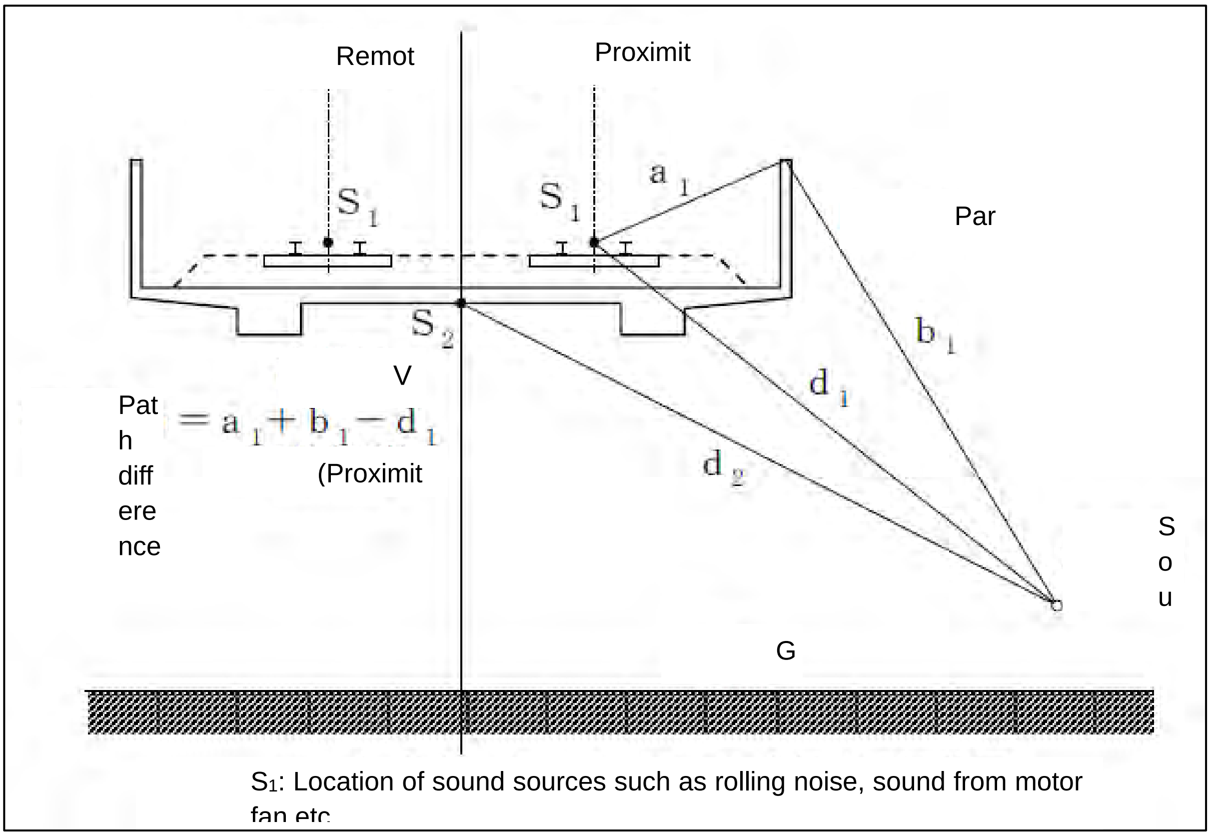
Based on section structure and train velocity, the maximum of the noise level at the time of the run of 1 train (L_{Amax}) is estimated firstly. Moreover single event sound exposure level (L_{AE}) is estimated from train transit time. Finally equivalent continuous sound pressure level (L_{Aeq}) by train number every train type of time zone is calculated.

- Prediction model

The prediction model by Japanese formula is applied. The noise by train operation compounds 3 main sound sources such as rolling noise of running train, structure sound from vibration of slab on concrete viaduct, and railway vehicle sound. The formula is calculated by combining these sound sources.

- Estimation of maximum value of noise level (L_{Amax})

The prediction formula for train length l m and train velocity V km/h indicates Formula 1 - 4 by definition of each variable shown in Figure 5.6.4.



Source: Proposal of a Prediction Model for Noise of Conventional Railway, Noise Control Engineering 20(3), 1996, Institute of Noise Control Engineering, Japan

Figure 5.6.4 Arrangement of Sound Source, Sound Receiving Point and Explanation of Path Difference

(a.1) Rolling noise

$$L_{Amax}(R) = PWL_R - 5 - 10log_{10}d_1 + 10log_{10}\left(\frac{\left(\frac{l}{2d_1}\right)}{1+\left(\frac{l}{2d_1}\right)^2} + \tan^{-1}\left(\frac{l}{2d_1}\right)\right) + \alpha_1 \quad --- \text{Fomula 1}$$

Where, $L_{Amax}(R)$: maximum value of noise level (decibel)

PWL_R : Sound source power level (decibel)

$PWL_R = 30.0 \log_{10}(V) + 42.6$

D_1 : Distance between center of run orbit and sound receiving point (m)

L : Train length (m)

V : Train velocity (km/h)

α_1 : damping effect by balustrade (decibel)

(a.2) Structure sound

$$L_{Amax}(C) = PWL_C - 5 - 10log_{10}d_2 + 10log_{10}\left(\frac{\left(\frac{l}{2d_2}\right)}{1+\left(\frac{l}{2d_2}\right)^2} + \tan^{-1}\left(\frac{l}{2d_2}\right)\right) + \varDelta L_C \quad --- \text{Formula 2}$$

Where, $L_{Amax}(C)$: Maximum value of noise level (decibel)

PWL_C : Sound power level of structure sound (decibel)

$PWL_C = 72$

d_2 : Distance between center of structure underside and sound receiving point (m)

$\varDelta L_C$: Correction value

$r < 4h$: $\varDelta L_C = 0$

$r > 4h$: $\varDelta L_C = -10 \log_{10}(r/4h)$

r: Horizontal distance between center of viaduct and sound receiving point (m)

h: Height of viaduct underside from ground (m)

(a.3) Maximum value of noise level (L_{Amax})

The maximum value of noise level for one (1) train formation is calculated by combining noise levels calculated by Formula 1 - 2.

$$L_{Amax} = 10log_{10}\left(10^{\frac{L_{Amax}(R)}{10}} + 10^{\frac{L_{Amax}(C)}{10}}\right) --- \text{Formula 3}$$

b. *Relation between estimation of maximum value of noise level (L_{Amax}) and single event sound exposure level (L_{AE})*

The relation between estimation of maximum value of noise level (L_{Amax}) and single event sound exposure level (L_{AE}) is calculated by using Formula 4.

$$L_{AE} = L_{Amax} + 10log_{10}(l/(1000V/3600)) --- \text{Formula 4}$$

c. *Calculation of equivalent continuous sound pressure level (L_{Aeq})*

$$L_{Aeq} = 10log_{10}\left(\frac{1}{T}\sum_{i=1}^{n} 10^{L_{AEi}/10}\right) --- \text{Formula 5}$$

Where, L_{AEi}: Single event sound exposure level by direction and train type (decibel)

N : Number of trains

T : Time for L_{Aeq} (second)

・ Condition of prediction:

Prediction year		2058
Train length		20m x 8 cars
Maximum operation speed		100km/h
Total number of operated train(on-way)		284 Day time(7:00~22:00) 252 Night time (22:00~7:00) 32
Structure	Width of viaduct	3m+4m+3m
	Height of rail	8m
	Truck	Slab
	Rail type	Long rail
	Mitigation measures	Noise barrier H=1.0m, 1.5m

・ Criteria: Noise guideline values for the new project and large-scale modification of the conventional railway in Japan (Environmental Agency, 1995)

Results of the prediction are shown on Table 5.6.9.

Table 5.6.9 Prediction of Noise Level during Train Operation after

		Day time (7:00~22:00)	Night time (22:00~7:00)
Mitigation measures (Noise barrier)	No mitigation measures	71.8	65.1
	1.0m	59.5	52.8
	1.5m	59.0	52.2
Guideline values Noise guideline values for the new project and large-scale modification of the conventional railway in Japan (Environmental Agency, 1995)		60	55

Source: JICA Study Team

Without the mitigation measures, railway noise will exceed the guideline. With installation of noise barrier, railway noise is expected to meet the guideline. Since noise barrier is very common measures for noise mitigation, the installation of noise barrier is proposed as noise mitigation measures of the project.

6) Ground Subsidence

Based on geological survey, study team is examining suitable structure and construction method to secure ground stability. This F/S proposes tunnel boring by shield machine for the alignment of underground. Details of structure and construction plan will be developed on D/D (detail design) study. Safety against ground subsidence should be continuously monitored on D/D study.

7) Bottom Sediment

As mentioned in “Water Quality”, the alignment passes through the water bodies by underground structure. Therefore, the project will not directly cause negative impacts to bottom sediment.

8) Ecosystem

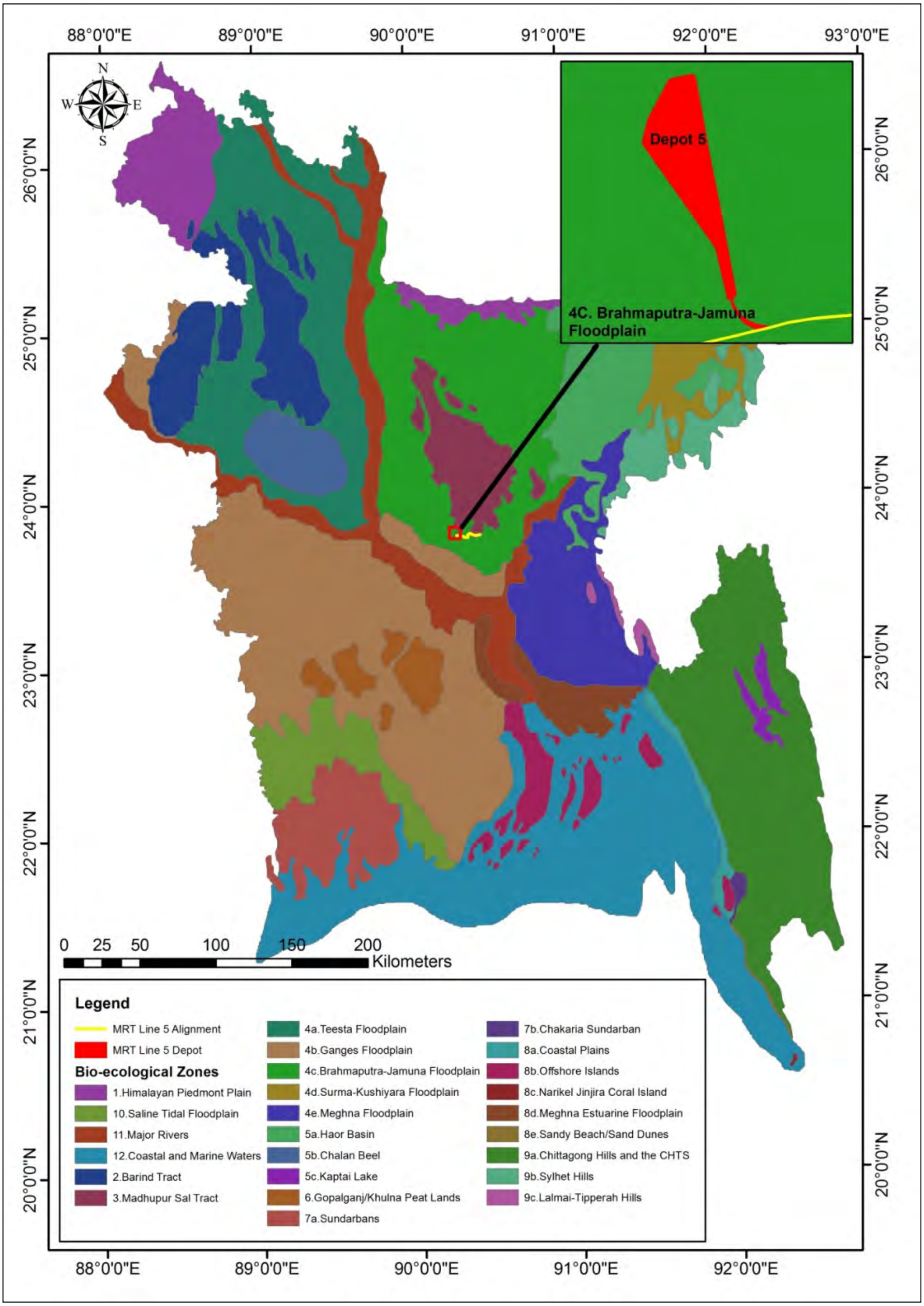
(1) Ecosystem

In the project sites which are urbanized, the only Agro-ecosystem, Homestead ecosystem and wetland ecosystem are still existed in the west of Amin Bazar.

The depot area of MRT line 5 is a depressed land as well as agricultural land. During the monsoon season the depot land is inundated by the River water whereas the agricultural production has been carried out in the depot area during the dry period. Fish are found in the depressed area as the depot site is connected with the River.

(2) Bio-Ecological Zone

Twenty-five bio-ecological zones have been delineated within Bangladesh by the IUCN. Six parameters were used to determine the areas including: physiography, soil, rainfall and temperature, floral distribution, faunal distribution and flood depth (IUCN 2002). The depot site falls in Brahmaputra-Jamuna Floodplain bio-ecological zone (Figure 5.6.5).



Source: IUCN 2002

Figure 5.6.5 Depot Location in Bio-ecological Zones of Bangladesh

(3) Floral Component

The depot area of MRT Line5 has the following floral components. No rare species were observed.

Agricultural Land Vegetation

Some land in the depot area is used for agricultural activities. Generally paddy is cultivated in the agricultural land. Vegetable and mustard has been cultivated in the depot area agricultural land during winter season.

Fallow Land Vegetation

Regarding fallow land vegetation, 75% among the 12 species are medicinal plants, 17% vegetables and 8% cattle fodder.

Grass Land Vegetation

7 families have been recorded with 11 different species and Cyperraceae family has been found three times among those species. The second dominating family was Poaceae and Compositae which found twice during the survey tenure. Among the common grasses species *Cyperus rotundus, Cynodon doctylon, Amaranthus philoveroides, Alternanthera sessilis, Alerodendron viscosum* and *Eurena loba were notable*.

Trees

Although the depot site is almost occupied by the agricultural land vegetation, groups of trees are scattered. Table 5.6.10 shows observed trees. On the table, *Swietenia mahogoni* is designated as Endangered species. However, it isestimated that it is not an inherent species in Bangladesh, but planted

Table 5.6.10 List of Trees in the Depot Area

Spot Number	Location	Local name of tree found	Scientific name	Number
T1	23°47'59.5"N 90°16'36.0"E	Mango Java Plum Guava Indian Jujube Indian ash tree Aambra Jackfruit	*Mangifera indica* *Syzygium cumini* *Psidium guajava* *Zizyphus mauritiana* *Lannea coromandelica* *Spondias pinnata* *Artocarpus heterophyllus*	8 3 4 2 15 1 2
T2	23°48'3.80"N 90°16'35.16"E	Eucalyptas	*Eucalyptus spp.*	35
T3	23°48'26.2"N 90°16'26.7"E	Peepul tree neem Jackfruit Acacia LC Mango Mehogani	*Ficus religiosa* *Azadirachta indica* *Artocarpus heterophyllus* *Acacia auriculiformis* *Mangifera indica* *Swietenia mahagoni*	5 2 1 4 1 2
T4	23°48'23.0"N 90°16'26.7"E	Peepul tree	*Ficus religiosa*	2
T5	23°48'19.8"N 90°16'26.7"E	Teak tree Rain tree Eucalyptus Mehogani	*Tectona grandis* *Samanea saman* *Eucalyptus spp.* *Swietenia mahagoni*	2 7 22 24
T6	23°48'15.3"N 90°16'26.8"E	Rain tree	*Samanea saman*	2
T4	23°48'23.0"N	Peepul tree	*Ficus religiosa*	2

Spot Number	Location	Local name of tree found	Scientific name	Number
	90°16'26.7"E			
T5	23°48'19.8"N 90°16'26.7"E	Teak tree Rain tree Eucalyptus Mehogani	*Tectona grandis* *Samanea saman* *Eucalyptus spp.* *Swietenia mahagoni*	2 7 22 24
T6	23°48'15.3"N 90°16'26.8"E	Rain tree	*Samanea saman*	2
T7	23°48'16.7"N 90°16'24.1"E	Showy Silk Cotton Tree Rain tree	*Bombax insigne* *Samanea saman*	12 14
T8	23°48'15.4"N 90°16'22.2"E	Mehogani Rain Tree	*Swietenia mahagoni* *Samanea saman*	7 18
T9	23°48'20.4"N 90°16'31.0"E	Peepul tree Crack willow	*Ficus religiosa* *salix fragilis*	4 1

Source: JICA Study Team

Aquatic Vegetation

Total of 16 aquatic species belonging 12 families were found. List of aquatic vegetation is shown in the following Table 5.6.11.

Table 5.6.11 List of Aquatic Vegetation in the Depot Area

	Common Name	Family name	Scientific name	Types	Uses	Red Data Book of Bangladesh (National Herbarium Bangladesh 2001)
1.	Alligator Weed	Amaranthaceae	*Alternanthera philoxeroides*	Herb	Medicine	Not Evaluated
2.	Coco Yam	Araceae	*Colocasia esculenta*	Herb	Medicine	Not Evaluated
3.	Flatsedge	Cyperaceae	*Cyperus sp.*	Herb	Medicine	Not Evaluated
4.	Common Water Hyacinth	Pontaderiaceae	*Eichhornia crassipes*	Herb	Medicine	Not Evaluated
5.	Helencha	Cyperaceae	*Enhydra fluctuans*	Herb	Medicine	Not Evaluated
6.	Swamp Morning-Glory	Convolvulaceae	*Ipomoea aquatica*	Herb	Vegetable	Not Evaluated
7.	Four Leaf Clover	Mersileaceae	*Marsilea quadrifolia*	Herb	Vegetable	Not Evaluated
8.	Arrow Leaf Pondweed	Pontaderiaceae	*Monochoria hatata*	Herb	Fertilizer	Not Evaluated
9.	Water Lily	Nymphaeaceae	*Nymphaea nouchali*	Herb	Ornamental & vegetable	Not Evaluated
10.	Tall Reed	Gramineae	*Phragmites karka*	Herb	Grass	Not Evaluated
11.	Denseflower Knotweed	Polygonaceae	*Polygonum glabrum*	Herb	Grass	Not Evaluated
12.	Bishkatali	Polygonaceae	*Polygonum lanatum*	Herb	Medicinal	Not Evaluated
13.	Asian Water moss	Salviniaceae	*Salvina cucullata*	Herb	Fertilizer	Not Evaluated
14.	Common Duckweed	Lemnaceae	*Spirodela polyrhiza*	Herb	Fertilizer	Not Evaluated
15.	Sticky Nightshade	Solanaceae	*Solanum sisymbriifolium*	Shrub	Aesthetic	Not Evaluated
16.	Water Lettuce	Araceae	*Pistia stratiotes*	Herb	Fertilizer	Not Evaluated

Source: JICA Study Team

(4) Faunal Component

Birds (Avifauna)

A total of 22 species belongings of 15 families have been founded at the depot site. All species are least concern (LC) according to IUCN Red List 2015. A detail of bird's species checklist is presented in Table 5.6.12.

Table 5.6.12 Bird Species in the Depot Area

	Local Name	Common Name	Scientific name	Family	IUCN status Bangladesh 2015
1.	Doyel	Oriental Magpie Robin	*Copsychus saularis*	Muscicapidae	LC
2.	Deshi Kanibok	Indian Pond Heron	*Ardeola grayii*	Ardeidae	LC
3.	Chhoto pankouri	Little Cormorant	*Microcarbo niger*	Phalacrocoracidae	LC
4.	Kala Fingey	Black Drongo	*Dicrurus macrocercus*	Dicruridae	LC
5.	Gash pakhi	Striated Grass bird	*Megalurus palustris*	Locustellidae	LC
6.	Pati Chorui	House Sparrow	*Passer domesticus*	Passeridae	LC
7.	Telia Ghughu	Spotted Dove	*Spilopelia chinensis*	Columbidae	LC
8.	Pati Hoodhood	Common Hoopoe	*Upupa epops*	Upupidae	LC
9.	Pakra Shalik	Asian Pied Starling	*Gracupica contra*	Sturnidae	LC
10.	Dhan salik	Common Myna	*Acridotheres tristis*	Sturnidae	LC
11.	Pati Maachranga	Common Kingfiher	*Alcedo atthis*	Alcedinidae	LC
12.	Pati Kak	House Crow	*Corvus splendens*	Corvidae	LC
13.	Bulbuli	Red-vented Bulbul	*Pycnonotus cafer*	Pycnonotidae	LC
14.	Sada Bok	Little Egret	*Egretta garzetta*	Ardeidae	LC
15.	Dar Kak	Jungle Crow	*Corvus levaillantii*	Corvidae	LC
16.	Moutusi	Sun bird	*Nectarinia asiatica*	Nectariniidae	LC
17.	Dholagola Maachranga	White-throated Kingfisher	*Halcyon smyrnensis*	Alcedinidae	LC
18.	Metepith Latora	Grey-backed Shrike	*Lanius tephronotus*	Laniidae	LC
19.	Pati Fotikjol, Towfi	Common Iora	*Egithina tiphia*	Aegithinidae	LC
20.	Bon salik	Jungle Myna	*Acridotheres fuscus*	Sturnidae	LC
21.	Kath Shalik	Chestnut-tailed Starling	*Sturnus malabaricus*	Sturnidae	LC
22.	Lenja Latora	Long tailed shrike	*Lanius schach*	Lanidae	LC

Source: JICA Study Team

Amphibians and Reptiles

A total 5 species belonging same number of families has been found in the depot area. Among the observed species, Bengal Monitor (*Varanus bengalensis)* has been found Near Threatened according to the IUCN red list status 2015 whereas rest of the species is Least Concern. Because Bengal Monitor is categorized to NT but not endangered species, some special considerations will be not required. A detail species list has been provided in Table 5.6.13.

Table 5.6.13 List of Amphibians and Reptiles in Depot Area

SL.	Local Name	*English Name*	Scientific Name	Family	IUCN Red List Status (Regional)
1.	Anjon	Common Skink	*Eutropis carinata*	Scincidae	LC
2.	Gui shap	Bengal Monitor	*Varanus bengalensis*	Varanidae	NT
3.	Lamba Leiz Roktochusa	Long-tailed Lizard	*Takydromous khasiensis*	Lacertidae	LC
4.	Kono bang	Asian Common Toad	*Duttaphrynus melanostictus*	Bufonidae	LC
5.	Tiktiki	Common House Gecko	*Hemidactylus frenatus*	Gekkonidae	LC

Note: LC-Least Concern, NT-Near Threatened

Source: JICA Study Team

Mammals

It has been recorded 4 mammal's species belonging three families in the study area. Mammals that were found within the project area are Small Asian Mongoose (*Herpestes auropunctatus*), Golden Jackal (*Canis aureu*), Little Indian field mouse (*Mus booduga*), and House mouse (*Mus musculus*). According to the IUCN red list status 2015, all species are least concern.

Fish

The depot site is almost depressed area and it is inundated by the River water during the monsoon season. Water present in the depressed area almost throughout the year and different types of fish species has been found in the depressed area. According to the fisheries officer and local people total 15 fish species belongings to 10 families are found in the depot area. All species are least concern status according to the IUCN red list status 2015. The checklist of the fish species in the depot area has been provided in Table 5.6.14.

Table 5.6.14 Checklist of Fish Species in the Depot Area

Sl.	Local Name	English Name	Scientific Name	Family	IUCN Red List Status Bangladesh 2015
1.	Guchi Baim	Striped spinyeel	*Macrognathus pancalus*	Mastacembelidae	LC
2.	Khailsha	Giant gourami	*Colisa fasciata*	Osphronemidae	LC
3.	Lal Khalisha	Red gourami	*Colisa lalia*	Osphronemidae	LC
4.	Koi	Climbing perch	*Anabas testudineus*	Anabantidae	LC
5.	Bele	Tank goby	*Glossogobius giuris*	Gobiidae	LC
6.	Shol	Striped snakehead	*Channa striatus*	Channidae	LC
7.	Taki	Spotted Snakehead	*Channa punctatus*	Channidae	LC
8.	Shing	Stinging catfish	*Heteropneustes fossilis*	Heteropneustidae	LC
9.	Magur	Air breathing Catfish	*Clarias batrachus*	Clariidae	LC
10.	Gutum	Cross fish	*Lepidocephalichthys guntea*	Cobitidae	LC
11.	Rui	Rohu	*Labeo rohita*	Cprinidae	LC
12.	Catla	Catla	*Catla catla*	Cyprinidae	LC
13.	Chola Punti	Swamp barb	*Puntius chola*	Cyprinidae	LC
14.	Jat punti	Pool barb	*Puntius stigma*	Cyprinidae	LC
15.	Mola	Mola carplet	*Amblypharyngodon mola*	Cyprinidae	LC

Note: LC-Least Concern

Source: JICA Study Team

Most of the project area is developed area. On the other hand, the depot location is still undeveloped. As results of field survey on the depot location, various species were observed. However, no rare species such as "threatened" of IUCN Red List were observed.

However, the area around the depot site is still undeveloped, natural environment will be left in future. Monitoring of the natural environment around the project site should be conducted continuously.

9) Hydrology

As mentioned in “Water Quality”, the alignment passes through the water bodies by underground structure. Therefore, the project will not directly cause negative impacts to hydrology.

10) Groundwater

To understand current conditions of groundwater quality along the MRT Line 5, water quality survey was conducted. Ground water samples were taken from 6 existing wells along the MRT line 5. The ground water samples were collected on 19th to 22nd March 2017. Detail Sampling Locations are provided in the following Table 5.6.15 and shown in the Figure 5.6.2.

Table 5.6.15 Ground water Sampling Location of MRT Line 5

	Location	Sampling ID	Geographic Coordinate
1.	Abdul Malek house, Guydar Tak, Gabtoli	GW5-1	23°46'44.0"N 90°20'49.7"E
2.	Mirpur Bangla College WASA pump	GW5-2	23°47'03.6"N 90°21'10.5"E
3.	Mirpur 10 WASA Pump	GW5-3	23°48'24.4"N 90°22'24.5"E
4.	Police Staff Collage Mirpur 14	GW5-4	23°48'15.3"N 90°22'47.1"E
5.	Banani DOHS Pump House	GW5-5	23°47'33.59"N 90°23'51.38"E
6.	Vatara WASA Pump house	GW5-6	23°47'44.7"N 90°26'14.6"E

Source: JICA Study Team

Results of the survey are shown on Table 5.6.16. In Bangladesh, there is no standard for groundwater. Whole parameter of whole locations meets the permissible limit in accordance with the Environmental Conservation Rules (Standards for drinking water), 1997. As drinking water, the underground water keeps good condition.

In Bangladesh, arsenic contamination of groundwater is crucial problem. Fortunately, concentration of arsenic along the project area is very low comparing the standards. Even comparing Japan standards on underground water quality (Arsenic: 0.01mg/l: MoE, J), it is still low.

Table 5.6.16 Ground Water Quality of MRT Line 5

Parameter	Unit	GW5-1	GW5-2	GW5-3	GW5-4	GW5-5	GW5-6	ECR, 1997 Standard
Depth of the Tube well/Pump	m	122	275	275	305	275	275	-
Colour	Hazen	0.9	1.3	1.0	1.7	0.8	1.0	15
Temperature	˚C	25.9	23.8	24.9	29.3	28.3	26.8	-
pH	-	6.75	7.14	6.78	6.96	7.06	26.80	6.5-8.5
Sodium	mg/l	28	29	24	28	23	17	200
Potassium	mg/l	04	04	03	03	03	03	12
Calcium	mg/l	10	15	07	07	09	05	75
Bicarbonate	mg/l	170	205	135	160	165	90	-
Chloride	mg/l	12	16	13	15	14	12	150-600
Sulfate	mg/l	02	1.0	02	1.0	1.0	1.0	400
Nitrate	mg/l	0.10	< LOQ	< LOQ	2.38	< LOQ	0.28	10
Nitrite	mg/l	< LOQ	< LOQ	0.017	< LOQ	< LOQ	< LOQ	<1.0
Arsenic	mg/l	0.002	0.001	0.001	0.003	0.002	0.001	0.05
Fecal Coliforms	N/ 100ml	0	0	0	04	0	0	0

Source: JICA Study Team, EQMS Laboratory and Department of Public Health and Engineering Lab; Analysis date: 22/03/2017- 30/04/2017 and 30/04/2017-22/05/2017 Note: LOQ- Limit of Quantitation

Dhaka city depends on groundwater for water supply. The underground structure may cause negative impacts to the ground water.

Water extraction in Dhaka is conducted below 100m of ground level. (see “depth of the tube well/pump” of Table 5.6.15) The railway level of the underground structure is about -10m to -40m (refer to 4.1.4). Therefore the underground structure will not cause negative impacts to the groundwater.

11) Geographical Features

(See “6) Ground Subsidence”)

12) Resettlement and Land Acquisition

The project will have direct impact on 1,107 PAUs including 29 residential households. In addition, 24 CPRs are going to be affected.

All these losses will be compensated and it is expected that they will find their own place or means to resettle and rehabilitate them. Certainly the project will extend additional support to the vulnerable APs. Without RAP, restoration oh livelihood would be very difficult for them.

A total of 21.995 ha land will be required to be acquired and 1.57 ha of land will be required in different pockets along the route, mainly in the station areas.

13) Poor People

It is defined that annual income less than Tk 108,000 is hard core poor in Bangladesh. Considering the economic condition of the project area, these 4.8% affected households may be considered as hard core poor. The hard core poor and poor households will get special assistance under the policy of RAP. Special assistance will be paid to those who are women headed, old aged and physically handicapped and supported income generation activities under LIRP.

14) Ethnic Minorities and Indigenous Peoples

More than 97% of the affected HHs are Muslim and rest are Hindu by religious believe. No other religious group of people was identified among the affected people in the project area.

In Bangladesh, the term “indigenous people” is a generic term that includes many different cultural categories including ethnic minorities, tribals, upajati, paharis and jhumias. However, the most commonly used and preferred term today is adibasi,or ethnic minority which encompasses all of the above under one “identity” as indigenous people who have distinct social origins and cultural lives. They constitute nearly 1.1% of the total population of Bangladesh, with a major concentration in the Chittagong Hill Tracts (CHT) area. Among the project affected people no ethnic minority people have been identified in the project area.

15) Local Economies, such as Employment, Livelihood, etc.

Many of the stations under this project are located nearer to the business center where people usually gather. This is why people who are living around the area have established business and some small shops by some arrangement or are just encroachers on government land, where they got the opportunity. It is found that approximately 91% household heads are involved in business. A total of 0.7% of the household heads’ principal occupation is service in government or other organizations, 1.5% are involved in rickshaw/van pulling or work as mechanic and 1.4% are involved with household work. They are mainly the female heads of the households. On the other hand 0.3% is aged/retired and have no specific income source. About 0.6% household heads are involved with other type of occupation; many of them are working as labor with special skill.

16) Land Use and Utilization of Local Resources

The most of the acquired land is being used for agricultural purpose and portion of it being used as homestead. However and majority of the land area where MRT routes would pass above and under the ground and the stations above and under the ground is owned by the government and mostly being used as road network in the city. Along these routes and station area most of the project affected units are business and commercial premises. Some industries are coming in the vicinity, mainly along the road from Amin Bazar to Hemayetpur. People are having their livelihood and operating business by utilizing the road network facilities.

There are some green areas or some tree covered area in the project area. This area is again mostly around the depot area in Hemayetpur. The project will also require felling of 938 trees of various sizes and categories from the surveyed area. Majority are fruit bearing trees.

17) Water Usage

As mentioned on "Groundwater", the project will not cause negative impacts the groundwater which is origin of water supply in Dhaka. Therefore the project will not cause negative impacts to water usage.

18) Existing Social Infrastructures and Services

The project area covers both the DNCC and DSCC of Dhaka and Savar Upazila and administered by Mayors and councillors as part of local government. However, for administration the project area is within Dhaka District. In addition to Dhaka district administration many other agencies are involved like RAJUK, DWASA, PDB, RHD and others.

The alignment of MRT will cross existing power cable, drinking water pipe, and water drainage etc., further study aims to specify those utilities and to take actions to protect or divert them.

19) Social Structure such as Social Capital and Local Decision-Making Institutions

The society in Bangladesh in general is a traditional society. However, the city society has some unique characteristics like any other city dwellers with diversified social back ground of the migrant people coming from different areas of the country.

The identified 24 Common Property Resources (CPR) as social institutions or resources which are going to be affected by the project. The CPRs include mosque, madrasa, school/college, mazar, offices etc.

20) Misdistribution of Benefits and Damages

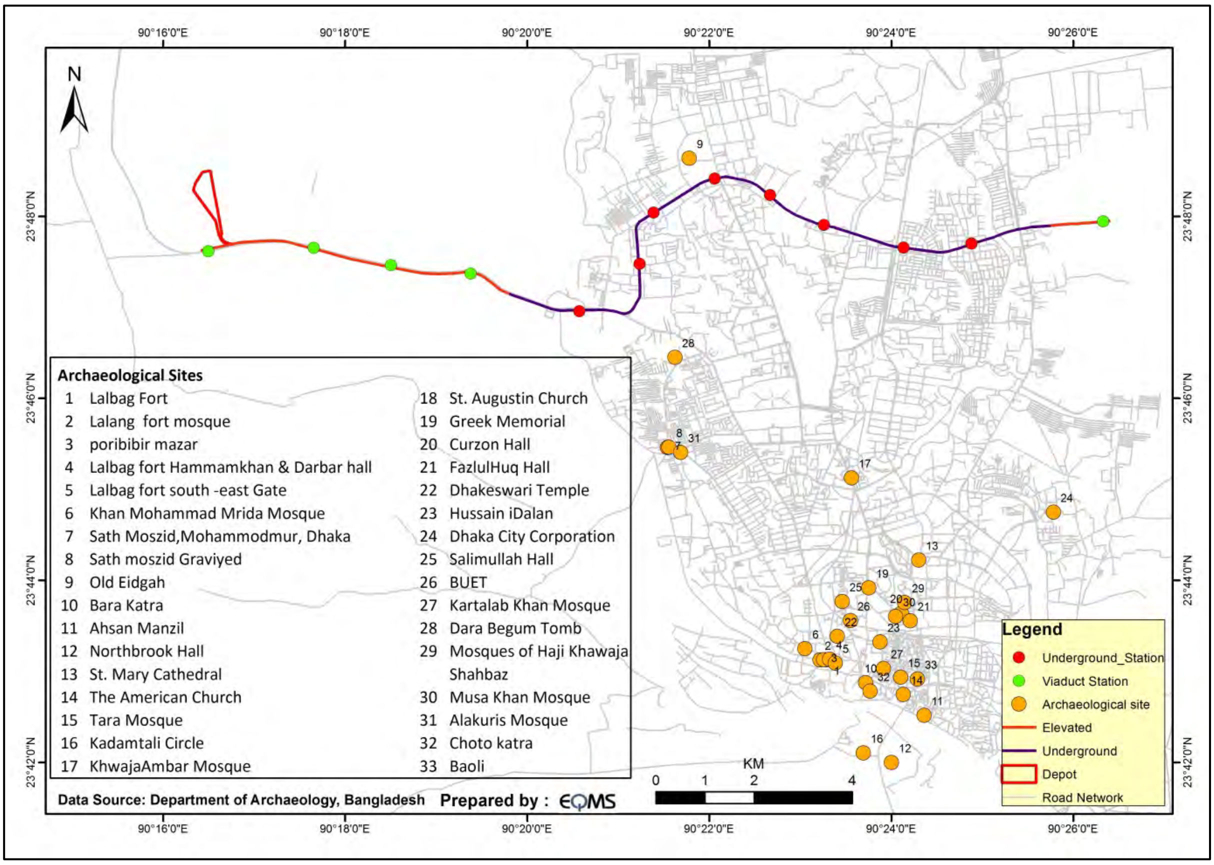
The benefit of the MRT line will not be distributed evenly to all the people along the line equally. Certainly the people near the station area in general will be benefitted more. However, only the affected people will have to bear the burden of damages like loss of assets and livelihood. It is speculated that the economically solvent affected people will be able to recover their damages through receiving compensation and utilizing the locational opportunity of the new infrastructure provided by the project. But the vulnerable and marginal APs will be difficult without assistance and they need support on income generation activities under LIRP.

21) Local Conflicts of Interest

Local conflicts are mainly generated through abuse of power by some group of people or by some individuals. Local problems and conflicts are mainly resolved through local informal and formal groups with the help of representatives from local government and when necessary other respective agencies get involved.

22) Cultural Heritage

Dhaka has a lot of cultural heritage. However, the cultural heritages concentrated on the Old Dhaka area. As a result of the survey of secondary materials such as an official information (List of Monuments: Department of Archaeology), there is no cultural heritage around the project. The project will cause negative impacts to cultural heritages.



Source: Department of Archeology, Bangladesh

Figure 5.6.6 Archaeological Heritage in Dhaka city

23) Landscape

On the section between Amin Bazar and Hemayetpur, viaduct structure is adopted. Since the area is wetlands, lakes and agricultural lands where brick factories scatter, viaduct may affect landscape.

On stakeholder meetings (second stage), the attendants of the meetings were asked about issues of landscape. However, there are no response. Because tangible design cannot be proposed on the F/S stage, landscape and design of the viaduct should be continuously consulted with stakeholders on D/D stage.

24) Gender

As a result of focus group discussion which targeted women group, their needs were specified as follows.

Design of Station

- Separate ticket booths for male and female passengers
- Separate washrooms for male and female passengers
- Separate prayer rooms (space) for male and female passengers
- Adequate lighting facilities
- Clean waiting room (space) and platform
- Installation of escalator/lift
- Installation of drinking water facility
- Allocation of vendor (small business) area (space) for women

Design of Rolling Stock

- Separate compartments for male and female passengers
- Reserved/priority seats for pregnant women, women with young children, children, elderly people and physically challenged passengers
- Adequate lighting

Construction

- Employment of women for construction work
- Equal pay/work/opportunities for male/female workers
- Employment of women for construction project related work (e.g.: supporting staff, cooking, cleaning, laundry, catering, etc.)
- Separate prayer rooms (space), washroom, changing rooms, dining space (different timing between male/female for lunch break) for male/female workers/staff
- Provision of training to raise awareness on gender
- Provision of training on prevention of HIV/AIDS

Operation

- Deployment of female staff for both ground operation and on board
- Setting affordable fares
- Setting time schedule to meet women's needs
- Keep clean (station, platform, train, etc.)
- Responding to gender issues, measures on sexual harassment and implementation of those

Others

- Concerning the resettlement plan, consideration should be given to the women so that they will also be able to obtain financial compensation

- In relation with the above, not only the financial compensation but provision of employment opportunities should be also considered

During the planning stage, women's opinions should be heard as well as women's participation of decision making should be secured.

25) Children's Rights

As a result of the survey of maps, it was confirmed that there was a lot of school around the project site, especially in Mirpur area. (Figure 5.6.9) Because the structures of the project are viaduct and underground, school-commuting roads will not be divided. However, on the construction stage, appropriate considerations to secure the school-commuting roads will be required on construction plan.

26) Infectious Diseases such as HIV/AIDS

HIV prevalence rate is less than 0.1% and it is still low in Bangladesh. However, the sufferers are sometimes found among sex workers in Mongra and Chittagong. It is reported that that risk due to the turn used needles is much higher than sexual intercourse.

Influx of construction workers by the project may trigger the prevalence of the HIV/AIDS. To avoid the prevalence of the HIV/AIDS, Appropriate education and enlightenment for the construction workers should be introduced on construction sites.

27) Working Conditions (including Occupational Safety)

It is necessary to secure the safety of workers, pedestrians and vehicular traffics in both in construction and operation phases. Many temporary shops and vendors are found in crowded streets. There might be a possibility that those shops have tendency the lack of consideration on occupational safety. The construction sites have to pay attention to those small shop workers.

28) Trans-Boundary Impacts or Climate Change

Construction machinery will temporarily increase greenhouse gas. Reducing the emission of greenhouse gas, the machinery needs to well maintain. And/or the introduction of energy saving machinery is desirable.

On the depot site, it is expected that 938 trees are logged. Tree cutting losses absorption of greenhouse gas. Because annual CO_2 absorption of a tree is roughly 80kg, totally CO_2 absorption of roughly 75t is lost. It is equivalent to CNG of roughly 28t. As mitigation measures, the study team proposes replanting for tree cutting.

Train operation generates modal shift from vehicle traffic to mass transit system. The operation of the railway can increase greenhouse gasses by power consumption generated by thermal power plants. However, because train operation is remarkably energy saving measures comparing vehicle traffic, the project will contribute to reduce the emission of greenhouse gas. The implementation of the project will decrease 39,491t of CO_2 emission a year. (Chapter7, 7.1.4)

Table 5.6.17 Reduction Volume of CO2 Emission by MRT Line 5

			Value	Unit
Emission reduction			39491	tCO_2/year
Baseline emission			139381	tCO_2/year
	Number of passenger of the project activity in year y		448,950,000	passenger/year
	Average trip distance of the passenger of the project activity in year y		7.9	km
	CO_2 emission factor per passenger kilometer for transport mode i	Auto Tempo	3.41945E-05	tCO_2/passenger-km
		Microbus	0.000117188	tCO_2/passenger-km
		Standard Bus	2.35647E-05	tCO_2/passenger-km
	Share of passengers by transport mode i in the baseline scenario in year y	Auto Tempo	7.289	%
		Microbus	15.729	%
		Standard Bus	76.982	%
		Other1	0	%
		Other1	0	%
		Other1	0	%
Project emission			99890	tCO_2/y
	Annual electricity consumption associated with the operation of the project activity in year y		219058	MWh/year
	CO_2 emission factor of the grid electricity		0.456	tCO_2/MWh

Source: JICA Study Team

29) Risk of Flood

Dhaka city is flood prone area. (see 2.3.2 Hazards) On the past major inundations, a part of the project such as Gulshan2 and Mirpur10 has been inundated. (Figure 5.6.7)

Source: RSTP, Figure6.28 The inundation map of Greater Dhaka, 2004, location of MRT Line5 is added.

Figure 5.6.7 Inundation Risk around MRT Line 5 (location of inundation on September, 2004)

Flood disaster may cause inundation to underground structure of the project. And the project may also encourage flood disaster. Against the negative impacts of flood and inundation, the project proposes the following mitigation measures.

(1). Mitigation measures on the project

Against potential risk of flood hazard, the project will introduce the anti-inundation measures taken in subway projects in Japan such as the followings.

- Provision of waterproof wall considering the flood level against 100-year probability rainfall
- Provision of roof
- Provision of waterproof door at entrance of tunnel
- Provision of drain pump

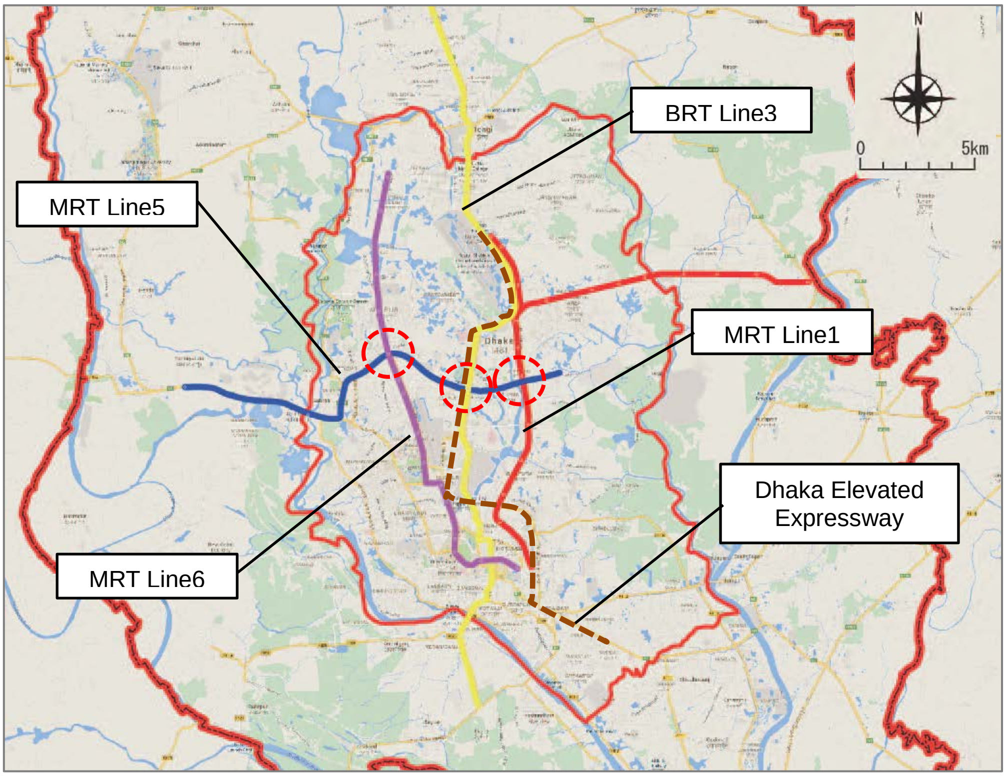
(2). Negative impacts by the project

Because of underground and viaduct structures, the alignment of the project does not hamper draining and flow of inundation, and does not encourage the flood disaster.

RSTP which is a basic plan of the project proposes the decentralization of urban areas. Backbone which supports the scenario is MRTs. The project is expected to connect suburb and urban areas effectively, and promote dispersion from inundation areas to suburb areas which is anti-disastrous.

5.6.2 Accumulated Impacts by other Projects

There are some major projects in Dhaka city. Due to overlapping with construction of other projects, it is expected that negative impacts increase. Particularly, it should be noted that negative impacts increase at crossing points or parallel sections especially on construction period. Therefore construction period of both projects needs to be confirmed. MRT Line 5 will cross MRT Line6, BRT Line3, Dhaka Elevated Expressway and MRT Line1. (see Figure 5.6.8)



Source: JICA Study Team

Figure 5.6.8 Major Projects in Dhaka

1) MRT Line 6

MRT Line 6 is an urban railway which connects the northwest and the south in Dhaka city. MRT Line 6 crosses the project at the intersection at Mirpur10. Mirpur10 station is a junction station with MRT Line 6 station.

To aim at the operation in 2021, MRT Line6 project is commencing construction work at a part of section. Construction Package including Mirpur 10 station (CP-4) is going to be commenced from 2017 to 2020. Because construction period of MRT Line 5 is from 2022, construction work of both projects will not overlap. Therefore accumulated impacts are not expected.

2) Dhaka Elevated Express

Dhaka Elevated Express (DEE) is an elevated road project which connects Shahjalal International Airport, Mohakhali, Kamalapur and Dhaka Chittagong Highway. DEE crosses MRT Line 5 at the intersection at Banani station.

DEE project is ongoing, and is going to reach the completion at December 2020. Since commencement of the construction work of MRT Line 5 is 2022, construction work of both projects will not overlap. Therefore, accumulated impacts are not expected.

3) BRT Line 3

The route of BRT Line 3 is divided to North and South section. North section which ADB has sponsored connects Gazipur and Uttara. South section which WB has been sponsored connects Uttara (Airport) -Mohakhali – Ramna- Gulisthan -Keranigonj. A part of the south section of BRT Line 3 shares DEE route, and crosses MRT Line 5 at Banani as same as DEE. Regarding BRT Line 3, some assessments on project feasibility are being conducted by project proponents and donors. Because BRT Line 3 will run existing road or proposed road, accumulated negative impacts will not significant even if construction works of the both projects overlap.

4) MRT Line 1

MRT Line 1 is an urban railway which connects the north, the south and Purbachal area in Dhaka city. MRT Line 1 crosses the project at the intersection at Natun Bazar. Natun Bazar station is a junction station with MRT Line 1 station. Stations of both projects adopt underground structure.

At present, master schedule of MRT Line 1 shows construction period from 2021 to 2025 to aim at the operation in 2026. Since the construction period of MRT Line 5 is from 2022, construction work of both projects may overlap. Natun Bazar is remarkably congested area. In case that construction work of both projects overlaps, cumulative negative impacts including deterioration of traffic congestion, air pollution and traffic noise are expected. To avoid accumulated negative impacts, construction schedule of both project should be sufficiently managed.

5) Cumulative impacts on the Operation Phase

The project connects MRT Line 1, Line 6 and BRT Line 3 at junctions. The junctions will make more liveliness. On the other hand, it is expected that traffic concentration to the junctions causes more congestion. On development around the junctions, considerations to avoid the congestion is required.

5.6.3 Traffic Management in Construction and Expected Negative Impacts

Construction of the alignment is almost carried out at underground. However, because underground stations are constructed by open-cut method, road traffic will be affected by restriction of lanes. During the construction of stations, traffic management will be conducted to minimize restriction of lanes and a part of construction work will be conducted at night to avoid road congestion. As negative impacts by lane control, traffic congestion and pollution caused by the traffic congestion are assumed.

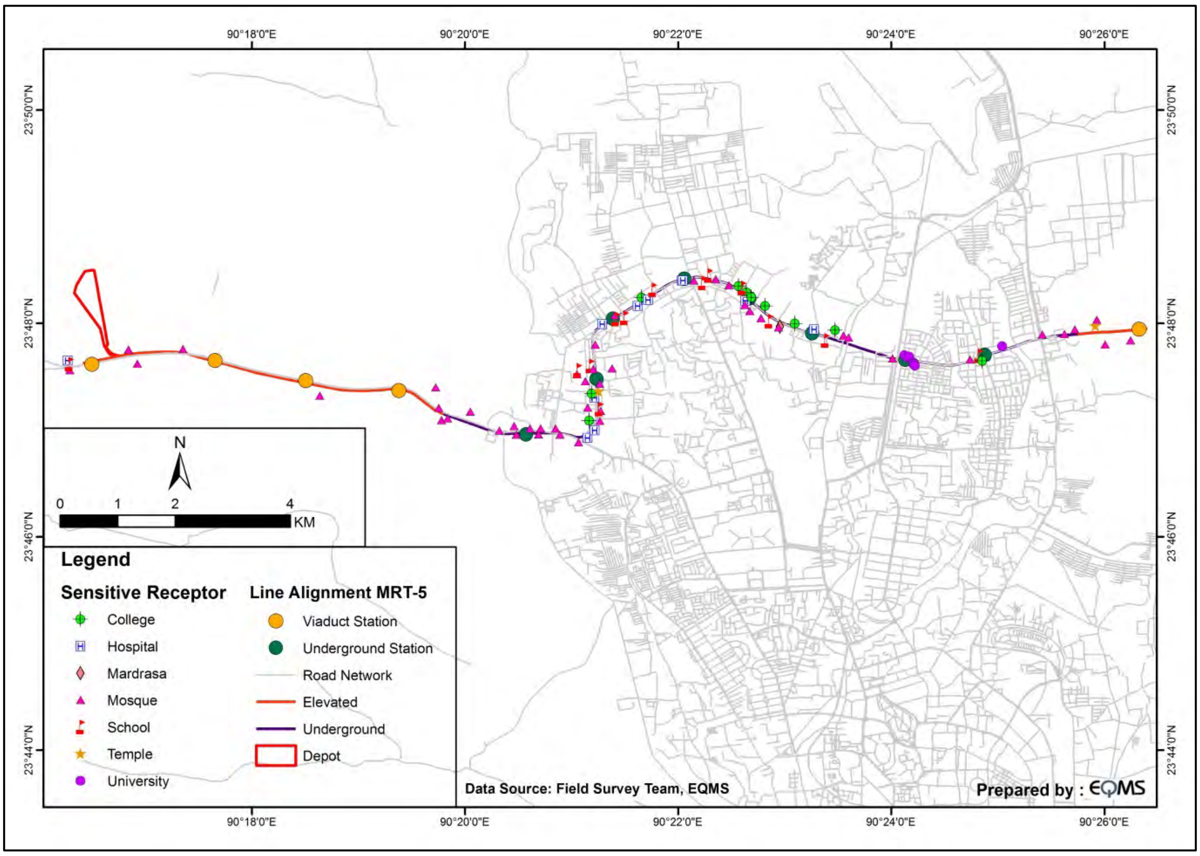
Regarding air pollution, because cause of the air pollution in Dhaka is thought of as dust, road congestion will not directly cause increase of dust. Regarding traffic noise, because it depends on traffic volume, traffic noise will not increase without increase of traffic volume.

5.6.4 Concentration of Vehicle Traffic around Stations

Because the project runs parallel to major roads, it is expected that the traffic volume of the major roads is reduced. On the other hand, it is also expected that vehicle traffic concentrates the new stations. In case that, noise and air pollution may be worsen. To handle the vehicle traffic smoothly and mitigate the negative impacts, appropriate developments around the stations are needed. In this study, expected impact of MRT and development policy of TOD were studied. As measures for handling road traffic concentrating around stations, development in front of /around the stations, access to MRT including pedestrian, connection to other MRTs /BRT/BR were proposed. Regarding development in front of /around the stations, conversion of construction yards, public land and road space are expected.

5.6.5 Sensitive Facilities

The alignment of the project passes the urban area, and there is a lot of sensitive facilities along the alignment. Figure 5.6.9 shows locations of sensitive facilities such as educational, religious and medical institutes around the alignment of the project. Mosques are evenly scattering on the whole section. On the other hand, educational and medical institutes are concentrating from Dar-Us-Salam to Banani, especially around Mirpur area. The structure of these areas is underground. However, station will be constructed by open-cut. More flexible considerations against air pollution and noise should be taken on these areas. Since the structure of the project is underground and viaduct, there is no possibility that the structure cuts access path to these facilities.



Source: JICA Study Team

Figure 5.6.9 Sensitive Facilities along MRT Line5

5.6.6 Considerations on Procurement of Materials

The project requires to procure general materials used on construction work. The quantity of concrete which is a main material is expected to approximately 470 thousand m3 (except pile work). Because aggregate which is raw materials of concrete is gathered from quarry sites, mass gathering of aggregate may cause negative impacts around quarry sites.

On the other hand, because Bangladesh is no mountainous, it is difficult to gather the aggregate, and depends on import from neighboring countries. The project also similar to other projects. (On the advance work of MRT Line 6 project, aggregate is imported from Thailand.) Because of import, it is out of object of EIA system of Bangladesh. (ECC for quarry site)

Regarding the considerations for material procurements including aggregate, the study team is consulting with the counterpart about the considerations including green procurements. On the consultation which is held on September 2017, this issue was discussed, and the counterparts mentioned that bidding documents can take the considerations on the material procurement. The study team proposes procurement from quarry sites which acquire environmental permit on each country as essential conditions on procurement. About more considerations including the green procurement, consultation is continued with the counterpart.

Construction of the depot site needs filling soil of approximately 680 thousand m3. Because specifications of the filling soil are fixed by detail design, so far location of procurement is not able to be fixed. The counterpart describes this based on the detail design. MRT Line 6 procures filling soil for the depot site from Megna river and Sylheti (north east of Bangladesh). it is expected that the project also follows it.

5.6.7 Issues on Projects assisted by other Donors

Around Dhaka city, BRT Line 3 (north section: Gazipur – Airport) assisted by ADB is being implemented. As results of interview to the person in charge of environmental and social matters*, the following issues and problems were raised:

(Social Considerations)

(1). In Dhaka city, land rights are very complicate. It is very difficult to find out true owners of lands.

(2). It is difficult to acquire lands of apartments and commercial buildings. Power of land owners is very strong, and compensation cost is rocketing up.

(3). Identification of squatters and hawkers is difficult because they are wandering.

(Environmental considerations)

There is no problem on environmental matters.

As above, BRT Line 3 project has mainly land acquisition and social issues.

* Md. Momenul Islam Mridha, Project Manager, Greater Dhaka Sustainable Urban Transport Project

5.7 The Assessment of Impacts

Draft scoping and results of the survey are shown on Table 5.7.1.

Table 5.7.1 Draft Scoping and Results of the Survey

No	Items	Evaluation				Reason of evaluation
		Scoping		After survey		
		Before/ under construction	Operation	Before/ under construction	Operation	
Pollution Control						
1	Air Pollution	B-	B+	B-	B+	Construction Phase: ･Construction works and operation of construction equipment will generate dust. Convergence with construction work of MRT Line1 will cause more negative impacts. Operation Phase: ･Air pollution will be mitigated by reducing traffic congestion.
2	Water pollution	B-	B-	D	B-	Construction Phase: ･The project crosses the major water bodies by underground structure. Therefore, there are few significant impacts of water pollution. Operation Phase: ･Waste water from the depot and stations is treated to meet the standards of Bangladesh, and discharged. No mitigation measures may cause water pollution to water bodies.
3	Soil pollution	B-	B-	B-	B-	Construction Phase: ･Bad maintenance construction machinery and vehicles may cause soil contamination by leak of oil. In case that filling soil for embankment is contaminated, the vicinity of the depot site may be contaminated. In case that excavation soil is contaminated, there is a possibility of a spread of hazardous materials. Operation Phase: ･Maintenance facility of depot may cause soil contamination by leak of oil.
4	Waste	B-	B-	A-	B-	Construction Phase: ･Construction work will vast quantity of excavation soil. About suitable measure of the excavation soil should be proposed on D/D stage. Operation Phase: ･Illegal dumping from stations and depot may cause negative impacts on the environment.

No	Items	Evaluation				Reason of evaluation
		Scoping		After survey		
		Before/ under construction	Operation	Before/ under construction	Operation	
5	Noise and Vibration	B-	B-	B-	B-	Construction Phase: ・Without mitigation measures, construction works will cause noise and vibration. Operation Phase: ・Without mitigation measures, operation of trains may cause noise around viaduct sections.
6	Ground subsidence	C	C	B-	D	Construction /Operation Phase: ・Because appropriate methods will be adopted to avoid ground subsidence, there will be few negative impacts to ground subsidence.
8	Bottom sediment	B-	D	D	D	Construction Phase: ・ The project crosses the major water bodies by underground structure. Therefore, there are few significant impacts of water pollution.
Natural Environment						
10	Ecosystem	B-	B-	B-	B-	Construction / Operation Phase: ・There are no negative impacts to rare species. However, monitoring survey is recommended to minimize negative impacts to the ecosystem including Near Threaten species around the depot site. In case that some impacts are found, appropriate mitigation measures are examined and implemented. For logged trees found on the detail design phase, replanting is implemented and monitoring.
11	Hydrology	C	C	D	D	Construction / Operation Phase: ・ The project crosses the major water bodies by underground structure. Therefore, there are few significant impacts of water pollution.
12	Groundwater	B-	D	D	D	Construction / Operation Phase: ・Because extraction level of groundwater in Dhaka city is below underground structure of the project, there will be few impacts to groundwater. However, to correspond uncertainty of forecast, monitoring of the groundwater is proposed.
13	Geographical features	B-	D	D	D	Construction Phase: ・ Because appropriate methods will be adopted to avoid ground subsidence, there will be few negative impacts to ground subsidence.
Social Environment						

No	Items	Evaluation				Reason of evaluation
		Scoping		After survey		
		Before/ under construction	Operation	Before/ under construction	Operation	
14	Resettlement/ Land Acquisition	A-	D	A-	A-	Pre-Construction Phase: ・721 affected families (out of 39 will lose residence) will be displaced. Operation Phase: Impact will remain if RAP is not carried out appropriately.・Additional physical resettlement and land acquisition will not be required for this Project.
15	Poor people	A-	A-	A-	A-	Construction Phase: ・Poor whose income is less than 60,000 BDT are living in the project sites are affected. Operation Phase: ・Further impact will be mitigated by the prepared RAP.
16	Ethnic minorities and indigenous peoples	C	C	D	D	Construction / Operation Phase: ・No ethnic minority or indigenous people is found, therefore the impact is nil.
17	Local economies, such as employment, livelihood, etc.	B-/B+	C	D	D	Construction Phase: ・Involuntary resettlement may cause negative impacts on rikisya or taxi. On the other hand, construction work will increase employment. Operation Phase: ・The MRT will be used as long distance transportation, and rikisya and taxi will be used as para transit from stations as medium/short distance transportation.
18	Land use and utilization of local resources	B-/B+	B+	B+	B+	Construction / Operation Phase: ・Some extent of negative impacts were assumed however those will be very small.
19	Water usage	C	C	D	D	Construction / Operation Phase: ・Because extraction level of groundwater in Dhaka city is below underground structure of the project, there will be few impacts to groundwater.
20	Existing social infrastructures and services	C	C	D	D	Construction / Operation Phase: ・Affected CPRs will be compensated and re-built, therefore negative impacts will be very small.
21	Social structure such as social capital and local decision-making institutions	C	C	B-	B-	Construction / Operation Phase: ・Gates and fence will be affected with some extent.
22	Misdistribution of benefits and damages	B-	B-	B-	B-	Construction / Operation Phase: ・Since the benefits will be not distributed evenly, misdistribution will arise among them.

No	Items	Evaluation				Reason of evaluation
		Scoping		After survey		
		Before/ under construction	Operation	Before/ under construction	Operation	
23	Local conflicts of interest	B-	B-	D	D	Construction / Operation Phase: ・Local conflict will be solved with the help of respective local agency, therefore the impact will be very small.
24	Cultural heritage	C	C	D	D	Construction / Operation Phase: ･There is no cultural heritage in/around the project site.
25	Landscape	B-	B-	B-	B-	Before Construction / Construction Phase: ･So far there is no concerns of stakeholders. However considerations on viaduct design is needed.
26	Gender	C	C	D	D	Construction / Operation Phase: Following measures will be taken in accordance with the Gender Action Plan. In construction phase: ・ Equal pay/work/opportunities for male/female workers. ・Provision of separate toilet ・Resettlement planning which consider gender issue. In operation phase: ・Deployment of female staff ・Separate compartment, reserved/priority seat for women ・ Equal pay/work/opportunities for male/female workers
27	Children's rights	C	C	D	D	Construction / Operation Phase: ･There is a lot of educational facility. The structures of the project are underground and viaduct. Therefore school-commuting road will be divided by the project. However, on the construction period, considerations to secure the school-commuting road is required.
28	Infectious diseases such as HIV/AIDS	B-	D	B-	D	Construction Phase: ･Infection risks of HIV/AIDS may be increased among construction workers.
29	Working conditions (including occupational safety)	B-	B-	B-	B-	Construction Phase: ･Inappropriate safety measures of contractor will deteriorate occupational safety. Operation Phase: ･Inappropriate safety measures of railway operator will deteriorate occupational safety.
Others						

No	Items	Evaluation				Reason of evaluation
		Scoping		After survey		
		Before/ under construction	Operation	Before/ under construction	Operation	
30	Trans-boundary impacts or climate change	B-	B+/-	B-	B+/-	Construction Phase: ・Operation of construction machinery and vehicles will occur greenhouse gas (CO2). Operation Phase: ・Modal shift to from vehicles to railway will reduce greenhouse gas.
31	Accidents	B-	B-	B-	B-	Construction Phase: ・There is a risk of accident on construction activity. Operation Phase: ・Collision of vehicle and viaduct, and accident in depot are expected.
32	Risk of flood	B-	B-	B-	B-	Construction / Operation Phase: ・Because the project site has a risk of flood, detail of mitigation measures is examined on detail design phase.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected
* Impact Items refer to "JICA Guidelines for Environmental and Social Considerations April 2010"
Source: JICA Study Team

5.8 Mitigation Measures and Costs

Regarding the items which were evaluated as A-, B-, or C on the scoping matrix (Table 5.7.1), mitigation measures are shown on Table 5.8.1.

Table 5.8.1 Mitigation Plan and Cost on Construction Phase

No	Items	Mitigation Measures	Cost	Responsibilities of implementation
1	Air Pollution	・ Water spray on construction site to prevent dust generation ・ Suitable and continuous maintenance of construction machinery to control exhaust gasses ・ Installation of temporary walls on the construction sites ・ Formulation of rational construction plan to reduce operation hours of construction machinery	To be included in service fee of construction	Contractor (supervised by DMTC)
2	Water pollution	・ Suitable and continuous maintenance of construction machinery to prevent oil leak ・ Periodic monitoring water quality of crossing rivers	To be included in service fee of construction Monitoring cost is shown on Table6.9.1.	Contractor (supervised by DMTC)
3	Soil pollution	・ Suitable and continuous maintenance of construction machinery to prevent oil leak ・ Check contamination of soil for the depot embankment ・ Check contamination of excavation soil	To be included in service fee of construction	Contractor (supervised by DMTC)

No	Items	Mitigation Measures	Cost	Responsibilities of implementation
4	Waste	・ Regarding disposal of the excavation soil, less negative impact measure will be studied and taken.	To be including service fee of consultation	Contractor (supervised by DMTC)
5	Noise and Vibration	・ Suitable and continuous maintenance of construction machinery to control noise emission ・ Installation of temporary walls on the construction sites to prevent noise propagation ・ Formulation of rational construction plan to reduce operation hours of construction machinery ・ Monitoring of construction noise	To be included in service fee of construction Monitoring cost is shown on Table6.9.1.	Contractor (supervised by DMTC)
6	Ground subsidence	・ Appropriate planning of construction plan on detail design phase ・ Confirmation houses along the project site before construction work ・ Monitoring of shoring on construction work	To be included in detail design fee To be included in construction cost	Contractor (supervised by DMTC)
10	Ecosystem	・ Monitoring of ecosystem around the depot site ・ Tree planting to mitigate tree cutting	Monitoring cost is shown on Table6.9.1.	Contractor (supervised by DMTC)
12	Groundwater	・ Monitoring of ground water level and quality during construction period and until one year after completion	Monitoring cost is shown on Table6.9.1.	Contractor (supervised by DMTC)
13	Geographical features	・ Same as No.6 Ground subsidence		
14	Resettlement/ Land Acquisition	・ Appropriate implementation of land acquisition and resettlement based on RAP	To be shown on RAP	DMTC,
15	Poor people	Ditto	Ditto	DMTC
22	Misdistribution of benefits and damages	Ditto	Ditto	DMTC
25	Landscape	・ Information disclosure and continuous discussion with residents, and adoption of opinions of residence to secure landscape	To be included in service fee of construction	DMTC, Contractor
27	Children's rights	・ Information disclosure and continuous discussion with residents ・ Preparation of construction plan to secure school-commuting roads	To be included in service fee of construction	Contractor (supervised by DMTC)
28	Infectious diseases such as HIV/AIDS	・ Education and enlightenment for construction workers to prevent prevalence of HIV/AIDS	To be included in service fee of construction	Contractor (supervised by DMTC)
29	Working conditions (including occupational safety)	・ Preparation of work safety plan and implementation	To be included in service fee of construction	Contractor (supervised by DMTC)
30	Trans-boundary impacts or climate change	・ Suitable and continuous maintenance of construction machinery to reduce fuel consumption ・ Introduction of energy saving construction machinery	To be included in service fee of construction	Contractor (supervised by DMTC)

No	Items	Mitigation Measures	Cost	Responsibilities of implementation
31	Accidents	• Installation of suitable safety facility on construction site • Suitable use of personal safety equipment to secure safety of workers • Education and enlightenment for construction workers to prevent accidents	To be included in service fee of construction	Contractor (supervised by DMTC)
32	Risk of flood	• Preparation of hazard management plan to avoid flood damage on construction period	To be included in service fee of construction	Contractor (supervised by DMTC)

Source: JICA Study Team

Table 5.8.2 Mitigation Plan and Cost on Operation Phase

No	Items	Mitigation Measures	Cost	Institutional Responsibilities
2	Water pollution	• Check of waste water from stations and maintenance facilities	To be included in routine operation	DMTC (Operator)
3	Soil pollution	• Suitable and continuous maintenance of maintenance facility of depot to prevent leak of oil and other chemicals	To be included in routine operation	DMTC (Operator)
4	Waste	• Enlightenment for users to prevent illegal dumping from stations • Preparation of waste management plan including depot operation	To be included in routine operation	DMTC (Operator)
5	Noise and Vibration	• Introduction of noise mitigation measures such as noise barrier on viaduct sections • Suitable and continuous maintenance of rail structure to reduce noise generation	To be included in the project cost to be finalized during D/D	DMTC (Operator)
10	Ecosystem	• Monitoring of ecosystem around the depot site • Tree planting to mitigate tree cutting (4 trees per a logged tree)	To be shown on table6.9.1.	DMTC (Operator)
15	Poor people	• Confirm APs if displacement is carried out appropriately in accordance with RAP. • Confirm the present situation of APs	DMTC will hire outsourced monitoring firm.	DMTC
23	Misdistribution of benefits and damages	• Confirm APs if displacement is carried out appropriately in accordance with RAP. • Confirm the conducted compensation and LIRP are appropriate or not.	DMTC will hire outsourced monitoring firm.	DMTC
25	Landscape	• Information disclosure and continuous public consultation, • Mitigation plan to secure landscape to incorporate public opinions (on detail design phase)	To be included in detail design fee	DMTC
29	Working conditions (including occupational safety)	• Preparation of operation plan to secure occupational safety	To be included in routine operation	DMTC (Operator)
31	Accidents	• Preparation of operation plan to secure occupational safety	To be included in routine operation	DMTC (Operator)
32	Risk of flood	• Development of safety management plan • Maintenance of anti-flood facilities of alignment and stations	To be included in routine operation	DMTC (Operator)

Source: JICA Study Team

5.9 Monitoring Plan

5.9.1 Monitoring plan

In Bangladesh, there is no system of environmental monitoring and inspection. To prevent deterioration of environment and social situation, monitoring of environment and social items which were evaluated as possible negative impacts should be monitored, reported and inspected. Monitoring plans are shown on Table 5.9.1 and Table 5.9.2.

Table 5.9.1 Monitoring Plan and Cost on Construction Phase

No	Items	Method of monitoring	Locations	Frequency	Cost	Responsibilities of implementation
1	Air Pollution	Confirmation of mitigation measures on a construction plan	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）
		Confirmation of implementation of mitigation measures on field	Construction sites	During construction period	To be included in consulting fee	Consultant (DMTC)
		Sample collection and laboratory analysis PM10, PM2.5, NOx	5 locations	Two times a year 24 hours	3,500,000BDT a year	Contractor (supervised by DMTC)
2	Water pollution	Confirmation of mitigation measures on a construction plan	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）
		Confirmation of implementation of mitigation measures on field	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）
		Sample collection and laboratory analysis DO, COD, PH, TSS oil grease, and total coliform index.	5 locations	Two times a year	900,000BDT a year	Contractor (supervised by DMTC)
3	Soil pollution	Confirmation of records of construction activities (regular maintenance of construction machinery)	Construction sites	During construction period	To be included in construction cost	Contractor (supervised by DMTC)
		Referred to 6.9.2				
4	Waste	Confirmation of records of construction activities	Construction sites	During construction period	To be included in construction cost	Contractor (supervised by DMTC)
5	Noise and Vibration	Confirmation of mitigation measures on a construction plan	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）
		Confirmation of implementation of mitigation measures on field	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）
		Noise measurements Vibration measurements	9 locations	One time a month 24 hours	5,000,000BDT a year	Contractor (supervised by DMTC)

No	Items	Method of monitoring	Locations	Frequency	Cost	Responsibilities of implementation
6	Ground subsidence	Confirmation of mitigation measures on a construction plan	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）
		Confirmation of implementation of mitigation measures on field	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）
		Confirmation of records of construction activities	Construction sites	During construction period	To be included in construction cost	Contractor (supervised by DMTC)
10	Ecosystem	Survey of fauna and flora	Depot site	One time a year	1,000,000BDT a year	Contractor (supervised by DMTC)
12	Groundwater	Sample collection and laboratory analysis Groundwater level and quality Colour, Temperature, pH, Sodium, Potassium, Calcium, Bicarbonate, Chloride, Sulfate, Nitrate, Nitrite, Arsenic, Fecal Coliforms	6 locations	One time a year 4 time a year for groundwater level	1,980,000BDT a year	Contractor (supervised by DMTC)
13	Geographical features	Same as “6 Ground subsidence”				
14	Involuntary resettlement	Implementation record on land acquisition/resettlement	Implemented sites	During land acquisition and resettlement	Included in Consultant fee	I-NGO
15	Poor people	Yearly income of APs	Vulnerable people	Before and after resettlement	Included in Consultant fee	I-NGO
22	Misdistribution of benefits and damages	Yearly income of APs	Implemented sites	Before and after resettlement	Included in Consultant fee	I-NGO
25	Landscape	Confirmation of records of public consultations	Along viaduct sections	During detail design	To be included in detail design fee	DMTC
28	Infectious diseases such as HIV/AIDS	Confirmation of records of construction activities	Construction sites	During construction period	To be included in construction cost	Contractor (supervised by DMTC)
29	Working conditions (including occupational safety)	Confirmation of safety plan of construction work	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）
		Confirmation of records of construction activities	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）

No	Items	Method of monitoring	Locations	Frequency	Cost	Responsibilities of implementation
30	Trans-boundary impacts or climate change	(Maintenance of construction machinery) Confirmation of construction records	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）
		(Replanting) Confirmation of records of construction activities and field reconnaissance	Subject fields	After completion of replanting	To be included in consulting fee	Consultant（DMTC）
31	Accidents	Confirmation of safety plan of construction work	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）
		(Implementation of safety plan) Confirmation of records of construction activities	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）
32	Risk of flood	Confirmation of safety plan	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）
		(Implementation of safety plan) Confirmation of records of construction activities	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）

Source: JICA Study Team

Table 5.9.2 Monitoring Plan and Cost on Operation Phase

No	Items	Monitoring Methods	Locations	Frequency	Cost	Responsibilities of Implementation
2	Water pollution	Sample collection and laboratory analysis DO, COD, PH, TSS oil grease, and total coliform index.	1 location around the drainage of the depot site	Two times a year	400,000BDT a year	DMTC (Operator)
3	Soil pollution	(Depot site) Confirmation of maintenance records of maintenance facilities	Depot site	Every month	To be included in a project cost	DMTC (Operator)
4	Waste	(Stations and depot site) Confirmation of operation records	Stations and depot site	Every month	To be included in a project cost	DMTC (Operator)
5	Noise and Vibration	Noise measurements Vibration measurements	3 locations along the viaduct section	Yearly	150,000BDT a year	DMTC (Operator)
10	Ecosystem	Survey of fauna and flora	Depot site	Yearly during two years after launching operation	1,000,000BDT a year	DMTC (Operator)

No	Items	Monitoring Methods	Locations	Frequency	Cost	Responsibilities of Implementation
12	Groundwater	Sample collection and laboratory analysis Groundwater level and quality Colour, Temperature, pH, Sodium, Potassium, Calcium, Bicarbonate, Chloride, Sulfate, Nitrate, Nitrite, Arsenic, Fecal Coliforms	5 locations	Yearly Quarterly for groundwater level)	1,650,000BDT a year	DMTC (Operator)
15	Poor people	Yearly income of APs	Vulnerable people	Once	DMTC	Out-sourced monitoring firm
22	Misdistribution of benefits and damages	Yearly income of APs	Implemented sites	Once	DMTC	Out-sourced monitoring firm
29	Working conditions (including occupational safety)	Confirmation of occupation safety plan	-	Before implementation of operation	To be included in a project cost	DMTC
		Confirmation of operation records	-	During operation	To be included in a project cost	DMTC
32	Risk of flood	Confirmation of safety management plan	-	Before implementation of operation	To be included in the project cost	DMTC
		Maintenance for anti-flood facilities of the alignment and stations	-	During operation	To be included in the project cost	DMTC

Source: JICA Study Team

5.9.2 Monitoring of Soil Contamination

Because the structure of the project is mostly underground structure, construction of the project generates vast quantity of excavation soil. In case that the excavation soil is contaminated, contaminants may scatter to other places. On the contrary, depot site needs vast quantity of soil for forming embankment. In case that the embankment soil is contaminated, the vicinity of the depot site may be contaminated. To prevent spread of contaminants, monitoring of soil contaminant should be conducted on carrying soil in and out.

1) Carrying out of Excavation Soil

(1) Soil Contamination Monitoring on Whole Section

On the whole construction section, excavation soils are sampled and analysed. Status of soil contamination is confirmed. (Frequency of sampling: roughly 1 sample / 200 thousand m3)

(2) Monitoring of Unnatural Soil Contamination

Sources of contaminants in ROW (such as factory) are found by map reading and field reconnaissance. For the source of contaminants, possible contaminants are identified by hearing survey from the land owners and residents around the site. In case that there is high probability of discharge of contaminants, soil contamination is monitored by sampling survey. (Frequency of sampling: roughly 1 sample / 1,000m2)

(3) Management of Contamination Soil

In case that results of monitoring show significant high concentration comparing standards, management and mitigation measures for disposal of contamination (such as containment, purification, elimination and etc.) is examined.

(4). Implementation and Management

Regarding soil contamination survey, DMTC (consultant committed by DMTC) instructs sampling locations considering the conditions of construction sites, and contractors carries out the survey. From the results of the survey, DMTC assesses existence or nonexistence of soil contamination. In case that the site is contaminated, DMTC and the contractor consult with Dhaka city and carry out it to appropriate sites.

2) Carrying in of Embankment Soil

(1) Identification of Origin of Soil

On borrow pits of filling soil, information such as location, status of land use, existence of contaminant source and land history are found by map reading, field reconnaissance and hearing survey.

(2) Confirmation of Soil Contamination

In case that no discharge of contaminants is confirmed as results of (1), natural soil contamination is confirmed by sampling survey. (Frequency of sampling: 1 sample / every site) In case that discharge of contaminants is confirmed, soil contamination is confirmed around the source of contaminants by sampling survey. (Frequency of sampling: roughly 1 sample / 1,000m2) If concentration of contaminants is remarkably high, no filling soil is acquired from the site.

(3) Implementation and Management

Regarding soil contamination survey of filling soil, DMTC (consultant committed by DMTC) confirms sites of filling soil materials, and assesses necessity of soil contamination survey. In case of necessity, the contractors carry out the soil contamination survey. DMTC confirms the result of the survey, and assessed procurement from the site.

3) Contaminants and Standards

Soil contaminants which affect human health by intake are shown on Table 5.9.3. As criteria, soil contamination standards of Japan or other countries are referred.

Table 5.9.3 Example of Soil Contaminants

Category	Contaminants	
Volatile Organic Compounds (VOCs)	chloroethylene carbon tetrachlorid 1,2-dichloroethene 1,1-dichloroethylene sys-1,2- dichloroethylene 1,3- dichloropropene	dichloromethane tetrachloroethylene 1,1,1-trichloroethane 1,1,2- trichloroethane trichloroethylene benzene
Heavy Metal	cadmium and compounds hexavalent chrome cyanogen compound mercury and compounds selenium and compounds	lead and compounds arsenic and compounds fluorine and compounds boron and compounds
Pesticide/PCB	simazine benthiocarb thiuram	PCB organic phosphorus

Source: Law of Soil Contamination Protect (Japan), Annex

5.9.3 Reporting and Inspection

Results of the monitoring survey need to be reported, and reflected to conservation of environment and social condition.

On the construction phase, most of the monitoring are implemented by contractors. The contractors compile monitoring reports from the results of the monitoring, and submit the reports to DMTC. DMTC submits the monitoring reports to JICA and relating donors. Moreover, DMTC should share the reports with DoE. Although there is no legal basis of DoE’s involvement to the monitoring, DoE’s involvement is recommended to be inspected from specialist point.

On the operation phase, DMTC (operator) has a responsibility of the implementation of the monitoring. DMTC compiles monitoring reports from the results of the monitoring, and submit the reports to JICA and relating donors. As same as construction phase, DMTC should share the reports with DoE.

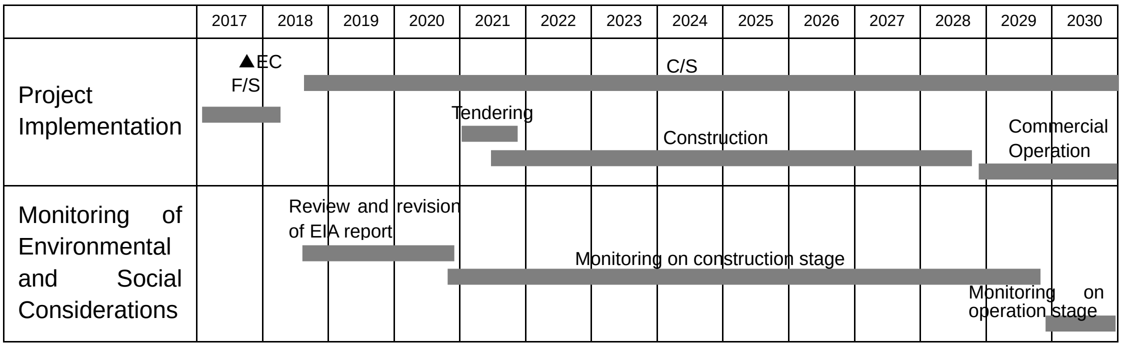
Table 5.9.4 Monitoring report

	Construction Phase	Operation Phase
Preparation	By contractors	By DMTC (operator)
Contents of report	Progress of construction works Results of monitoring Implementation status of mitigation measures Issues to be solved, and etc.	Progress of operation works Results of monitoring Implementation status of mitigation measures Issues to be solved, and etc.
Frequency	quarter during construction period	Half-yearly
Submission	To DMTC DMTC submits to JICA and relating donors, and shares with DoE	To JICA and relating donors DMTC shares with DoE

Source: JICA Study Team

Monitoring schedule is shown on Table 5.9.5.

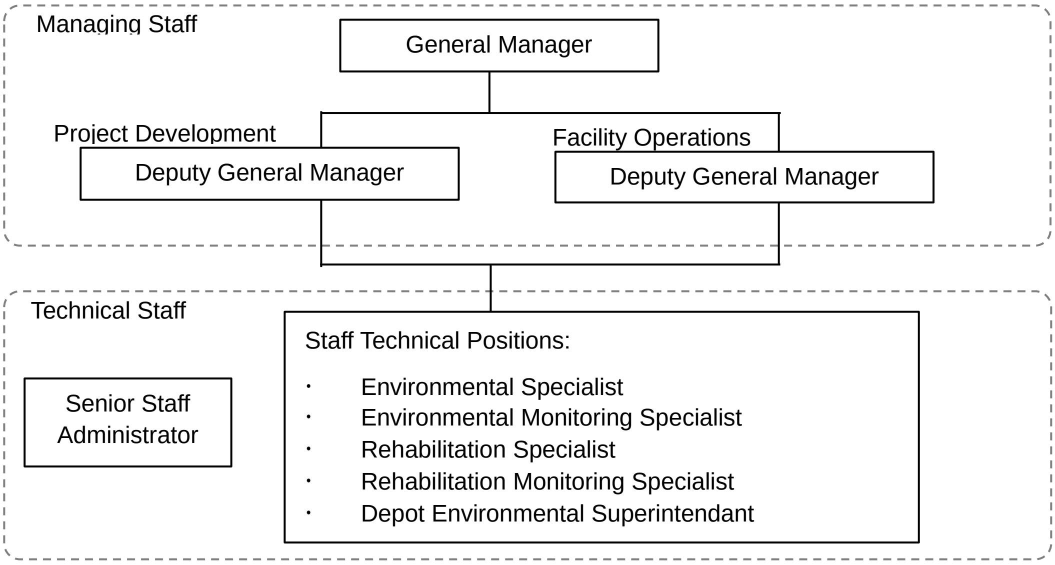
Table 5.9.5 Monitoring Schedule



Project schedule is based on 4.8.3, Figure4.8.8.

5.9.4 Implementation Structure

Implementation structure of the environmental and social considerations for the project follows the operation of MRT Line 6. MRT Line6 organizes an operation section (referred to 4.11.1) in DMTCL (Dhaka Mass Transit Company Limited). ERD（Environment and Rehabilitation Division） prepared in this section handles the management of environmental matters except land acquisition and resettlement. Organization of ERD is shown on Figure 5.9.1. ERD conducts; instruction and supervision for environmental management of contractors; monitoring; and report to JICA. MRT Line 6 proposes procurement of environmental survey equipment for environmental management. However because an environmental survey requires special knowledge and technical skill, the study team recommends commission to consultants.



Source: Environmental Impact Assessmnet Main Report of Consultancy Services for Design, Construction Supservision, Procurement support and Managemnet of Dhaka Mass Rapid Transit Development Project (January 2016, DMTCL)

Figure 5.9.1 Organization Chart of ERD

5.10 Stakeholder Meetings (EIA)

To collect opinions of the stakeholders including residents near the project site and reflect the opinions to the project, stakeholder meetings were held on 4 venues along the MRT Line 5 route. the stakeholder meetings have two stages. The first stage is meetings to explain the outlines of the project and EIA study. The second stage is meetings to explain the outlines of expected impacts by the project and mitigation measures.

5.10.1 First Stage Stakeholder meetings

Date / Venue / Participants	15, March, 2017 / Hemayetpur High School / 53 persons 16, March, 2017 / Rozina Filling Station , Gabtoli / 45 persons 18, March, 2017 / Mirpur 10, Office of zonal Executive Officer / 52 persons 19, March, 2017 / Kisholoy Kinder Garten, Notun Bazar, Vatara / 22 persons
Contents	Explanation of project outlines Project outlines, alignment, location of stations (explained by Google Earth) Explanation of EIA, scoping and potential environmental impacts Gathering of public opinions
Methods of inform of meetings	Informed through local politician, local governments, leader of women, NGO (disable, gender, minority and others), publicity on the street, visit to houses on the vicinity

Table 5.10.1 Opinions on Stakeholder Meetings (First round)

Category	Comment/Question	Answer and Policy of Countermeasure
Planning	Want will be the depth of underground tunnel of metro rail.	Feasibility study is going on and the depth of tunnel construction will decide after the study completion
	What will be the underground metro rail depth and its viaduct height?	It will be decided after completion of the feasibility Study
	The metro rail line should be extended to sadar ghat or a new line is required from Gabtoli to Jatrabari or Sadarghat via Shymoli, Asadgate and Science laboratory.	Design team will consider this issue.
	What will be the width of underground tunnel of the Metro Rail?	Feasibility study is going on so the exact width of the underground tunnel is not fixed yet.
	What about the viaduct height and tunnel depth? How many days will it take to complete?	Feasibility study is going on. The exact height and tunnel depth are not finalized yet.
	Is the project design final?	No, the project design is not final. The feasibility study is going on. After completion of the study detail design will come up.
	After completion of this project people should be trained up to travel and maintain metro rail appropriately as it is new in our transportation system.	Authority will provide awareness program through media. Authority will also provide awareness program on all station through sign.
	All types of direction label/sign/signal should be in Bengali along with English so that people can easily understand what they should do or not and how to travel.	It will be recommended in the EIA report.
	The soil type of Dhaka city is Deep-Red brown or alluvial soil. Is the soil appropriate for such kind of underground project? Do the soil been tested? Earthquake should also be a major concerning issue for such mega project. Is there any technology to mitigate the vibration during construction and how?	JICA is doing geological survey to understand the feasibility of underground metro rail project. Proper mitigation measures will be taken for the vibration control. Design consultant will consider earthquake impact during detailed design stage. It will be recommended in the EIA report.
	Is there any evacuation plan for fire and earthquake hazard	Proper disaster management and evacuation provision will be kept. Design team will consider this during detail design stage.
	What will be depth of underground tunnel?	Feasibility study is in progress. Exact depth is not yet completed. After completion of the feasibility study it will be decided.
	I hope the metro rail project will be a sustainable project. I think the major issue will be disaster e.g. earthquake and fire hazard during operation. Soil management will be big challenge for this project during construction. Hope authority will take proper step to mitigate the soil management related problems. Adequate sign both in Bangla and English need to be highlighted in the station area that will help local people to understand.	It will be recommended in the EIA report.
	I always support all kinds of development works. Metro rail will make our life easier so I strongly support the project.	Thank you for your complements.
	Please keep provision of separate compartment or reserve seat for the women in the metro rail.	Design team will consider this issue. It will recommend in the EIA report as well.
Construction	What will be the major environmental pollution due to the metro rail construction	As the MRT 5 Line will be mostly underground so minimum environmental impact will be taken place. During construction, main environmental impacts will be dust pollution, noise pollution & vibration, traffic congestion. A comprehensive mitigation plan will be recommended in the EIA report to minimize the environmental impact.
	Is there any possibility of damage to surface infrastructure during underground tunnel construction?	No, latest TBM technology will be used. So there is no chance of damage to the surface infrastructure during underground tunnel construction.

Category	Comment/Question	Answer and Policy of Countermeasure
	Dhaka is a densely populated city. So how to manage the entire project related construction and preconstruction works?	• As the metro rail 5 will be underground so no traffic congestion will occur during construction period. Alternative traffic management plan will be developed for the viaduct section.
	As far I understood this is a mega project and a lot of materials will be used. Where the pre-construction fabrication work will be held?	It is not yet selected. Feasibility study team will finalize the construction yard.
Environment	Is there any technology or any other system to mitigate dust pollution during the construction period?	Yes, authority will take step to mitigate all types of pollution and advanced technology will be used. Proper mitigation plan will be incorporated in the EIA report to mitigate the environmental impact
Land Acquisition and Resettlement	Is there any possibility to acquire the land except the depot area?	No, there is no possibility of land acquisition except the depot area.
	How much land will be acquired for this project?	Land acquisition team will clarify this issue.
	What will be the compensation rate of land	Land acquisition will be carried out based on the national as well international regulation
	Is there any possibility of acquisition of the nearer filling stations which are located along the road side?	MRT 1 will be underground so there is no possibility of acquisition of the filling station. RAP study team will cover this issue.
	If someone having business in a rental place and the place will be acquired for this project then what will be the compensation package for the tenant?	Land acquisition team will clarify this issue.
	Authority should compensate to the land looser perfectly as we already lost lots of land	Yes it will be compensated if there will any damages or loss. Proper compensation will be provided in accordance with the national and international regulation
	We always appreciate the development work in our country. Design team should consider the minimum damage and land acquisition as much as possible	Study team will consider the issue.

5.10.2 Second Stage Stakeholder meetings

Date / Venue / Participants	25, July, 2017 / DNCC Zonal Office, Mirpur 10 / 39 persons 26, July, 2017 / DNCC, Darus Salam, Dhaka / 22 persons 26, July, 2017 / Holy Touch Model School, Hemayetpur / 53 persons 30, July, 2017 / Notun Bazar, Vatara / 23 persons
Contents	Explanation of project outlines Explanation of results of EIA survey and mitigation measures Gathering of public opinions
Methods of inform of meetings	Informed through local politician, local governments, leader of women, NGO (disable, gender, minority and others), publicity on the street, visit to houses on the vicinity

Table 5.10.2 Opinions on Stakeholder Meetings (Second round)

Category	Comment/Question	Answer and Policy of Countermeasure
Planning	If there any accident occurs at the operation phase in the underground how it will be managed?	An emergency management plan will be prepared for the operation phase. This plan will be followed to manage any emergency situation both in construction and operation phases.
	What will be the ticket price? Is it bearable for all users?	Authority will try to keep the ticket price within the capacity for every types of citizen and ticket price will be finalize during detail design stage.
	Is there any discount in the ticketing system for students?	It will be decided by the DTCA authority.
	Govt. takes a great step to minimize the traffic congestion in Dhaka city. Thanks to the JICA team to come forward for construction of MRT line-5 project.	Thank you for your complement.
	What step will be taken to keep clean the underground	Station will clean periodically. A designated cleaning team will

Category	Comment/Question	Answer and Policy of Countermeasure
	station?	work to keep clean the station.
	What is the process of Oxygen supply at the underground station?	Ventilation system will be present in the metro rail system. Design team will be considered this issue during final design of the underground station
	What kind of fuel will be used to run the Metro Rail?	Metro rail will be powered by electricity.
Construction	How the excavation materials will be managed?	Authorities will talk with the responsible organization to use the excavation materials in different purposes as well as dump in the designated site. All the possible option will consider during the detail design stage.
	How the excavation materials will be managed?	Authorities will talk with the responsible organization to use the excavation materials in different purposes as well as dump in the designated site. All the possible option will consider during the detail design stage.
	Construction activities will cause huge traffic congestion in the project area. How it will be managed?	Most of the alignment of MRT line-5 will be underground. So, very minimum traffic congestion will be taken place. However, a traffic management plan will be prepared and followed accordingly to minimize the traffic congestion.
Environment	Is there any possibility to damage the river system due to the underground metro operation?	No, there is no possibility to damage the river system due to the underground construction of the project as it will pass several meter below the river.
	What will be the major environmental pollution due to the metro rail construction	For every construction activities there have some environmental pollution. Air, sound pollution will be major concern for the metro rail construction.
	What will be the major environmental pollution due to the metro rail construction	As the MRT 1 Line will be mostly underground so minimum environmental impact will be taken place. During construction, main environmental impacts will be dust pollution, noise pollution & vibration, traffic congestion. A comprehensive mitigation plan will be recommended in the EIA report to minimize the environmental impact.
	Station should be pollution free(mainly air pollution);	Thank you for your suggestions.
	How major environmental pollution will be managed during the metro rail construction	As the MRT 5 Line will be mostly underground so minimum environmental impact will be taken place. During construction, main environmental impacts will be dust pollution, noise pollution & vibration, traffic congestion. A comprehensive mitigation plan will be recommended in the EIA report to minimize the environmental impact.
	Is there any possibility of damage of environment in our area?	A detail environmental management plan will be incorporated in the EIA report and it will be followed during construction and operation phase to minimize the impact.
Land Acquisition and Resettlement	Authority should be informed to the local people before the project start. Procedure of the Land acquisition and compensation for the affected people must be clarified before construction phase.	Thank you for your valuable comments and it will consider by the authority.
	What will be the compensation rate of land	Land acquisition will be carried out based on the national as well international rules and regulation
	If there any private land at the underground station or alignment and do the land owner get compensation?	If there any property damage of the land owner obviously he/she will get the compensation.
	What will be the compensation rate of land	Land acquisition will be carried out based on the national as well international regulation
	Compensation should not be time consuming process.	Thank you for your suggestions.

5.10.3 Summary of Opinions of Stakeholders

Opinions of the stakeholders are classified into: planning, construction, environment, land acquisition and resettlement.

About the planning issues, there are questions on structure such as depth of underground, disaster mitigation plan including earthquake and fire. Some participants proposed introduction of separate compartment for women and language of sign board. Since these are general matters adopted in other railway projects, opinions on the planning will be adopted (except installation of a new station).

A lot of participants raised concerns on construction phase including environmental issues. The concerns include pollution, especially dust control, excavation soil management, construction management such as traffic control.

About the environmental issues, outline of negative impacts, impacts by construction and impacts on rivers were asked. The mitigation measures which are proposed must be implemented definitely.

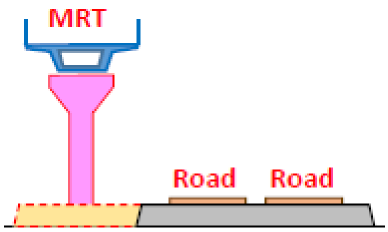
About the land acquisition and resettlement, expected size of land acquisition and a level of compensation were asked. And appropriate and prompt compensation were requested. Based on RAP prepared on this study, land acquisition and resettlement must be implemented appropriately.

Among 8 stakeholder meetings, there are no clear objection. However, some concerns about compensation for land acquisition and resettlement were raised.

On the detail design phase, stakeholder consultation should be continued about more tangible project design. For example, although the project has a viaduct section, information on evaluation for “landscape” has not presented this study. On the detail design phase, based on more tangible design, agreement should be gotten.

5.11 Necessity of Land Acquisition and Resettlement

MRT Line 5 consists of 19.5km long and 14 stations which connects Hemayetpur to Vatara. The line stretches the west to the east of Dhaka City, 5 stations are above ground and 9 stations are underground. A depot is planned at the north of MRT line between Hemayetpur and Baliapur and because the Highway is expected to run the middle of existing National Road, therefore alignment of MRT is located along the north of the Highway. After that, the alignment will cross the Highway between Baliapur and Bilamaria and stretches along the south of Highway until Gabtoli station.



Source: JICA Study Team

Figure 5.11.1 Typical Cross Section of Via-duct between Hemayetpur and Aminbazar

Gabtoli is an underground station. Other stations from Dar-Us-Salam to Notun Bazar are underground which will be located in the middle of existing roads. MRT Line 5 will underpass MRT Line 6 at Mirpur 10 and MRT Line at Notun Bazar. Vatara station is a viaduct terminal.

Due MRT Line 5 aligns away from existing Highway from Hemayetpur to Gabtoli many untitled PAHs will be affected. Mirpur 10 is one of the traffic congested area where many cellar phone vendors and temporary shops are carrying on their business.

A total of 21.995ha of private land has to be acquired for depot at Hemayetpur.

Source: Google Map is manipulated by JICA Study Team

Figure 5.11.2 MRT Line 5 Map

MRT will stretch within the existing ROW in principle; however, 1.57ha of private land to construct ancillary facilities such as entrances/exits, ventilation duct is required. Therefore, affected PAHs will be 1,107 (29 will be resident PAHs) and 4,660 PAHs, respectively.

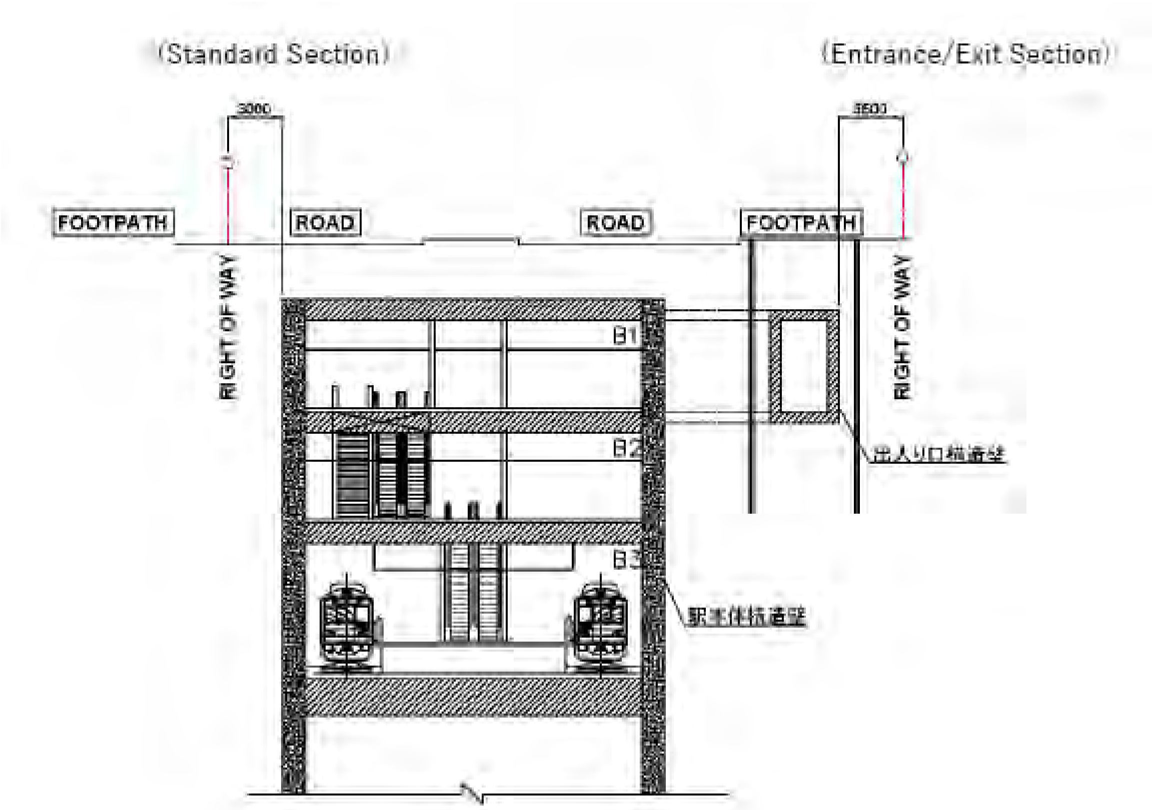


Figure 5.11.3 Typical Cross Section of Underground Station

The number of affected PAPs might be more than 200; therefore the project will fall in **category A**: displaced population is more than 200 people and significant impacts are assumed, therefore, Resettlement Action Plan (RAP) is prepared in line with JICA's Guidelines.

The basic principles of the Multi-Modal Hub of the Gabtoli Bus Terminal which will cause a significant impact are:

1) The new bus terminal will be constructed as part of the Gabtoli Station as Multi Modal Hub allowing inter-modal transportation between inter/intra city bus and MRT.

2) The temporary Gabtoli Bus Terminal during the construction of MRT station will be built at the construction yard of MRT Line 6 Project (casting yard of the CP-05/06) by extending the contract period with Ministry of Agriculture. The temporary Gabtoli Bus Terminal shall be constructed prior to commencement of demolishment of the present premises.

3) The cost of the re-construction of the Gabtoli Multi Modal Hub will be included in the Project.

The relocation of Gabtoli Bus Terminal during the construction phase of the Project may cause adverse impacts to transportation means of citizen and to livelihood means of various workers in the present location. In accordance with the JICA Environmental Guidelines, such adverse impacts should be avoided or mitigated, and if adverse impacts to livelihood and living standards are visible, improvement or, at least, restoration of livelihood and living standards shall be ensured. While design and implementation schedule will be prepared and finalized during the Detailed Design stage of the Project, DTCA and DMTC will explain how to avoid/mitigate such impacts by showing a tentative action plan, as follows, which should be included in the Resettlement Action Plan.

1) Identification of potential adverse impacts during the construction of Gabtoli MRT station, including potential affected persons, and details of their impacts;

2) Explanation of concepts/outlines of the above-said basic principles, and rationales on how they will be avoided/mitigated, and;

3) Explanation of responsibility of and possible timeline through design, construction and operation of the temporary Gabtoli Bus Terminal and Gabtoli Multi Modal Hub, so that avoidance and mitigation of such impacts are assessed as visible and feasible.

Furthermore, the attached annexures are consisted of Annex-1: Form of Census and Inventory of Losses, Annex-2: Form of Questionnaire for Property Valuation and Others, Annex-3: List of PAHs, Land Owners, CPRs, Vulnerable and Wage Workers, Annex-4: TOR for RAP Implementing Agency, Annex-5: Minutes of SHM, Annex-6: TOR for External Monitoring Consultant and Annex-7: Gender, in the Report.

5.12 Legal Framework of Land Acquisition and Resettlement

5.12.1 Current Legislation on Land Acquisition and Resettlement

The current legislations governing land acquisition for Bangladesh are the Acquisition and Requisition of Immovable Property Ordinance 1982 and subsequent amendments during 1993 - 1994. The Ordinance requires that compensation be paid for (i) land and assets permanently acquired (including standing crops, fisheries, trees, houses); and (ii) any other damages caused by such acquisition. The Deputy Commissioner (DC) determines the market price of assets based on an approved procedure and in addition to that pays an additional 50 percent (as premium) on the assessed value as the market price established by the Land Acquisition Officer (LAO) which still remains much below the replacement value. The 1994 amendment made provisions for payment of compensation for crops to tenant cultivators. The Ordinance, however, does not cover project-affected persons without titles or ownership records, such as informal settlers/squatters, occupiers, and informal tenants and lease-holders (without documents) and does not ensure replacement value of the property acquired. The act has no provision for resettlement assistance or transitional allowances for restoration of livelihoods of the non-titled affected persons. The Acquisition and Requisition of Immovable Property Ordinance (ARIPO, 1982) with its subsequent amendments will be applied for this project.

In addition, Government of Bangladesh enacted Land Acquisition and Requisition of Immovable Property Act, 2017. This act revises compensation of land which is 200% additional over market value if Government will acquire. It will be 300% additional over market value for privately acquire land.

1) Land Acquisition

The DC processes land acquisition under the Ordinance and pays compensation to the legal owners of the acquired land. The Ministry of Lands (MOL) is authorized to deal with land acquisition through the DCs. Khas (government owned) lands should be acquired first when a project acquires both khas and private land. If a project acquires only khas, the land will be transferred through an inter-ministerial meeting following the preparation of an acquisition proposal submitted to DC/MOL.

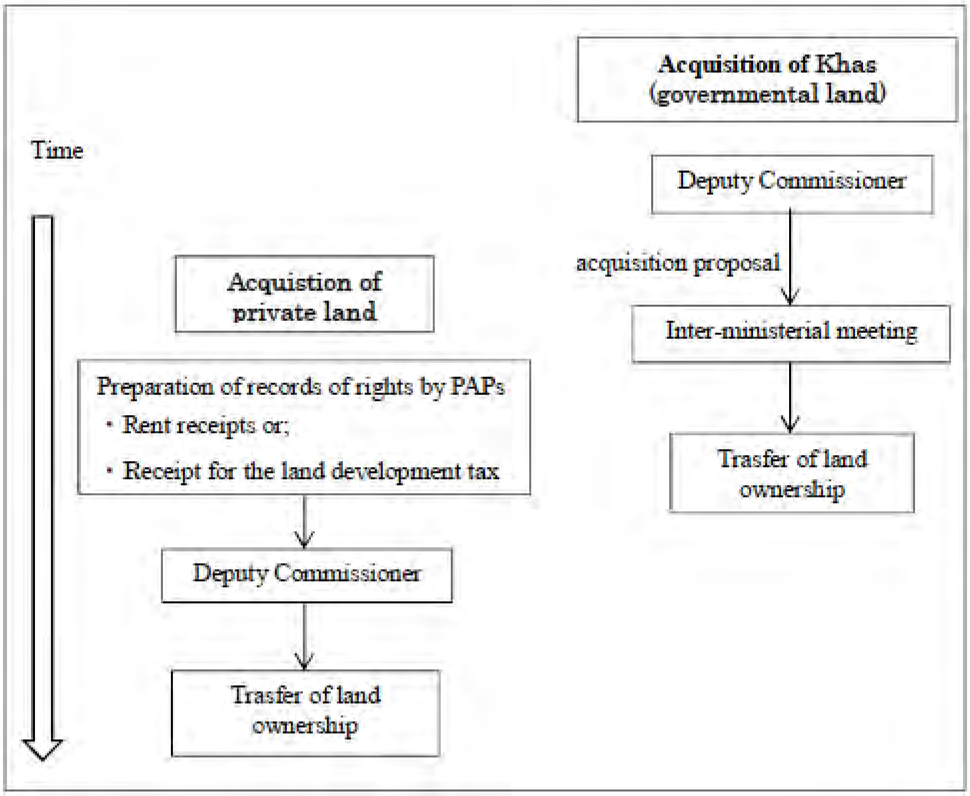
2) Land Ownership

The land owner has to establish ownership by producing a record-of-rights in order to be eligible for compensation under the law. The record of rights prepared under Section 143 or 144 of the State Acquisition and Tenancy Act 1950 (revised 1994) are not always updated and as a result legal land owners have to face difficulties in trying to “prove” ownership. The APs must also produce rent receipts or receipt for the land development tax, but this does not assist in some situations as a person is exempted from payment of rent if the area of land is less than 25 bighas (3.37 ha).

3) Draft National Policy on Involuntary Resettlement

The Government of Bangladesh, funded by ADB, has prepared a draft national policy on involuntary resettlement that is consistent with the general policy of the Government that the rights of those displaced by a development project shall be fully respected, and persons being displaced shall be treated with dignity and assisted in such a way that safeguards their welfare and livelihoods irrespective of title, gender, or ethnicity, but it is yet to be enacted.

The draft Policy was submitted to the Government in November 2007. It was approved by the Ministry of Land on 1 January 2008 and was placed before the Cabinet later in February 2008. After cabinet approval, the draft Policy is going to be enacted as legislative resettlement rights by law in 2017, however, it is not enacted yet.



Source: JICA Study Team

Figure 5.12.1 Flow of Land Acquisition

5.13 Gap between JICA's Guidelines and Related Ordinances in Bangladesh

5.13.1 Gap between JICA's Guidelines and related Ordinances in Bangladesh

The land acquisition law of Bangladesh, the Acquisition and Requisition of Immovable Property Ordinance (ARIPO) 1982 with subsequent amendments during 1993 – 1994 is followed for acquisition and requisition of properties required for the development project in Bangladesh, which is not consistent with the Government's commitment to reducing poverty. There are some gaps in the land acquisition law of Bangladesh and the JICA Guidelines for Environmental and Social Considerations (GESC, April 2010). Below is the comparative analysis between the GoB laws (ARIPO) related to land acquisition, compensation, and involuntary resettlement and JICA's requirements as prescribed in the GESC 2010. The Table 5.13.1 describes the details.

Table 5.13.1 Gap and Gap Filling Measure

No.	JICA's Guidelines (2010)	GOB's Acquisition and Requisition of Immovable Property Ordinance (ARIPO) of 1982	Gaps Between JICA's Guidelines and ARIPO	Proposed Gap Filling Measures
1	Involuntary resettlement should be avoided wherever possible.	Not specified	The 1982 ordinance legislated nothing in this regard, while the JICA Guidelines require to avoid/minimize resettlement/loss of livelihood	Like other donor funded projects in Bangladesh, the approach of avoiding involuntary resettlement had already been taken by this project. The measure will be developed in design and implementation stages, furthermore.
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken.	Not specified for non-titled people	There is no provision for compensation for non-titled residents in the Bangladesh ordinance, while JICA's Guidelines acknowledges all affected persons whether legally residing or not, are eligible for compensation.	Compensations are proposed even for non-titled people as follows. - Compensation for structures, trees - Structure transfer assistance - Structure reconstruction assistance - Moving assistance for residential house owner - Tenant moving allowance
3	People who must be settled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.	Not specified for maintaining living standard of affected people at the same or above of pre-project levels.	There is no provision for maintaining living standard of affected people at the same or above pre-project levels in Bangladesh ordinance, while JICA's Guidelines require that no one is worse off as a result of resettlement and would maintain their living level at least at original levels	Assistances were proposed in the form of: - Grant for business loss - Compensation for loss of plant and fish-stock - Grant for loss of wage employment - Rental fee loss for displaced rented house owner - One time moving assistance for tenant business owner - Introduction of micro-credit - Provision of job training Provision of priority employment etc.
4	Compensation must be based on the full replacement cost as much as possible	Compensation is made based on the pre-determined government prices which are usually much lower than full replacement cost.	There are no related provisions in the Bangladesh ordinance, while JICA's Guidelines require that the replacement cost plus tax and remittance charge shall be included in compensation.	The resettlement plan addresses all these issues and spells out a mechanism to fix the full replacement costs as follows. District Commissioner: Pay compensation for PAPs based on ARIPO. DTCA: Pay compensation for PAPs the difference between full replacement cost and determined by DC.

5	Compensation and other kinds of assistance must be provided prior to displacement	Payment is made at a predetermined time, regardless of whether it is before or after the construction starts	Compensation and other assistance are made regardless of whether it is before or after construction, while JICA Guidelines requires to pay compensation prior to relocation	The resettlement plan addresses all these issues and spells out a mechanism for all the compensation to be paid prior to possession of the acquired land and prior to displacement
6	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public.	There is no provision for the formulation of RAP or public hearings. The Deputy Commissioner contacts the land owner through the land Acquisition Officer (LO), and if the landowner has no objection, confirms the compensation amount etc. and proceeds.	There is no provision for the resettlement plan that describes all features of resettlement requirements should be disclosed to the public.	The Resettlement Action Plan (RAP) prepared for this project with all features of resettlement requirements and mechanism of disclosure to the public is an integral part of F/S. DTCA is requested to disclose the RAP with their consensus.
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	The 1982 Ordinance has provisions to notify only the owners of property to be acquired	There is no provision in the law for consulting the stakeholders, but the land allocation committees at district, division and central government level are all involved.	The RAP for the project has been prepared by consultation process which involves all stakeholders (affected persons, government department/line agencies, local community, NGO, etc.), and the consultation will be conducted in continuous process at all stages of the project development, such as project formulation, feasibility study, design, implementation, and post-implementation, including the monitoring phase.
8	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people	There are no provisions	Requirements of JICA Guidelines are not specifically mentioned in the Bangladesh laws and rules	The RAP has been prepared based on the consultation process in local language. And participatory process involves questions and explanations on the components of RAP. The consultation will be a continuous process at all stages of the project development, such as project formulation, feasibility study, design, implementation, and post-implementation, including the monitoring phase.
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans	There is no provision for the monitoring related activities with the participation of affected people	There is no provisions in Bangladesh ordinances, while JICA Guidelines recommend participation of affected people in planning, implementation and monitoring of the RAP	The RAP has been prepared by following a consultation process with all stakeholders. The consultation will be a continuous process at all stages of the project development, such as project formulation, feasibility study, design, implementation, and post-implementation, including the monitoring phase.

10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities	If PAPs have objection regarding the compensation amount, he should protest and entrust the matter to an Arbitrator. If he has to appeal against the Arbitrator's decision, then he should file a law suit and wait for the decision.	The law of Bangladesh states it should be settled through Arbitrator as court case, while JICA's Guidelines recommend to establishing an appropriate grievance redress mechanism for amicable settlement to minimize the legal confrontation.	The RAP for this project has made a provision for setting up a grievance redress mechanism accessible for all the affected people including non-titled affected people.
11	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socio-economic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers or others who wish to take advantage of such benefit.	No such an activity is required	There is no provision in Bangladesh ordinances, while JICA Guidelines recommend identification of affected people in the least possible time preferably at the project identification stage.	This RAP has been prepared based on the data collected through conducting a census, socioeconomic survey for the displaced persons and making an inventory of losses. Video filming has also been recorded to the affected properties.
12	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who do not have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying	There is no provision.	Requirement of JICA's Guidelines is not specifically mentioned in the Bangladesh laws and rules.	The RAP ensures compensation and assistance to all affected persons, whether physically displaced or economically displaced, irrespective of their legal status. Eligibility depends on the cut-off date, and affected persons listed before the cut-off date will be eligible for assistance.
13	Preference should be given to land–based resettlement strategies for displaced persons whose livelihoods are land-based.	There is no provision.	Requirement of JICA Guidelines is not specifically mentioned in the Bangladesh laws and rules.	Though this option may be a difficult proposition given the lack of government lands and the difficulties associated with the acquisition of private lands, the resettlement plan proposes land-for-land compensation as its priority, if feasible. Attempts will be made to find alternate land for the loss of land, in case it is available and if it is feasible, looking at the concurrence of the host community and land value.
14	Provide support for the transition period (between displacement and livelihood restoration)	There is no provision for support for the transition period.	There is no provision in Bangladesh ordinances, while JICA Guidelines require providing support for the transition period.	The following are provided in the RAP: Transfer assistance for residential house owners Tenant moving allowance

15	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.	There is no provision either acknowledgment of or compensation to vulnerable groups	There is no provision in Bangladesh ordinances, while JICA Guidelines require providing special attention to vulnerable people and groups.	Vulnerable allowances were proposed to widowed, old, disabled and poor house head families such as : Special Assistance for Vulnerable households. Focus group discussion was held to cope with gender.
16	For a project that entails land acquisition or involuntary resettlement of more than 200 people, a resettlement action plan is to be prepared	There is no provision	Requirement of JICA Guidelines is not specifically mentioned in the Bangladesh laws and rules	The RAP has been prepared since the displaced people in Line 5 are estimated to be more than 200.

Source: JICA Study Team

5.14 Census and Socio-economic Survey

5.14.1 Eligibility Criteria

The census and a socio-economic survey was carried out in March through April 2017 to provide requisite details on the Project Affected Units (PAUs) of MRT line 5 to further assess the magnitude of likely impacts and to identify measures for mitigation of adverse impacts. The survey included (i) full census and socioeconomic survey with structured questionnaire and inventory of losses (Annex-1), (ii) surveys for property valuation and other assets through structured questionnaire (Annex-2); (iii) video filming of the affected properties and (iv) community based public consultation etc. The survey identified the households, commercial and business enterprises, land owners, sharecroppers, squatters, tenants and community properties on project right of way.

The census questionnaire incorporated the basic questions for identification of the affected unit, its owner/user, and types and extent of losses and other relevant data. These data are collected to prepare the Inventory of Losses (IOL) generated by the project.

The socioeconomic survey collected a wide range of data, for example, demography, age/sex distribution, education, occupation, income/poverty data, types of businesses, types and ownership status of affected structures and other assets.

5.14.2 The Project Area

The project area extends in both Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC) and Savar Upazila starting from Hemayetpur, extended towards east and ended at Vatara. The users would be able to use other lines like Line 1 and Line 6 through junction facilities. Total length of the MRT Line 5 is 19.5 Km with one depot in Hemayetpur in Savar Upazila. There are 14 stations and five of them will be on the surface and rest will be underground.

The depot has sold over to the land development companies, however, the record of mouza map still shows old name and has not revised fully yet. Therefore, the census was carried against mightily affected people excepting former landowner in depot. It is expected to identify the latest landowner in detailed design stage in the future.

5.14.3 Profile of Affected Households

1) Population

Community Property Resources (CPR) (24) have not been considered in calculating population. A total of 4,660 people have been identified as affected by losing residential structure, commercial structure, trees, ponds and other minor infrastructure. A total of 10 households will be displaced from their own residence, 15 will be displaced from the rented housing structure and 4 household will lose both homestead and CBE. On the other hand 369 households will lose their commercial structure, 46 household will lose their trees or other minor structures like gates, drains, walls etc. A total of 663 vendors or temporary shop owners will have to be displaced for the project intervention. Average household size of the project area is 4.2 which are lower than the national average (4.5). Out of the total affected population, 2,617 (56.1%) male and 2,043 (43.9%) female. Location wise number of affected male and female population is shown in the Table 5.14.1.

Table 5.14.1 Number of Male and Female Population by Location

Location	Total HH	Population		
		Male	Female	Total population
Hemayetpur	40	109	93	202
Baliarpur	12	33	28	61
Bilamalia	7	17	12	29
Amin Bazar	106	283	248	531
Gabtoli	357	879	657	1,536
Dar-Us-Salam	28	68	62	130
Mirpur-1	17	36	35	71
Mirpur-10	314	647	479	1,126
Mirpur-14	4	07	12	19
Kochukhet	38	85	70	155
Banani	13	25	25	50
Gulshan 2	0	0	0	0
Notun Bazar	47	101	92	193
Varara	80	231	173	404
Depot Area	46	99	61	160
Total	1,107	2,671	2,043	4,660

Source: Census & Socioeconomic Survey, April 2017

2) Ethnicity, Religion and Gender

Based on findings of the survey, the Project will affect 1,107 households for this project. Out of total 1,107 households 1,073 are Muslim and 34 are Hindu. No ethnic minority is found in the proposed project locations. Detail of households in terms of religion is shown in Table 5.14.2.

Table 5.14.2 Affected Households by Location and Religion

Location	Religion				Total (No)	%
	Muslim (No)	%	Hindu (No)	%		
Hemayetpur	40	100.00	0	0.00	40	100.00
Baliarpur	12	100.00	0	0.00	12	100.00
Bilamalia	7	100.00	0	0.00	7	100.00
Amin Bazar	106	100.00	0	0.00	106	100.00
Gabtoli	343	96.08	14	3.92	357	100.00
Dar-Us-Salam	27	96.43	1	3.57	28	100.00

Location	Religion				Total (No)	%
	Muslim (No)	%	Hindu (No)	%		
Mirpur-1	16	94.12	1	5.88	17	100.00
Mirpur-10	306	97.45	8	2.55	314	100.00
Mirpur-14	4	100.00	0	0.00	4	100.00
Kochukhet	35	92.11	3	7.89	38	100.00
Banani	13	100.00	0	0.00	13	100.00
Gulshan 2	0	0.00	0	0.00	0	0.00
Notun Bazar	44	93.62	3	6.38	47	100.00
Varara	74	94.87	4	5.13	78	100.00
Depot Area	46	100	0	10.00	46	100.00
Total	1,073	96.93	34	3.07	1,107	100.00

Source: Census & Socioeconomic Survey, April 2017

Among the affected households 1,072 are male headed and 35 are female headed. In total less than 3.16 percent of the heads are headed by female.

3) Level of Education

The numbers of school going children are increasing. Today, almost all the young children are going to school, girl children are more advanced in this regard as the GOB is providing facilities for them. This is an urban area with good opportunity to go to school. Young generations irrespective of sex have much higher level of education than compared to the heads of the households.

Table 5.14.3 Level of Education of the Head of the Households

Location	Level of Education						Total
	Illiterate	Class-I-V	Class VI-X `	SSC & HSC	Graduate	Above Graduate	
Hemayetpur	0.00	52.50	27.50	12.50	2.50	5.00	100.00
Baliarpur	0.00	58.30	33.30	8.33	0.00	0.00	100.00
Bilamalia	14.30	42.90	42.90	0.00	0.00	0.00	100.00
Amin Bazar	0.94	30.20	48.10	17.90	0.00	2.80	100.00
Gabtoli	1.96	32.21	35.01	9.24	8.12	13.45	100.00
Dar-Us-Salam	3.57	64.29	17.86	14.29	0.00	0.00	100.00
Mirpur-1	0.00	64.71	23.53	11.76	0.00	0.00	100.00
Mirpur-10	0.00	38.85	39.81	15.61	3.18	2.55	100.00
Mirpur-14	0.00	100.00	0	0.00	0.00	0.00	100.00
Kochukhet	0.00	63.16	23.68	7.89	2.63	2.63	100.00
Banani	0.00	38.50	30.80	15.40	0.00	15.4	100.00
Gulshan 2	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Notun Bazar	0.00	25.50	42.6	17.02	8.51	6.38	100.00
Varara	1.28	43.59	28.21	14.10	5.13	7.69	100.00
Depot Area	13.04	41.30	39.13	0.00	2.17	4.35	100.00
Total	1.54 (17)	38.57(427)	36.22 (401)	12.38(137)	4.52 (50)	6.78 (75)	100.00 (1,107)

Source: Census & Socioeconomic Survey, April 2017

4) Age and Occupation

The largest proportion of population is in age group 15-29 followed by age group of 30-44 and up to 14 irrespective of male and female population in all the locations. Population within the age group 45-59 is 17.45% and above 60 is more than 11%. Highest percentage of young population is found in Mirpur 14 followed by Bilamalia and Gabtoli. Table 5.14.4 shows in detail.

Table 5.14.4 Age Distribution of Affected Population by Location

Location	Age Group										Total	
	Up to -14		15-29		30-44		45-59		60 & Above			
	No	%	No	%	No	%	No	%	No	%	No	%
Hemayetpur	47	23.30	53	26.20	40	19.80	35	17.30	27	13.40	202	100.00
Baliarpur	13	21.30	15	24.60	13	21.30	11	18.00	9	14.80	61	100.00
Bilamalia	7	24.10	08	27.60	5	17.20	3	10.30	6	20.70	29	100.00
Amin Bazar	118	22.20	162	30.50	114	21.50	86	16.20	51	9.60	531	100.00
Gabtoli	342	22.27	396	25.78	331	21.55	389	18.82	178	11.59	1,536	100.00
Dar-Us-Salam	28	21.54	37	28.46	28	21.54	19	14.62	18	13.85	130	100.00
Mirpur-1	13	18.31	26	36.62	14	19.72	13	18.31	5	7.04	71	100.00
Mirpur-10	203	18.03	376	33.39	229	20.34	200	17.76	118	10.48	1,126	100.00
Mirpur-14	6	31.58	4	21.05	4	21.05	2	10.53	3	15.79	19	100.00
Kochukhet	32	20.65	50	32.26	27	17.42	31	20.00	15	9.68	155	100.00
Banani	10	20.00	12	24.00	12	24.00	9	18.00	7	14.00	50	100.00
Gulshan 2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Notun Bazar	43	22.28	54	27.98	44	22.80	31	16.06	21	10.88	193	100.00
Varara	104	26.2	100	24.9	102	24.6	51	12.8	47	11.3	404	100.00
Depot Area	104	26.20	99	24.94	98	24.69	51	12.85	45	11.34	397	100.00
Total	993	21.31	1,324	28.41	999	21.44	813	17.45	531	11.39	4,660	100.00

Source: Census & Socioeconomic Survey, April 2017

5) Income and Poverty Dimensions

Poverty in Bangladesh is measured through per capita income or through Direct Calorie Intake (DCI) where persons having DCI of less than 2,122 kcal are considered to be living in poverty. Based on the census and socioeconomic survey (March-April 2017) indicating yearly income and expenditure of the project affected households it is found that about 4.79% households earn less than Tk 108,000 per year (Table 5.14.5).

Table 5.14.5 Poverty Level and Annual Income (BDT) of Head of the Households

Location	Annual Income (BDT)					
	Up to 108,000	108,001 to 200,000	200,001 to 300,000	300,001 to 500,000	5,00,001 to 7,00,000	Above 7,00,000
Hemayetpur	2	7	12	8	4	7
Baliarpur	0	7	1	2	0	2
Bilamalia	1	2	1	3	0	0
Amin Bazar	6	13	14	13	15	45
Gabtoli	8	40	87	51	33	138
Dar-Us-Salam	5	13	6	3	1	0
Mirpur-1	1	5	4	6	0	1
Mirpur-10	6	134	131	39	1	3
Mirpur-14	4	11	11	10	0	2
Kochukhet	0	3	1	0	0	0
Banani	2	0	6	0	1	4
Gulshan 2	0	0	0	0	0	0
Notun Bazar	3	7	14	1	3	19
Varara	9	9	10	24	5	21
Depot Area	6	24	10	1	1	4
Total	53 (4.79%)	275 (24.84%)	308 (27.82%)	161 (14.54%)	64 (5.78%)	246 (22.22%)

Source: Census & Socioeconomic Survey, April 2017

The survey identified 166 vulnerable households in the project area. These are almost all the project affected female headed households, households headed by elderly persons, disable persons, male headed household but under the poverty line. The vulnerable households of different locations are shown in the Table 5.14.6**.**

Table 5.14.6 Vulnerable Households in Percentage and by Location

Location	Vulnerability				Total
	Female Headed HHs	Elderly (<60yr,)	Disabled Male HHHs	Male Headed Households under poverty line	
Hemayetpur	2	2	1	1	6
Baliarpur	0	1	0	0	1
Bilamalia	2	1	0	0	3
Amin Bazar	1	8	2	6	17
Gabtoli	13	45	1	8	67
Dar-Us-Salam	1	2	0	5	8
Mirpur-1	1	1	1	1	4
Mirpur-10	2	5	2	6	15
Mirpur-14	1	1	0	3	5
Kochukhet	1	0	0	0	1
Banani	0	1	0	2	3
Gulshan 2	0	0	0	0	0
Notun Bazar	1	1	0	3	5
Varara	9	3	2	8	22
Depot Area	1	3	0	5	9
Total	35	74	9	48	166

Source: Census & Socioeconomic Survey, April 2017

5.14.4 Scope of Land Acquisition

A total of 23.565ha private land will be required of which consist 21.995ha for depot area and 1.57 ha for some pockets. This land is mainly for the depot area in Hemayetpur and the area is marshy land and rural in nature. This patch of depot is from two mouzas namely Bilamalia and Konda covering two types of land. Majority of the land is agriculture land followed by homestead land. It is found that the land of depot area is agricultural land; however, the owners are being used as homestead land in near future. In addition to this acquired land some government owned land (khas) will be used to construct MRT line 5 and its components, mostly stations. Mouza wise type of land and route segments based on type to be acquired is shown in the Table **5.14.7.**

Table 5.14.7 Land Acquisition of the Project by Mouza and Route Segment

Mouza	hectare	Name of Route Segments based on Type	hectare
Bilamalia	5.8825	Hemayetpur – Amin Bazar	1.29
Konda	16.1125	Amin Bazar – Notun Bazar	0.10
		Notun Bazar - Vatara	0.18
Total	21.995		1.57

Source: Census & Socioeconomic Survey, April 2017

Sub-categorization of Public Land Requirements is presented in Table 5.14.8 of which a total 10.64ha is required.

Table 5.14.8 Land Acquisition of the Project by Mouza and Route Segment

Name of Route Segments based on Type	Public Land for Stations (hectare)	Public Land for Line (hectare)	Name of Organization
Hemayetpur – Amin Bazar	1.16	4.74	RHD
Gabtoli	2.46	-	DNCC
Amin Bazar – Notun Bazar	0.42	-	DNCC
Notun Bazar - Vatara	0.42	1.44	RAJUK
Total	4.46	6.18	

Source: Census & Socioeconomic Survey, April 2017

5.14.5 Displacement and Other Impacts

In addition to land acquisition, the project will have direct impact on 1,107 Project Affected Units (PAUs). It is to be mentioned here that there will not be any affected people in one proposed station namely Gulshan 2. The project works will affect 25 residential households, 369 Commercial & Business enterprises (CBEs) and 4 residential cum CBEs, 46 household are going to lose varieties of properties like wall, trees, drains etc. and 663 vendors or temporary shops are going to be affected with a total affected units of 1,107. The list of PAHs, land owners, CPRs, vulnerable and wage workers is attached in Annex-3. The location wise impact is presented in Table 5.14.9.

Table 5.14.9 Displacement of PAHs and Impacts by Location

Location	Location wise Number of PAHs						Total
	Loss of Residence	Loss of Business	Loss of Business and Residence	Loss of Residence by Rented	Vendors on Govt. land	Others	
Hemayetpur	2	17	0	0	21	0	40
Baliarpur	0	3	0	0	9	0	12
Bilamalia	0	0	0	2	5	0	7
Amin Bazar	1	51	1	3	50	0	106
Gabtoli	0	265	0	0	92	0	357
Dar-Us-Salam	0	1	0	0	27	0	28
Mirpur-1	0	1	0	0	16	0	17
Mirpur-10	0	0	0	0	314	0	314
Mirpur-14	0	0	0	0	4	0	4
Kochukhet	0	0	0	0	38	0	38
Banani	1	4	0	0	8	0	13
Gulshan 2	0	0	0	0	0	0	0
Notun Bazar	0	10	0	0	37	0	47
Varara	6	17	3	10	42	2	78
Depot Area	1	1	0	0	0	44	46
Total	10	369	4	15	663	46	1,107

Source: Census & Socioeconomic Survey, April 2017

Among the Affected Units only 25 are title holders i.e. Owns the land and rest 1, 82 are on government land. Total affected persons are 4,660.

Amin Bazar will be a viaduct station and it is difficult to set back due to the existing residences, therefore some vendors will move towards the north which crosses the national highway and some will move to the east of the expected vertical shaft for shield tunnel because the parking lots locate nearby. Mirpur 10 will be an underground station and expected to be built at the west of junction. Present vendors will move towards east, south and north of junctions.

Therefore, present vendors both Aminbazar and Mirpur 10 will not move extremely from present places.

The affected households by legal status, type of loss and by location is shown in Table 5.14.10.

Table 5.14.10 Number of PAHs by Location on Private (Title-Holder) and Public Land (Non-Titled PAHs)

Name of Stations (Locations)	Title-holder PAHs					Non-title holder PAHs					Total PAHs	Total Population
	Home stead	Business	Both	Others	Total	Residence	Temporary Shops	Rented in Shops	Others	Total		
Hemayetpur	2	1	0	0	3	0	21	16	0	37	40	202
Baliarpur	0	2	0	0	2	0	9	1	0	10	12	61
Bilamalia	0	0	0	0	0	2	5	0	0	7	7	29
Amin Bazar	1	4	1	0	6	3	50	47	0	100	106	531
Gabtoli	0	0	0	0	0	0	92	265	0	357	357	1,536
Dar-Us-Salam	0	0	0	0	0	0	27	1	0	28	28	130
Mirpur-1	0	0	0	0	0	0	16	1	0	17	17	71
Mirpur-10	0	0	0	0	0	0	314	0	0	314	314	1,126
Mirpur-14	0	0	0	0	0	0	4	0	0	4	4	19
Kochukhet	0	0	0	0	0	0	38	0	0	38	38	155
Banani	1	0	0	0	1	0	8	4	0	12	13	50
Gulshan 2	0	0	0	0	0	0	0	0	0	0	0	0
Notun Bazar	0	1	0	0	1	0	37	9	0	46	47	193
Varara	6	1	3	2	12	10	42	16	0	68	80	404
Depot Area	1	1	0	19	21	0	0	0	25	25	46	160
Total	10	9	4	211	44	15	663	360	25	1,063	1,107	4,660

Source: Census & Socioeconomic Survey, April 2017

A total of 469 structures of 17,931 sq. m area of different categories will be affected, of which 7,765 sq. meters are pucca, and 5,117 sq. meters are semi pucca, 978 sq. meters are tin sheds, 3,842 sq. meters are katcha and 228 sq. meters are tarpaulin covered in Table 5.14.11.

Table 5.14.11 Quantity of all Affected Structure (sq. meter) by Type and by Location

Station Name	Type of Affected Structure						Total
	Thatched Structure	Katcha	Tin	Semi pucca	Pucca	Tarpaulin	
Hemayetpur	0	248.10	241.80	887.80	248.90	0	1,626.70
Baliarpur	0	27.88	207.50	80.97	02.88	06.51	325.74
Bilamalia	0	0	62.30	0	7.43	0	69.73
Amin Bazar	0	658.00	228.00	1,879.00	1,552.00	03.25	4,320.25
Gabtoli	0	2,049	33.09	1,203	2,348	0	5,633.00
Dar-Us-Salam	0	4.46	19.52	3.72	0	13.95	41.65
Mirpur-1	0	2.32	2.32	0	0	13.57	18.21
Mirpur-10	0	0	0	0	0	79.43	79.43
Mirpur-14	0	0	0	0	1.86	0	1.86
Kochukhet	0	2.32	24.62	0	416.4	98.61	541.95
Banani	0	0	0	0	362	1.86	363.86
Gulshan 2	0	0	0	0	00	0	0
Notun Bazar	0.93	91.5	30.4	27.9	232	10.9	393.63
Varara	0	759.1	128.6	601.3	2417	0	3906
Depot Area	0	0	0	433.1	177.00	0	610.0
Total	0.93	3,842	978.10	5,117	7,765	228.10	17,931.00

Source: Census & Socioeconomic Survey, April 2017

In addition to the project affected units or households 24 Common Property Resources (CPR) are going to be affected. The CPRs include mosque, madrasa, school/college, mazar, offices etc. Among the CPRs others (unspecified) seems to be outnumber other CPRs.

Table 5.14.12 Distribution of CPR by Stations of MRT line 5

Station Name	Type of CPRs							Total
	Mosque	School/ College	Club/ Community	Madrasa	Mazar	Office*	Others†	
Hemayetpur	0	0	0	0	0	0	5	5
Baliarpur	0	0	0	0	0	1	0	1
Bilamalia	0	0	0	0	0	0	2	2
Amin Bazar	0	0	0	0	0	0	1	1
Gabtoli	0	0	1	0	0	0	2	3
Dar-Us-Salam	1	0	0	0	0	1	1	3
Mirpur-1	0	1	0	0	0	0	1	2
Mirpur-10	0	0	0	0	0	0	0	0
Mirpur-14	0	0	0	0	0	0	0	0
Kochukhet	0	1	0	0	0	0	2	3
Banani	0	0	0	0	0	1	1	2
Gulshan 2	0	0	0	0	0	0	0	0
Notun Bazar	0	0	0	0	0	1	0	1
Varara	0	0	0	0	0	0	1	1
Depot Area	0	0	0	0	0	0	0	0
Total	1	2	1	0	0	4	16	24

Source: Census & Socioeconomic Survey, April 2017

5.14.6 AP Preference for Relocation

During the census survey as well as in stakeholder consultation meetings (SCM) and FGDs, the relocation choices of the affected persons were asked. The households to be relocated are homestead loser prefer to remain in the adjoining area of the project location to continue their present occupation. Almost all are demanding assistance from the project during relocation. Therefore the APs are encouraged for self-relocation to get mutual support of the kin groups.

More than 99% of the affected PAUs preferred assistance as cash grant so that they can buy/shift their structure in new location and continue their livelihood. Rest of them wanted similar space for continuing their business. Details are shown in Table 5.14.13.

* Nirbahi Prokoshouli office, Post office Hosrita which will lose either boundary wall in the front or gate or secondary structure etc. None of CRP main building or office will be affected by the project

† Developer Company office, Group Company office, Bus repair garage, Govt. Quarter police box Nursery, Park, Shopping Mall, Trading Enterprize which will lose either boundary wall in the front or gate or secondary structure etc. None of CRP main building or office will be affected by the project

Table 5.14.13 Preference of CBEs for Relocation by Location in Percentage

Name of Stations (Locations)	Preferred Compensation				Total
	Cash Compensation	%	Kind for Kind	%	
Hemayetpur	40	100.0	0	0.0	40
Boliarpur	12	100.0	0	0.0	12
Modhumoti	7	100.0	0	0.0	7
Aminbazar	105	99.1	1	0.9	106
Gabtoli	275	77.03	82	22.97	357
Darus Salam	28	100.0	0	0.0	28
Mirpur -1	17	100.0	0	0.0	17
Mirpur-10	312	99.4	2	0.6	314
Mirpur-14	4	100.0	0	0.0	4
Kachukhet	38	100.0	0	0.0	38
Banani	13	100.0	0	0.0	13
Noutun Bazar	47	100.0	0	0.0	47
Gulshan 2	0	0.00	0	0.0	0
Vatara	76	97.4	2	2.6	78
Depot Area	46	100.00	0	0.0	46
Total	1020	99.3	87	0.7	1107

Source: Census & Socioeconomic Survey, April 2017

DMTS is advised to apply the principle that the business of PAPs would be continued where PAPs' set-back is available without acquiring the additional land like in Purbachal or obtain a consensus from PAPs where set-back is not physically available due to a populated area. In the latter case DMTC is recommended to conduct stakeholder meeting on compensation.

5.15 Eligibility Policy and Entitlement Matrix

5.15.1 Eligibility Criteria

All APs will be entitled to compensation and resettlement assistance based on severity (significance) of impacts. Nevertheless, eligibility to receive compensation and other assistance will be limited by the cut-off date. The cut-off date for compensation under law (Ordinance II of 1982 and its 1994 amendments) is considered for those identified on the project right of way land proposed for acquisition at the time of serving notice under Section 3 or joint verification by DC whichever is earlier. The cut-off date of eligibility for resettlement assistance under this RAP is the commencement date of the disclosure of entitlements and consultation meeting with the stakeholders which is the 2nd round stakeholder meetings in April 2017 for the APs staying on public lands. The absence of legal title will not bar APs from compensation and assistance, as specified in the entitlement matrix presented in Table 5.15.1.

5.15.2 Compensation and Entitlement Policy

An Entitlement Matrix has been prepared on the basis of census and socioeconomic survey conducted in 9th March to 4th April 2017. It identifies the categories of impact based on the census & SES and shows the entitlements for each type of loss. The matrix describes the units of entitlements for compensating the lost assets, and various resettlement benefits. Cash Compensation under law (CCL) for lost assets (land, tree, structure & other physical establishments) will be accorded to the owners through the DCs as per market value assessed through legal procedure. The resettlement benefit for indirect losses and difference between replacement value and the CCL will be paid by DMTC through RAP Implementing Agency (IA).

Table 5.15.1 Compensation and Entitlement Policy

Item No.	Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/Guidelines
1	Loss of homestead, commercial, Agriculture land, pond, ditches and orchards etc.	Legal owner(s) of land	i. Replacement value (RV) of land (Cash Compensation under Law (CCL) and additional grant to cover the current market price of land and stamp duty & registration cost @ 11.5% of CMP for land) to be determined by PVAC. ii. Compensation for standing crops to actual owners/ cultivators as determined by PVAC.	a. Assessment of quantity and quality of land by Joint Verification Survey b. Assessment of Market Value by Land Market Survey (LMS) c. Assessment of Cash Compensation under Law (CCL) d. Updating of title of the affected persons e. Payment of Cash Compensation under Law (CCL) f. APs will be fully informed of the entitlements and procedures regarding payments g. Additional cash grant to be paid to cover the replacement value of land compensation based on DC's CCL. h. Stamp duty and registration fees will be added with current market price (CMP) for land @ 11.5% of CMP to facilitate the APs in purchasing alternative lands.
2	Loss of access to cultivable land by owner cultivator/ tenant/ sharecropper	Tenants/ sharecropper/ Legal owner/ grower/ socially recognized owner/ lessee/ unauthorized occupant of land	i. Compensation for standing crops to owner cultivator/ sharecroppers or lessees as determined by PVAC. ii. Owner/grower to take away the crop	a. All the individuals identified by the JVS as tenants or sharecroppers of land b. Grant to be paid after taking possession of land and the legal /socially recognized owner is paid CCL for land and on certification of receipt by legal/socially recognized owner c. Additional cash grant to cover current market value of crop compensation as prescribed by PVAC in case of private owner himself cultivating crop d. Crop compensation and the crop will be shared between owner and sharecropper as per terms of sharecropping in case of privately owned land/socially recognized owner e. In case of dispute over verbal agreement on sharecropping, certification from the elected representative will be considered as legal document
3	Loss of Trees/ Perennials/ fish stocks	1. Person with Legal Ownership of the land 2. Socially recognized owner/ Unauthorized occupant of the trees/ fishes	i. Cash compensation at market rates for replacement of trees/ perennials/ fish stocks value ii. For fruit bearing trees- compensation for fruits @ 30% of timber value X 1 year iii. Compensation for fish stocks as determined by PVAC. iv. 5 saplings will be distributed free of cost among each affected household losing trees v. Owners will be allowed to fell and take away their trees, perennial crops/ fishes etc. free of cost without delaying the project works.	a. Assessment of loss and market value of affected trees b. Payment of CCL for trees c. Adequate compensation will be paid and the owner will be allowed to fell and take the tree free of cost d. Compensation for fruit will paid for small, medium and large categories of trees. e. 5 saplings (2 fruit tree, 2 timber types and 1 medicinal tree) free of cost will be distributed among the tree losing households.

Item No.	Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/Guidelines
4	Loss of residential /commercial structure by owner(s)/ squatters	Legal Owners or squatters	i. Replacement value of structure at market price determined by PVAC. ii. Structure Transfer Grant (STG) @ Tk.12.50% of the replacement value of main structure iii Structure Reconstruction Grant (SRG) @ Tk.12.50% of the replacement value of main structure. iv. One time Transfer Grant (TG) for portable materials at the rate of (a) BDT 3,000 (three thousand) for katcha structure and (b) BDT 5,000 (five thousand) for semi Pucca structure and BDT 7,000 (seven thousand) for Pucca structures v. Cost of transfer and reinstallation of the utility services like reinstallation of electricity connection, water supply line, telephone line etc. as grant @ 10% of CMP (5% for the structure to be demolished now and another 5% for its reconstruction) vi. For the legal owners Monthly Hiring Allowance (MHA) for the similar type of space in other structures for running their activities for a period up to 6 (six) months with the rate would be determined by DMTC through market survey by the IA for various categories of structures like pucca, semi-pucca and katcha. vii. Salvageable materials will be taken away by the owners within the stipulated time notified by DMTC Owners to take away all salvage materials free of cost	a. Payment of CCL for the losses b. Verification of Joint Verification Survey (JVS) and other records c. APs will be fully informed about their entitlements and assisted to obtaining it.
5	Loss of access to Residential houses/ commercial structures (rented or leased)	Tenants of rented/ leased properties	i. House Transfer Grant (HTG) for shifting of furniture and belongings of residential structure (@ BDT 2,000 (two thousand) for katcha structure, BDT 4,000 (four thousand for semi-Pucca structure and BDT 6,000 (six thousand) for Pucca structure to each shifting tenant. ii. Stock Transfer Cost (STC) for commercial entities @BDT 5,000 (five thousand) for small business; BDT 10,000 (ten thousand) for medium business and BDT 15,000 (fifteen thousand) for large business. iii. One time cash grant for facilitating alternative housing/CBEs Tk. 5000 (Five thousand) per household or entity	a. Verification of JVS and records b. Transfer grants will be paid on relocation from project site
6	Loss of business by CBEs due to dislocation	Owner/operator of the business including vendors s as recorded by JVS	i. CCL for business loss. ii. Businesses without any income tax payment record: Transition allowance (TA) for the permanent loss of business/income equivalent to 03 (three) months' income subsistence at the rate of BDT 5,000 (five thousand) for Small business, BDT 10,000 (ten thousand) for medium business and BDT 15,000 (fifteen thousand) for	a. All persons recorded by the JVS b. Cash grant to be paid while taking possession of land c. Small business will be defined as having Investment up to BDT 50,000 (fifty thousand), Medium business with Investment between BDT 50,000 to BDT 250,000 and Large business will have investment above BDT

Item No.	Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/Guidelines
			large business. iii.Business with records of income tax payment: TA equivalent to 3(three) months' income calculated on the basis of income tax payment record for the preceding year, not exceeding BDT 20,000 (twenty thousand) for Small business, BDT 50,000 (fifty thousand) for medium business and BDT 75,000 (seventy five thousand) for large business.	250,000 (two hundred fifty thousand)
7	Loss of rental income	Owners of rental premises (residential, commercial) as recorded by JVS	i. Transition allowance (TA) for the loss of rental income equivalent monthly allowance for 3 (three) months for each affected rented out premises at the rate of (a) BDT 5,000 (five thousand) per month for katcha structure; (b) BDT 10,000 (ten thousand) per month for semi-Pucca structure (or Pucca structure less than 500 (five hundred) sft. and (c) BDT 15,000 (fifteen thousand) per month for Pucca structure/apartment.	a. All persons recorded by the JVS b. cash grant to be paid on relocation from project site
8	Loss of Income and work days due to displacement	Employees identified by the Joint Verification Committee (JVC)	i. Cash grant to the affected employees/wage earners equivalent to 45 days wage @ BDT 400/per day for unskilled laborers and @ BDT 600/per day for skilled laborers. ii. Preferential employment in the project construction work, if available.	a. All persons recorded by the JVS b. Cash grant to be paid while taking possession c. Involvement of the incumbents in project civil works d. Training on income generating activities.
9	Poor and vulnerable households	Poor and vulnerable households as identified by JVC	i. Additional cash grant of BDT 10,000 (ten thousand) for affected poor women headed households and other vulnerable households ii. Training on IGA for AP/ nominated by AP.	a. Identification of Vulnerable households b. Income restoration schemes for vulnerable households c. Arrange training on income generating activities
10	Temporary impact during construction	Community / Individual	i. The contractor shall bear the cost of any impact on structure or land due to movement of machinery and in connection with collection and transportation of borrow materials. ii. All temporary use of lands outside proposed RoW to be through written approval of the landowner and contractor. iii. Land will be returned to owner rehabilitated to original preferably better standard.	a. Community people should be consulted before starting of construction regarding air pollution, noise pollution and other environmental impact b. The laborers in the camp would be trained about safety measures during construction, aware of health safety, STDs, safe sex etc. The contractor shall ensure first aid box and other safety measures like condoms at construction site.

Source: RAP

5.15.3 Income and Livelihood Restoration Strategy

Additional measures will be taken to provide appropriate support to the livelihood restoration aspects of AHs.

In compliance with the RAP, the updated RAP will identify resources, in addition to compensation, for income restoration assistance. This will be through linking resettlement activities with a Livelihood and Income Restoration Program (LIRP).

The RAP includes the following categories of AHs for income restoration and livelihood support:

- Vulnerable households to be relocated from the project right of way. Eligible members of such family will be identified during planning the LIRP.
- Vulnerable households having no adult male members to shoulder household responsibility (women headed households in particular). The women heading the household will preferably be the eligible member.
- Vulnerable households of the employees and daily wage earners of the affected businesses or their nominated representatives.
- Vulnerable households losing access to agriculture land including sharecropper, and leaseholders.
- Vulnerable households losing access to commercial land including business proprietorship.
- Vulnerable households losing more than 10% of their agricultural income due to acquisition of agricultural land.

For additional support to usual income restoration assistance as mentioned above, the RAP Implementing NGO (INGO)/IA will specifically undertake assessment of needs and skill base of vulnerable APs of ages between 15 to 60 years. The IA (NGO or Consulting Firm) will recommend the eligible members of affected vulnerable households with their relevant profile to the LIRP implementing organization through DMTC. The short-term livelihood regeneration assistance under the RAP and long-term income generation program under the LIRP will be organized as follows:

Table 5.15.2 Livelihood Restoration Options

1. Eligible members of poor households to be relocated from the project right of way.	1.1 Short-term: Compensation for structure, shifting allowance, reconstruction assistance, cash assistance for loss of workdays due to relocation, and priority in employment in construction. 1.2 Long-term: Needs and capacity identification, human development and skill training, institutional support under the LIRP.
2. Eligible members from poor female headed households having no adult male members to shoulder household responsibility.	Similar to 1.1 and 1.2.
3. Poor and vulnerable employees of affected businesses.	3.1 Short-term: Subsistence for loss of income and employment. 3.2 Long-term: As 1.2 above.
4. Eligible members of poor households losing access to agriculture land including sharecroppers, and leaseholders.	4.1 Short-term: Compensation for crops. 4.2 Long-term: As 1.2 above.
5. Eligible members of poor households losing access to commercial land including business proprietorship.	5.1 Short-term: Compensation for loss of business income, shifting and reconstruction assistance. 5.2 Long-term: As per need, livelihood and income generating training and employment in project construction.
6. Eligible members of poor households losing more than 10% of their agricultural land.	6.1 Short-term: Compensation for crops, replacement value of land, assistance for land purchase, and employment in construction. 6.2 Long-term: As 1.2 above.

Source: RAP

5.15.4 Information on Depot (tentative)

Mouza (cadastral) map was obtained from Land Records & Survey, Tejgaon, Dhaka and tenants information from were collected for Savar and Alam Nagar Land Office in the beginning of March 2017 when census survey was started. There were 133 plots and 523 landowners were mentioned: one owner holds 420m^2 in average; however, information was old and not revised to the latest one precisely.

In Bangladesh, the land owner has to establish ownership by producing a record-of-rights in order to be eligible for compensation under the law. The record of rights prepared under Section 143 or 144 of the State Acquisition and Tenancy Act 1950 (revised 1994) are not always updated and as a result legal land owners have to face difficulties in trying to "prove" ownership. The APs must also produce rent receipt or receipt of land development tax.

Though 523 land owners are mentioned in the mouza map the lands are unused agricultural land. Because most of them were sold to land developer or absentee landlord for his house building plan in future, and approximate 60 local people are cultivating as seasonal paddy, vegetable field or fish pond.

Above situation and no residential structures in depot area were confirmed by the Study Team before cut-off date was declared (declared from 16th of April to 27th). After that, it was identified the names of 2 land developers who registered land plots at Savar and Alan Nagar Land Office. They are;

① Alam Chand Sugonda Housing (ACSH): registered 57 plots

② Jalalabad Metal Ltd.: registered 5 plots

It is available to identify the name of legal landowner at Land Office; however, 83 (57+5+21: individually owned) plots were identified. For remaining 440 plots it might be on the way to registration, or due absentee landowners it couldn't be identified by land developer. At this moment it is difficult to identify the title holders; therefore, the detail would be identified in the D/D stage.

In terms of compensation, land cost and crop cultivation cost or fish pond cost by 60 local people are quoted in the budget. And the rehabilitation of livelihood program would be applied to those local people. The absentee landlord will be compensated as well. When they require the compensation where the developer has not purchased it will be compensated through GRC in accordance with entitlement matrix.

5.16 Grievance Redress Committee

The complex land record system in Bangladesh leaves considerable room for conflicts over titles to land and properties involving land, structures, trees, ponds etc. Grievances may also be aired about the road alignment and/or the valuation of land and/or other properties in determining compensation. There are established procedures in the LA Ordinance of 1982 regarding compensation for some of these grievances. But recourse to law is always a complicated process, which usually discriminates against the poor due to their lack of knowledge and resources for litigation and is always time consuming. There are grievances, which can be easily resolved out of court if the law is properly explained and fair play made clear. It is with these objectives that a Grievance Redress Committee (GRC) will be set-up in each union where land acquisition will be taking place.

GRCs will be formed at Ward level for any grievances involving resettlement benefits, relocation, and other assistance. A gazette notification on the formation and scope of the GRCs will be required from the MORTB. The GRC for each Ward will comprised of;

Executive Engineer, DMTC - Convener

Area Manager, RAP Implementing Agency – member, secretary.

UP Chairman - member.

One representative of APs – member

One UP member (female) - member

And the Procedures and Mechanism are presented in Table 5.16.1 and Figure 5.16.1, respectively.

Table 5.16.1 Grievance Redress Procedures

Step 1	The Implementing Agency informs DPs/APs about their losses and entitlements. If satisfied, the DPs/APs claims of resettlement payments forwarded to the EA. If confused,
Step 2	The DPs/APs approach the IA field level officials for clarification. The IA will clarify the DPs/APs about their losses & entitlements as per RAP. If resolved, the DPs/APs claim resettlement payments to the EA. If not resolved,
Step 3	The DPs/APs approaches to the GRC. IA staff assists the DPs/APs producing the complaints and organize hearing in 15-21 days of receiving the complaints.
Step 4	GRC to scrutinize applications, cases referred to DC through EA if beyond their mandate as per scope of work
Step 5	If within the mandate, GRC sessions held with aggrieved DPs/APs, minutes recorded. If resolved, the Project Director approves. If not resolved,
Step 6	The DP/AP may accept GRC decision. If not, he/she may file a case to the court of law for settlement.
Step 7	The GRC minutes, approved by the Project Director, received at Conveners' office back. The approved verdict is communicated to the complainant DP/AP in writing. The DP/AP then claims resettlement payments to EA

Source: JICA Study Team

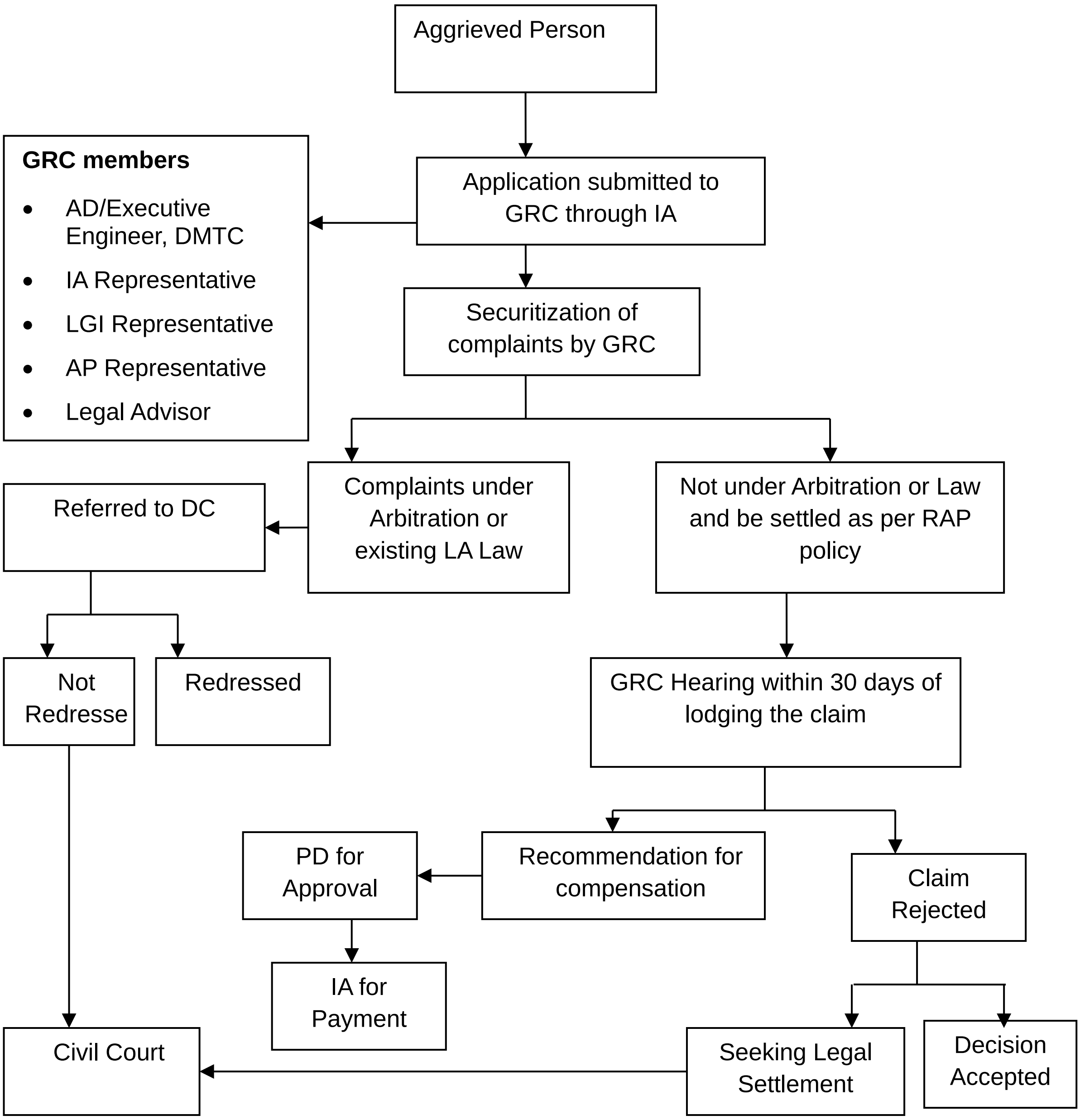


Figure 5.16.1 Grievance Redress Mechanism

Source: JICA Study Team

5.17 Implementation Organization

5.17.1 Implementation Organization

DMTC will establish a Project Implementation Unit (PIU) headed by a Project Director (PD), at the project office that will be responsible for the overall execution of the Project. The PIU will consist of three units: Engineering Service Unit (ESU), Environmental Management Unit (EMU) and Resettlement Unit (RU) for total implementation of the project. The PD will work on deputation from RHD at the level of Superintending Engineer or Additional Chief Engineer. The project will be overseen by the PD, RHD. The RU will be responsible for the overall implementation, management and monitoring of the RAP of the project. RAP Implementing Agency (IA) plays an important role in the field level in coordination with the DC, RHD and consultants. Their main activities are;

(a) To create ID numbers for each affected person as identified during the Joint Verification survey by JVT for both title and non-title holders.

(b) To assist the APs in preparing a record of rights to the property and receiving compensation under law (CCL) from DC office.

(c) To form focus groups with the affected people based on homogeneity and/or proximity and hold meetings on a regular basis to let them know their rights and entitlements as prescribed in the RAP.

(d) To form the union based resettlement advisory committee (RAC) to involve the local communities and APs in the implementation process.

(e) To prepare payment debit vouchers and other documents and disburse account payee checks to the APs.

The implementation organizations and hierarchy involved in the implementation process are shown in Figure 5.17.1**.**

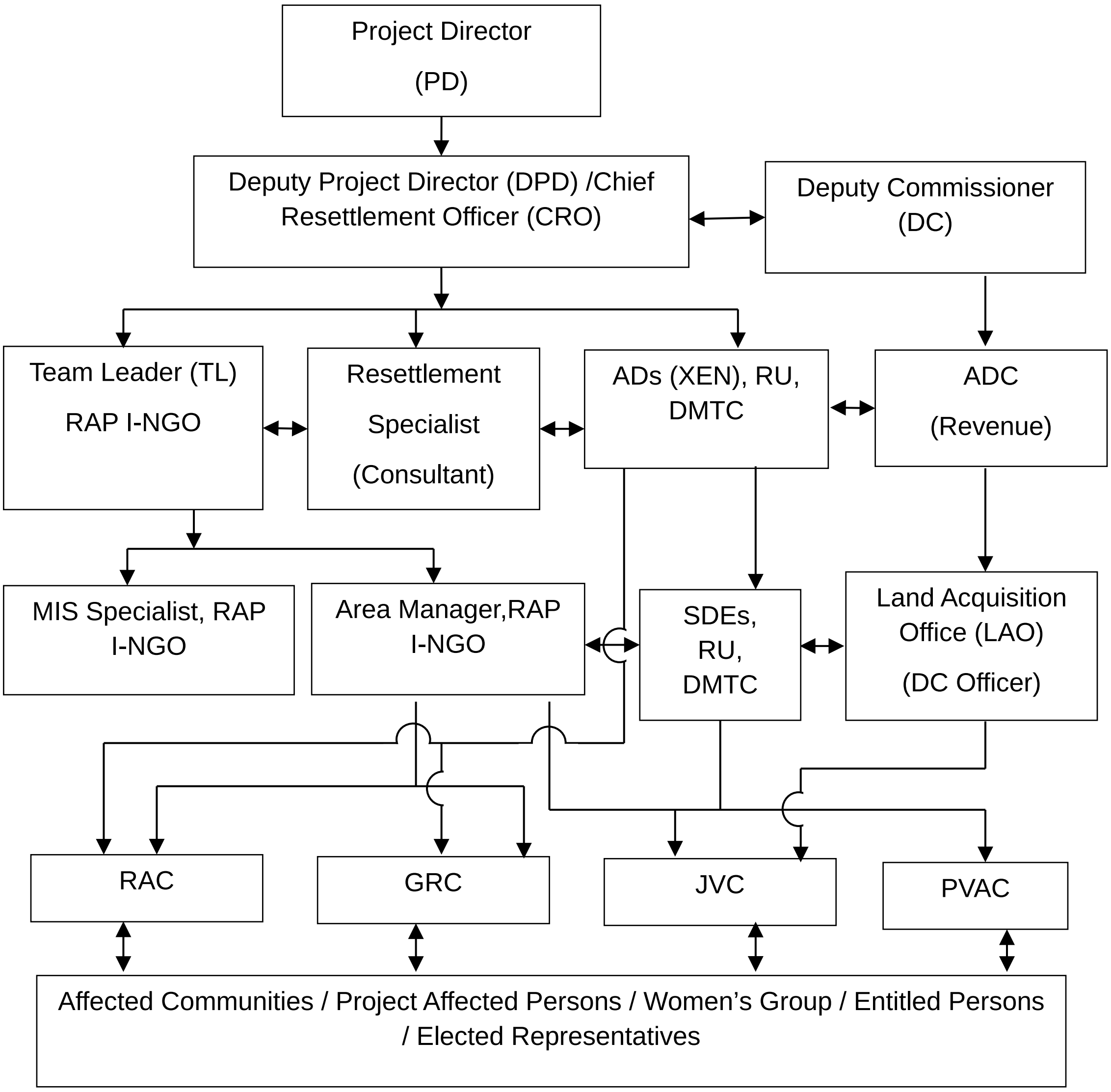


Figure 5.17.1 RAP Implementation Organogram

Source: JICA Study Team

5.17.2 Appointment of Implementing Agency (I-NGO)

DMTC will appoint an experienced Implementing Agency (IA) through standard procurement system. The IA can be a Non-Government Organization (NGO) or Social Consulting Firm. This IA will be appointed for implementation of the RAP in the field level in coordination with DC, DMTC and National Resettlement Consultant (NRS). The EA will contract out clearly defined tasks of the RAP with details Terms of Reference. A TOR is attached in Annex-4 of this document for the implementing agency.

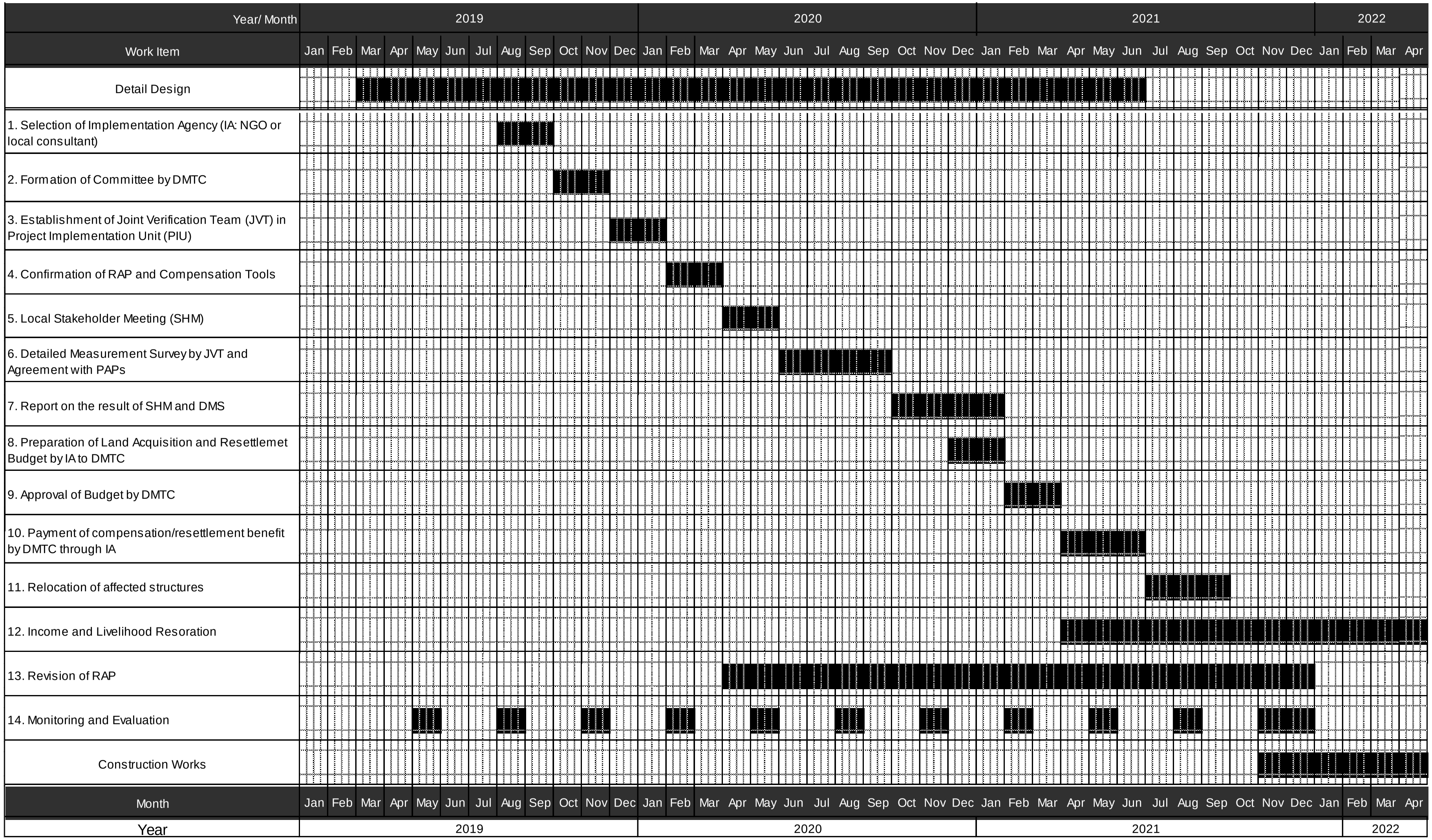
5.18 Implementation Schedule

A time-bound implementation schedule for the RAP has been prepared in accordance with the project construction schedule. The overall schedule of implementation is based on the principle that people affected by the project are paid their due resettlement benefits prior to displacement. The Implementing Agency (IA) will assist the APs in the process of relocation and resettlement. Individual entitlements on household basis will be processed by the IA. Each EP will receive an ID card and an entitlement card. The ID card will be issued to the EPs as identified by the DC and/or Joint Verification Survey (JVS) with joint signature of the DMTC and IA representatives. Photograph of the EPs will be attested by the concerned UP Chairman/Ward Commissioner and pasted on the ID card.

Implementation of RAP will be started before starting of the construction works and will continue up to one year after completion of the construction work for entertaining claims /grievances of the EPs regarding additional payment of compensation and other resettlement grants. However, some of the activities for RAP implementation may extend further. The preliminary time bound implementation schedule over a period of 32 months from March 2019 to October 2021 is presented in **Table 5.18.1**.

Restoration and rehabilitation of livelihood program is expected to start from April 2021.

Figure 5.18.1 RAP Implementation Schedule



Source: RAP

5.19 Resettlement and Compensation Costs & Budget

The RAP budgets for compensation for land, structures, other assets, crops and trees, and special assistance will be calculated using the market rates reflecting replacement cost at the time of dispossession. The costs for relocation and special assistance will be consistent with the resettlement policy. Other costs involving project disclosure, public consultations and focus group discussions, training on IGA have been included in the RAP budget under 'Operation cost for IA' head. There is also a budget allocation for 05% as contingency.

The budget also includes operational cost of the Implementing Agency (IA) and capacity building training cost of the Executing Agency (EA). The total estimated cost for implementation of the RAP is BDT- ***19,038,677,396*** including CCL amount to be determined by the DC for land and other physical assets. These estimates and the budget must be regarded as provisional, given the need for updating the RAP (if required) during implementation. Final rates per unit for land, structures, trees and other affected properties will be determined by the PVAC. Based on the rate and RAP policy a final resettlement budget would be prepared and approved by the EA. All resettlement funds will be provided by the EA (DMTC) based on the financing plan agreed by the GoB and the Donor. The total estimate is shown in the Table 5.19.1.

Table 5.19.1 Summary and Indicative Budget of Land Acquisition and Resettlement of MRT Line 5

Category of loss	Unit	Quantity	Rate in Tk.	Amount in Tk.
Land with Types				
Agriculture and Vita	hectare	21.995	524,270,000	11,531,318,650
Others	hectare	1.57218	1,177,666,679	1,851,504,000
Sub Total Land Acquisition,		*23.57*		*13,382,822,650*
Stamp duty and Registration fees (@11.5%				1,539,024,605
Main Structure (Residential and Commercial)				
Thatched	Sm	0.93	1,398.80	1,301
Katcha	Sm	3,842	2,399.48	9,218,802
Semipucca	Sm	5,117	8,575.00	43,878,275
Pucca	Sm	7,765	19,798.40	153,734,576
Tin	Sm	978	2,872.92	2,809,716
Tirpal	Sm	228	946.88	215,889
Sub-total of Main Structure		17,931		209,858,558
Secondary Structure				
Latrine (Pucca)	Nos	3	45846	137,538
Latrine (Slab)	Nos	-	5591	-
Latrine (Katcha)	Nos	-	3332	-
Tube well	Nos	-	30244	-
Boundary wall (Pucca and Tin)	RM	114	1696	193,344
Sub Total of Secondary Structure				*330,882*
Trees (Calculation made on average rate)				
Large	Nos	113	8,672.57	980000
Medium	Nos	31	6,151.61	190700
Small	Nos	99	2,143.43	212200
Sapling	Nos	6	14,200.33	85202
Bamboo	Nos	0		0
Banana	Nos	77	153.25	11800
Sub Total of Trees		*326*		*1,479,902*
Resettlement Benefit				
Crop compensation (80% of Agriculture/Others @ 400/dec. or 98,800/ha)	hectare	17.60	98,800.00	1,738,485
Fruit compensation (30% of timber value for fruit bearing trees, big and medium)				1,419,690
Sapling Cost for each affected households losing trees, 5 trees@cost 250=1250 taka	Nos	38.00	1,250.00	47,500
Structure Transfer Grant (STG) @12.5% of the replacement				26,232,320

value of main structure.				
Structure Reconstruction Grant (SRG) @12.5% of the replacement value of main structure.				26,232,320
One time Transfer Grant (TG) for portable materials at the rate of (a) Nos 83 @ BDT 3,000 (three thousand) for katcha structure and (b) Nos 52@ BDT 5,000 (five thousand) for semi Pucca structure and Nos 168 @ BDT 7,000 (seven thousand) for Pucca structures	Nos			1,685,000
Cost of transfer and reinstallation of the utility services like reinstallation of electricity connection, water supply line, telephone line etc. as grant @ 10% of CMP of structure				20,985,856
Monthly Hiring Allowance (MHA) for the similar type of space in other structures for running their activities for a period up to 6 (six) months, per month @1500/=	Nos	1037	9,000.00	9,333,000
One time cash payment for purchasing a subsurface easement @ 20% current market rate of the land				2,551,300,000
Cash compensation for CPRs on land without titles to be determined by PVAC to match RV for the structure (Cash compensation added Main Structure of Residential and Commercial)				-
Dismantling and reconstruction cash assistance of CPRs	Nos	24	300,000.00	7,200,000
House Transfer Grant (HTG) for shifting of furniture and belongings of residential structure to each shifting tenant.	Nos	29	4,000.00	116,000
Stock Transfer Cost (STC) for commercial entities @BDT 5,000 (five thousand) for small business (Nos-647); BDT 10,000 (ten thousand) for medium business (Nos-249) and BDT 15,000 (fifteen thousand) for large business (Nos-140).	Nos	1036		1,820,000
One time cash grant for facilitating alternative housing/CBEs Tk. 5000 (Five thousand) per household or entity	Nos	1065	5,000.00	5,325,000
Loss of business/income equivalent to 03 (three) months' income subsistence at the rate of BDT 6,000 (six thousand) (BDT 2,000X3) for Small business (Nos-647), BDT 12,000 (twelve thousand) (BDT 4,000X3) for medium business (Nos-249) and BDT 18,000 (eighteen thousand) (BDT 6,000X3) for large business (Nos-140).	Nos	1036		9,390,000
Transition allowance (TA) for the loss of rental income equivalent monthly allowance for 3 (three) months for each affected rented out premise	Nos	360	30000	10,800,000
Cash grant to the affected employees/wage earners equivalent to 45 days wage @ BDT 400/per day for unskilled laborers (Nos-1129) and @ BDT 600/per day for skilled laborers (Nos-96).	Nos	1225		22,914,000
Additional cash grant of BDT 10,000 (ten thousand) for affected poor women headed households and other vulnerable households	Nos	166	10000	1,660,000
Training on IGA for AP/ nominated by AP.	Nos	166	20000	3,320,000
Sub Total-F				*2,701,519,170*
Sub-Total of (A-F)				*17,835,035,767*
Others				
Operation Cost for RAP implementing NGO (INGO)			LS	40,000,000
Contingency for unforeseen issues @ 5% of total budget (Item A-F)			LS	891,751,788
Administration cost of DC on compensation (Item A, C,D and E) @ 2%			LS	271,889,840
Grant Total Taka				*19,038,677,396*

Source: RAP

5.20 Monitoring and Evaluation

5.20.1 Monitoring and Evaluation

The RAP implementation monitoring will be done both internally and externally to provide feedback to RU (DMTC) and to assess the effectiveness. Mid-term reviews of the resettlement activities drawing upon monitoring and evaluation reports and other relevant data to identify any action needed to improve resettlement performance or respond to the changing circumstances. Evaluation of the resettlement activities will be resorted to during and after implementation of the RAP to assess whether the resettlement objectives were appropriate and whether they were met, specifically, whether livelihoods and living standards have been restored or enhanced. The evaluation will also assess resettlement efficiency, effectiveness, impact and sustainability, drawing lessons as a guide to future resettlement planning.

5.20.2 Internal Monitoring

Internal monitoring will be undertaken by the RU with assistance from the NRS and IA. The IA will gather information on RAP implementation covering relevant activities as per schedule. All activities listed will be illustrated in Gantt Charts showing the target dates for completing resettlement activities. Internal monitoring reports on RAP implementation will be included in the quarterly Project Progress Report (PPR) to be prepared by RU, DMTC. The report of RU will contain: (i) accomplishment to-date, (ii) objectives attained and not attained during the period, (iii) challenges encountered, and (iv) targets for the next quarter. The internal monitoring report will then be integrated by the RU with the overall PPR submitted to Donor. The NRS will assist PMU preparing the overall PPR for Donor. However, the NRS will monitor the activities of IA and report to DPD/CRO, RU on a monthly basis. Table 5.20.1 shows the potential monitoring indicators that will be reported.

Table 5.20.1 Potential Monitoring Indicators

Monitoring Issues	Monitoring Indicators
Budget and Timeframe	• Have all land acquisition and resettlement staff been appointed and mobilized for field and office work on schedule? • Have capacity building and training activities been completed on schedule? • Are resettlement implementation activities being achieved against agreed implementation plan? • Are funds for resettlement being allocated to resettlement agencies on time? • Have resettlement offices received the scheduled funds? • Have funds been disbursed according to RAP? • Has all land been acquired and occupied in time for project implementation?
Delivery of AP Entitlements	• Have all APs received entitlements according to numbers and categories of loss set out in the entitlement matrix? • How many affected households have received land titles? • How many affected households relocated and built their new structure at new location? • Are income and livelihood restoration activities being implemented as planned? • Have affected businesses received entitlements? • Have the APs losing their eroded land received proper compensation? • Have the squatters, encroachers of DMTC or government land, displaced due to the project, been compensated? • Have the community structures are compensated and rebuilt at new site?
Consultation, Grievances and Special Issues	• Have resettlement information brochures/leaflets been prepared and distributed? • Have consultations taken place as scheduled including meetings, groups, community activities?

Monitoring Issues	Monitoring Indicators
	• Have any APs used the grievance redress procedures? What were the outcomes? • Have conflicts been resolved?
Benefit Monitoring	• What changes have occurred in patterns of occupation compared to the pre-project situation? • What changes have occurred in income and expenditure patterns compared to pre-project situation? • Have APs income kept pace with these changes? • What changes have occurred for vulnerable groups?

Source: RAP

5.20.3 External Monitoring

DMTC will monitor the project activities through an external monitor. The NRS will assist RU for preparation of quarterly report for Donor. The DMTC will as per their set guideline monitor land acquisition/resettlement activities in timely manner. External monitoring will be in two phases: compliance monitoring and social impact evaluation.

1) Compliance Monitoring

Compliance monitoring of RAP implementation will cover (i) Project compensation and entitlement policies, (ii) adequacy of organizational mechanism for implementing the RAP, (iii) restoration of APs incomes, (iv) settling complaints and grievances, and (v) provisions for adequate budgetary support by DMTC for implementing the RAP. DMTC will assess if the APs: (i) have re-established their houses in new location; (ii) have re-established their business; and (iii) were extended assistance to restore their incomes from pre-project levels. It will also appraise the accounting documents used in recording the payments of compensation to APs by the EA.

2) Social Impact Evaluation

DMTC will engage individual/firm to conduct a one-time social impact evaluation, at least six months following the completion of resettlement. It will use appropriate investigative and analytical techniques in assessing the post-project socio-economic conditions of the APs in relation to the baseline socio-economic data generated before undertaking of the resettlement implementation.

The evaluation will describe any outstanding future issues that are required to bring the resettlement into compliance with JICA’s Guidelines for Environmental and Social Considerations and Government policies, and further mitigation measures needed to meet the needs of any APs or families perceiving themselves to be worse off as the result of resettlement. It will include lessons learned from the evaluation that may be useful in developing future policies on involuntary resettlement of APs in Bangladesh.

The Resettlement Specialist within the project consultants will conduct periodic review and supervision mission during the implementation stage. In addition to regular review missions, DMTC will undertake a comprehensive mid-term review of the RAP implementation. A post-evaluation of RAP activities will be carried out by DMTC to assess the resettlement impact in terms of adequacy and deficiency in planning and R&R operations following the social impact evaluation. Terms of Reference (TOR) of the External Monitoring Agency (EMA) is attached as Annex -6.

5.20.4 Reporting Requirements

During the implementation phase, the Project Director will prepare quarterly report on the progress of resettlement activities and forward copies to the GoB and the donors. A format for resettlement implementation monitoring will be devised for quarterly monitoring and data collection by the field officials. The Resettlement Specialist of the Project Supervision Consultants and Supervision Missions every six months during the implementation stage will conduct review and report to DMTC and the donors on the progress of all aspects of land acquisition and resettlement activities.

Table 5.20.2 A model format for RAP implementation Monitoring – Quarterly Report

Component	Unit Total	Completed%	Cumulative Achievement Total	Completed%	Progress During Reporting Month			Status & Remarks
					Target	Achievement	%	
Resettlement Preparation								
Distribution of Brochures								
Identification of AHs/CBEs								
Issuance of ID cards								
Consultation Meetings								
Formation of PVAT/RAC/GRC								
Payment of Compensation								
Compensation for land								
Compensation for tree/crop/fish								
Res/Commercial structure								
Payment for rent/leaseholder								
Shifting/relocation costs								
Social Development Activities								
Grant for loss of wages								
Loss of business grant								
Business restoration grant								
Payment for indirect impact								
LIRP activities								

Source: RAP

5.21 Local Stakeholder Meeting (RAP)

Stakeholders meetings were conducted in two stages. At the first stage, consultations were held informing the goal, objective, component of the project Consultants also narrated the potential land acquisition status in that specific area. Feedback of the consultation meetings were incorporated and considered to finalize the project alignment/location in February and March, 2017 prior to start the census survey.

Consequently, the second stage of consultation took place in April and May after census survey was conducted. The Consultants disclosed the entitlements of the affected households and other stakeholders as designed in the RAP based on GOB policy and JICA's Guidelines, and the cut-off date was declared for eligibility of receiving resettlement benefits for the non-titled affected peoples.

The minutes of SHMs is attached in Annex-5.

It should be noted that women group in Bangladesh have not enough opportunity to participate the SHMs, therefore, the focus group discussion was considered and conducted. Details are described in Annex-7: Gender in the Report.

5.21.1 1st Round Local SHM

In the initial stage of the project in February 2017 the local potential affected persons of different locations along the RoW with local community leaders and other stakeholders like DMTC representatives, local government representatives were consulted through consultation meetings and personal contact. Stakeholders were informed about the meeting time and location ahead of time through personal contact and over telephone and through the local public representatives. Local people were also called by announcing in person and well as instantly through using hand microphone.

The consultants narrated the goal and objective of the project, different components of the project and proposed design of the stations with location were also discussed. Consultants also narrated the potential land acquisition status in that specific area. GoB policy, Donors' policy including JICA on land acquisition and compensation were discussed in the meetings. The opinion of the different levels stakeholders regarding the project was considered during finalization of the RoW and stations both above and under the surface with location for improvement.

Stakeholders of the most of the area expressed their positive view regarding the construction of the MRT line provided the affected people get appropriate compensation according to the present market price. However, during the initial level of discussion some stakeholders expressed their concern about the proposed location of construction of depot. Many of them expressed social issues like depot going to be built on private land, they are not in favor of giving up the land as previous experience of compensation receiving from government was not pleasant, some of the community institutions like mosque, school, graveyard, will be affected.

The inputs from the stakeholders meetings have been used to finalize the project, developed measures and principles for mitigation of loss on APs. Summary of consultation meetings with affected people and other stakeholders are described in Table 5.21.1.

Table 5.21.1 Summary of the Local Stakeholder Meeting

Line	Place	Participants		Inquiry	Answer
		Male	Female		
Line5	A.M. International School & College (26th February)	55	1	Request to relocate the station from north side to south side of the National Highway	Request will be transmitted to DTCA
Line5	Jamia Islamia Arabia Madrassa (28th February)	52	1	There is difference between governmental price and market price, how DTCA will fill up the gap?	DC will pay governmental price and remaining will be paid by DTCA
Line5	Mirpur Mofid-E-Aam School and College (2nd March)	58	3	Is the compensation paid based on mouza map or market price? Mouza value always lowers than market value.	It shall be assessed and paid based on market price

Source: JICA Study Team

5.21.2 2nd Round Local SHM

After finalization of the RoW of the project, community level stakeholders consultations were held in all the earlier locations in April 2017. Stakeholders were informed about the meeting time and location ahead of time through personal contact and over telephone as well as through public representative. Local people were also called by announcing in person as well as instantly through using hand microphone.

Process of land acquisition, DC’s payment procedure, donor’s policy on involuntary resettlement, entitlements of the affected PAUs and vulnerable people, declaration of cut-off-date for listing property and probable resettlement benefits, etc. were discussed in the meetings.

The RAP design, compensation, relocation options, benefits and adverse social impacts were discussed with the affected persons and their community. Stakeholders were asked for their views on the project overall as well as more specific discussion about their perception on land acquisition process, compensation payment process, relocation requirements, and views on alternative options.

The inputs from the stakeholders meetings have been used to develop measures and principles for mitigation of loss on APs. Most of the participants were favor to MRT project and compensation packages.

As a result, consensus was made by participants that the compensation with full replacement cost based on market price and agreed to MRT project. It is noted that draft of RAP was not distributed PAPs because preparation of RAP was on-going.

Furthermore, re-census was carried out between Hemayetpur and Aminbazar to minimize PAHs by shifting the alignment to existing road side.

Summary of consultation meetings with affected people and other stakeholders are described in Table 5.21.2.

Table 5.21.2 Summary of the Local Stakeholder Meeting

Line	Place	Participants		Inquiry	Answer
		Male	Female		
Line5	Notun Bazar Kisholaya Academy (Previously) (16th April)	22	5	I have three storied building in my own land. It will be affected by the project. I request that the authorities drop my building from the design. This is a very vital issue for me. Welcome the project. Compared to the mega size of the project small quantum of land will be required.	Alignment is tentative, final one will be fixed in detailed design stage. Full replacement cost on compensation will be applied. Compensation on CPR will be paid to community level management firm. PAPs can bring salvaged materials. House rental fee will be paid for some extent. Technical training program will be applied as LIRP
Line5	Hemayetpur AMJ Residential Academy (18th April)	38	1	Request project authority to take measures so that graveyard, mosque or other institutions are not affected. Our organization might be affected by Metro Rail project. Our organization is very positive about MRT project. I want to know the project alignment and requests project authority to take care so that adverse effect on the private property is kept at the minimum level. Residential supervisor cum manager of Jalalabad Group requests to save their area from acquisition. As the group has taken a vast project within this area, they will face a big problem.	Alignment is tentative, final one will be fixed in detailed design stage. Full replacement cost on compensation will be applied. Compensation on CPR will be paid to community level management firm. PAPs can bring salvaged materials. House rental fee will be paid for some extent. Technical training program will be applied as LIRP
Line5	Boliapur Jamia Islamia Arabia Kowmi Madrasha (25th April)	51	0	Want to know exact location of the Station. The project is important to the people of Boliarpur as well as Dhaka City. So I want to know about the detailed design of the project. Roads and Highways Department has acquired both sides of Dhaka-Manikganj highway and advised to reckon that. If necessary people of this area will part with their land but adequate compensation should be paid before the construction work starts.	Alignment is tentative, final one will be fixed in detailed design stage. Full replacement cost on compensation will be applied. Compensation on CPR will be paid to community level management firm. PAPs can bring salvaged materials. House rental fee will be paid for some extent. Technical training program will be applied as LIRP
Line5	Aminbazar Mofid-E-AM School & College (27th April)	74	2	Express wastage of time in the process of compensation payment in DC office. If I am dislocated I will lose my work and how I can survive is my prime concern.	Full replacement cost on compensation will be applied. Compensation on CPR will be paid to community level management firm. PAPs can bring salvaged materials. House rental fee will be paid for some extent. Technical training program will be applied as LIRP
Line5	Gabtoli Gabtoli Bus Terminal (17th January)	64	1	A huge vacant land which belongs to the government lying by the side of terminal could be used for the project. The demolition of the bus terminal will affect the good name of the government.	The temporary Gabtoli Bus Terminal during the construction of MRT station will be built at the construction yard of MRT Line 6 Project. The new bus terminal will be constructed as part of the Gabtoli Station as Multi Modal Hub

Source: JICA Study Team

5.21.3 Focus Group Discussion on Gender

At the project sites, 4 Focus Group Discussions (FGD) were held for both Line 1 and Line 5. Particularly, regarding the SHM, there were relatively limited female participants, and it was difficult for them to express their opinions in front of male counterparts. Thus, the FGDs which targeted only women were separately organized. Date and number of participants is presented Table 5.21.3.

Table 5.21.3 Summary of the Focus Group Discussion

Date	Venue	Number of Participant
20th of March	Amin Bazar	7
4th of April	Purbachal	5

Source: JICA Study Team

The needs of the potential female users are obtained through FGD as listed below. Those needs are reflected to design of station and rolling stock as well as compiled in the gender action plan. In addition, the needs will be reflected to items in bid documents those muse be complied by the Contractor. Furthermore, women are not accustomed not only METRO but also public transport system; adequate consideration must be taken on design and operation etc.

In detailed design stage, the policy on designing cares on station and rolling stocks, management of METRO and environmental social consideration will be taken. Especially, it is suggested that female employment at METRO is an urgent challenges to be achieved.

1) Design of Station

・ Separate ticket booths for male and female passengers
・ Separate washrooms for male and female passengers
・ Separate prayer rooms (space) for male and female passengers
・ Adequate lighting facilities
・ Clean waiting room (space) and platform
・ Installation of escalator/lift
・ Installation of drinking water facility
・ Allocation of vendor (small business) area (space) for women

2) Design of Rolling Stock

・ Separate compartments for male and female passengers
・ Reserved/priority seats for pregnant women, women with young children, children, elderly people and physically challenged passengers
・ Adequate lighting

3) Construction

・ Employment of women for construction work
・ Equal pay/work/opportunities for male/female workers
・ Employment of women for construction project related work (e.g.: supporting staff, cooking, cleaning, laundry, catering, etc.)
・ Separate prayer rooms (space), washroom, changing rooms, dining space (different timing between male/female for lunch break) for male/female workers/staff

- Provision of training to raise awareness on gender
- Provision of training on prevention of HIV/AIDS

4) Operation

- Deployment of female staff for both ground operation and on board
- Setting affordable fares
- Setting time schedule to meet women's needs
- Keep clean (station, platform, train, etc.)
- Responding to gender issues, measures on sexual harassment and implementation of those

5) Others

- Concerning the resettlement plan, consideration should be given to the women so that they will also be able to obtain financial compensation
- In relation with the above, not only the financial compensation but provision of employment opportunities should be also considered
- During the planning stage, women’s opinions should be heard as well as women’s participation of decision making should be secured. In addition to the opinions of participants of the FGDs mentioned above, suggestions and advice from the other donors and Department of Women, informal views of the said people/official concerned as well as the local staff of the Project are listed below.
- Many educational institutions such as universities, including girls' universities, have been established around the project sites. Specifically, along the MRT Line 1, there are approximately 30 educational institutions (high school level or above), for example, Viqarunnisa Noon School & College (girls), Motijieel Girls School, and Habibullah Bahar University College (co-education)[9]. It is expected that the students going to these educational institutions would utilize the MRT. Moreover, in consideration of the present situation in Bangladesh, when the daughters passed the university entrance examination, there are cases that the parents decide to relocate their houses/apartments to the nearby area of their daughters’ university[10]. It is due to the safety reason of the daughters. Given this situation, it is also expected that the women’s educational opportunities will be expanded as well as easy access to educational institutions will be secured.
- There is a necessity to take measures to prevent intrusion of homeless, etc. inside the station premises after closure of the business hour of the MRT operation. Particularly, as a security point of view, it is required to take thorough precautions to prevent women from not using the MRT because of the security reason.
- It is ideal to secure stroller and wheelchair spaces in the compartments of MRT.
- Followings are to enhance utilization of the MRT for children and women: cartoon images and soft music in the station and the compartments[11].
- Give due consideration to not only women but also physically handicapped people.
- As for the tickets, weekly and monthly passes to be issued.
- Clean separate “public type of “washrooms for men and women (open to non-MRT users)

[9] Refer to the Appendix 1.
[10] Those who do not have private cars, such as lower middle classes, they cannot send/pick up their daughters to/ from their schools. Thus there are cases that the family may relocate their homes to nearby their daughter’s school.
[11] With regard to this matter, advertisements can be an alternative plan.

5.21.4 Focus Group Discussion in the Depot Area

The proposed Depot area, though 523 land owners are mentioned in the mouza map the lands are unused agricultural land. Because most of them were sold to land developer or absentee landlord for his house building plan in future, and approximate 60 local people are cultivating as seasonal paddy, vegetable field or fish pond.

The FGD is being conducted by the team of consultants and people covered by the FGDs are mostly farmers including tenants, lease holders and owners of the land and the casual laborers. Information of date, venue and participants is presented in Table 5.21.4.

Table 5.21.4 Date, Venue and Participants of FGD

Date	Venue	Participants	
		Male	Female
9th of December	Hemayetpur	15	1

Source: JICA Study Team

The local consultant narrated the goal and objective of the project, different components of the project and proposed design of the stations with location were also discussed. He also referred to the earlier stakeholder consultation meetings in the locality related to this project. He also narrated the potential land acquisition status in that specific area. GoB policy, Donors' policy including JICA on land acquisition and compensation were discussed in the meetings. As a result, consensus was made by participants that the compensation with full replacement cost based on market price and agreed to MRT project.

Summary of FDG with affected people and other stakeholders is presented in Table 5.21.5.

Table 5.21.5 Summary of the Local Stakeholder Meeting

Inquiry	Answer
- Crop owners and other will be paid value of crop lost and other resettlement assistance before displacement - Farmers including sharecroppers, lease holders will be entitled for crop compensation - Training on income generating activities will be provided to the poor and vulnerable APs wherever needed - Workers of different industries - Stakeholders expressed shift the location if possible, as they have only this piece of land to live on	• Change of depot area should be made to save their land • Project Authority should use minimum land from the private owners • Payment procedure for compensation should be simple and hassle free • Adequate compensation for land, trees, crops, and other assets should be paid before the civil work takes off • Tenant Farmers/Lease holders should receive proper compensation • Local people should be employed during civil work of the project • People should be least affected by the project • Project authority should take appropriate measures so that livelihood of affected people is restored

Source: JICA Study Team