ACKNOWLEDGEMENTS

This report has been prepared by MMM Group Limited engaged by the Government of the People's Republic of Bangladesh, Public Private Partnership (PPP) Office at the Prime Minister's office to carry out the consultancy services for the provision of PPP Transaction Advisory Services for the upgrading of Joydevpur-Debogram-Bhulta-Madanpur (Dhaka By-Pass Road).

The additional support provided by:

- Ministry of Road Transport and Bridges, GOB
- Roads and Highways Department, GOB
- Ministry of Finance, GOB
- PPP Office, Prime Minister's Office, GOB

is gratefully acknowledged. Any errors of fact or interpretation are inadvertent and solely those of the author.

Dhaka, August 2014

THIS REPORT AND THE ASSOCIATED APPENDICES AND ATTACHMENTS ARE TO BE KEPT STRICTLY CONFIDENTIAL. THE INFORMATION AND ANALYSIS PROVIDED HEREIN WAS DEVELOPED SOLELY FOR THE PURPOSE OF INFORMING THE DHAKA BY-PASS STEERING COMMITTEE FOR DECISION MAKING PURPOSES ONLY. IT IS NOT TO BE DISTRIBUTED OUTSIDE OF THE STEERING COMMITTEE FOR THE DHAKA BY-PASS ROAD INITIATIVE, NOR IS IT TO BE COPIED OR DISTRIBUTED TO ANY PROSPECTIVE BIDDER, CONCESSIONAIRE, BANKER OR LENDING INSTITUTION.

THIS REPORT IS THE FIRST OF FIVE VOLUMES:

VOLUME I	FEASIBILITY STUDY
VOLUME II	ENVIRONMENTAL IMPACT ASSESSMENT
VOLUME III	SOCIO-ECONOMIC IMPACT ASSESSMENT
VOLUME IV	FINANCIAL REPORT
VOLUME V	HEADS OF TERMS AND PROCUREMENT PLAN

EXECUTIVE SUMMARY

The Roads and Highways Department, with support of the Public-Private Partnerships Office is currently planning and designing the four-laning of the Joydevpur-Debogram-Bhulta-Madanpur (N105) Road, colloquially known as the Dhaka By-Pass Road. This project would provide for a major arterial connection between the industrial zone of the North and North East, with the port connection to Chittagong in the South. The road is contemplated to include a controlled access toll road, in addition to a two-lane service road, along 50 kilometres that link with the National Highways N1, N2, N3, and N4.

This report brings together technical, economic, financial and commercial considerations to determine the feasibility of the Dhaka By-Pass Project. It builds upon previous reports,[1] providing an overview of key issues, and draws from further analysis in the aforementioned areas. The report is presented in two broad categories, technical and commercial. The technical study addresses engineering and hydrological components, analysis into the environment and socio-economic impacts of the project, and the economic feasibility of the project. The second half of the report deals with the commercial and financial viability and considerations.

TECHNICAL ANALYSIS

OVERVIEW

All things considered, and on the basis of the underlying assumptions and conceptual designs, we find *no major barriers* which might suggest that the proposed highway would not be technically feasible to construct. There are a number of encumbrances or hurdles to be resolved that would have a cost impact, but we have not found any that would suggest that the project is not technically feasible. The technical findings do impact the design approach for the proposed highway, which the Consultant Team proposes to be addressed through design solutions that will need to be considered further. These include, for example, the location and configuration of toll plazas, exit/entry points, retaining walls where land requirement exceed the ROW and options for separate crossings for motorized and non-motorized vehicles. Such design solutions could have a significant positive impact on the project viability.

Similarly, a number of *encumbrances* have been identified that would require a careful approach to resolve. For example, it was found that there is one multi-storey mosque that is partially located within the RHD owned right of way (ROW). Rather than having to relocate site of such public sensitivity and respect, and get involved in a potentially protracted negotiation, the Consultants propose design solutions that

[1] The Dhaka By-Pass Road Feasibility Study (Phase 1 of the PPP Transaction Advisory Services work) contemplates four primary milestones – an Inception Report, Preliminary Findings Report, Draft Feasibility Report and Final Feasibility Report. The first milestone, the Inception Report was issued to the PPP Office on January 14th, 2014. The Preliminary Findings Report was also delivered (April 2014); the document satisfies the second of the Phase 1 milestones and summarizes the preliminary findings following out of the technical and commercial components of the work mid-March. The aforementioned studies form the basis for the Feasibility Draft and Final Reports, due in June and August, 2014.

would permit the highway to proceed without the need for their relocation or replacement. Such a solution can provide for innovative improvements to the design without compromising long term traffic management options.

Since the project is on the existing ROW of the Dhaka By-Pass Road that has been in operation since 2007, the *socio-economic impact* due to homestead and livelihood displacement for the upgrade of the existing 2-lane facility to a 4-lane facility has been found to be minimal. However, since the ROW was never protected from encroachment by local businesses, religious institution development and illegal homestead developments, there may be a need to compensate non-land related loss due to displacement from the existing ROW as well as relocating semi-permanent and temporary religious and educational establishments. On the basis of the underlying assumptions and estimated capital costs, the anticipated socio-economic costs are summarized in Table 0-1, below.

Indicator	District Data		
	Gazipur	Narayangonj	Total
Length of road in Km	17	31.40	**45.50**[2]
Area of land to be acquisitioned in hectares	0.14	4.78	4.92[3]
Number of Project Displaced Persons (PDPs)	49	56	**105**
Number of Female PDPs	4	2	**6**
Number of Indigenous PDPs	1	.....	**1**
Total amount of cash compensation as per ADB Guidelines (2009) (millions)*	190.64	175.88	**366.52**
Total amount of money needed for other expenses (Millions) (includes implementing NGO=10% of total compensation)	19.06	17.59	**36.65**
Total of compensation and other expenses (Millions)	209.70	193.47	**403.17**

Table 0-1: Socio-Economic Impacts (as of March 31st, 2014)
*This accounts for the likely increase in PDPs between March 31st and the time of purchase

The land survey indicates that no additional lands are required for the construction of the four lane highway from the north portal to the south portal. However in order to meet the required highway design speed and to accommodate additional interchanges at mid-way points along the alignment (e.g., at the Bhulta/N2 interchange or the Purbachal intersection) and two service roads (4.8 m), some additional land will be required. While the analysis demonstrates minimal impact on the financial viability of the road as a PPP project, additional land will need to be underway prior to issue of the RFP, and fully procured and transferred prior to financial close. The proposed interchange, which would provide future access for the Purbachal Land development by RAZUK, will need additional land of 5.08 hectares.

In terms of *utility and in-ground services* relocations, our findings indicate that since the existing alignment is mostly within non-urbanized areas, there are no observed underground utilities such as water and sewerage lines. Furthermore, while no gas transmission pipelines were observed along the roadside, a

[2] Excludes the SASEC portion of the highway (north of Vogra).
[3] Does not include the land owned by RAZUK for proposed Trumpet Interchange for to/from Purbachal access.

number of gas-pits were observed which require further verification with the Titas Gas Company. There are in excess of 1,500 electric poles and several deep-tube wells and water pump houses located within the ROW which will require relocation.

The findings presented here also address the interface between the proposed Dhaka By-Pass Road and other RHD highway initiatives (mostly proceeding on the basis of Asian Development Bank (ADB) funding). The Consultant and RHD have met with the various other design consultants and the ADB Resident Mission for the purpose of clarifying any interface issues. There is now consensus among all parties as to the nature of the interface at five interchanges or crossings, namely the Mondanpur, Vogra, Bhulta, Purbachal and Zilla Road interchanges.

ECONOMIC ANALYSIS

There is sufficient evidence to suggest that the project will produce significant economic benefits. Two scenarios were considered; one in which the project will be delivered as a traditional Design-Bid-Build (DBB) model, and another, as a Public-Private Partnership (PPP) or DBFOM (Design-Build-Finance-Operate-Maintain)[4]. The PPP project delivery model indicates a marginally preferable scenario, although both have substantial net benefits and benefit-cost ratios. The former delivers a net benefit of over US$ 1.4 Billion and has a benefit-cost ratio of 4.52. For the latter, these figures are lower: $US 1.3 Billion and 3.93. The project's economic rate of return (ERR) for the PPP model has been calculated at 58%, with the traditional model slightly behind at 47%[5]; both could reasonably be considered to be sufficiently high to justify the execution of the Dhaka By-Pass Road, particularly through the alternative delivery model (PPP). These results were computed based on savings in vehicle operating costs, travel time and collision costs, which are likely to result from improved traffic conditions on the toll highway, and the separation of pedestrian and non-motorized traffic from long-haul and fast-moving traffic. A number of other inputs can also be quantified, such as savings in Greenhouse Gas Emissions (GHGs), which would further provide a case for the project's go-ahead.

[4] Traditional procurement is the conventional way by which governments deliver infrastructure projects. Under this method (Design-Bid-Build) the government contracts with separate entities for the design and construction of the project. In a Public Private Partnership (DBFOM) the government enters into a long term concession contract with a private partner who is responsible for the design, building, financing, operations and maintenance of the asset.

[5] ERR is a comparison of the costs and benefits of public investment in the Dhaka By-Pass Road. The costs of a project reflect the total capital and life cycle cost, including those covered by other parties (e.g., the concessionaire in a PPP). The quantified benefits include the calculated savings that are projected to arise as a direct result of the redevelopment of the Dhaka By-Pass Road in relation to vehicle operating costs, travel time savings, and accident avoidance cost savings. Other benefits such as person years of employment, direct, indirect and imputed benefits are discussed but have not been included in the calculation of ERR for this project. Traffic inputs are based on the Transaction Advisor's Forecasts, and other inputs were drawn from an existing feasibility study for the Priority Roads Project, which represents an extension of the Dhaka By-Pass Road.

COMMERCIAL ANALYSIS

OVERVIEW

Many of the commercial/transactional findings to date will need to be addressed in the context of the commercial conditions required of the bidders to the PPP. However, there are a number of findings that have arisen out of the technical work (e.g., additional acquisitions to accommodate interchanges) and the financial analysis, consultations with financial institutions, and contractors. These findings have been described as "Actions" required in order to put in place a number of enabling concessions from Government, primarily to encourage development of the capacity for PPP delivery by Bangladesh-based institutions. Such concessions include:

- Concessionaire benefits such as minimum toll revenue guarantees (from RHD/MRTB/MoF);
- Contractor benefits such as developer income tax "holiday" and VAT exemptions on labour and materials;

Financial institution benefits such as bank income tax relief on income from loans to PPP projects, repatriation guarantees, foreign exchange rate guarantees and sovereign guarantees (e.g., government backed bond issues).

These Government of Bangladesh actions are summarized in Table 0-2, below. Many of these GOB benefits and enabling tools have already been established on other public initiatives or for other industry sectors (e.g., power sector). They are necessary enabling tools both to contribute to reducing risk to the private sector as well as to demonstrate GOB's commitment to ensuring that these PPP structures for project delivery are a success. Additionally since the PPP approach to project delivery in Bangladesh is a relatively new one, it is essential that the appropriate structures are put in place to ensure that the interests of international bidders are protected in so far as they are able to repatriate their capital and profits on such ventures, and as importantly, to provide such bidders with the level of certainty that they require in connection with investments in foreign jurisdictions.

MARKETING & OUTREACH

Successful delivery of this project requires the support of a strong private sector partner with the experience in developing infrastructure of a similar size, scope and complexity. Given the substantial size of this project and the limited PPP experience in Bangladesh, the Consultant strongly advises GOB to proceed with additional and targeted marketing outreach to ensure that prospective regional and international contractors, concessionaries, and financial partners are made aware of this opportunity, as well as others in the pipeline, and encourage them to commence with teaming arrangements with Bangladeshi partners.

	GOVERNMENT AGENCY / DEPARTMENT ACTION	NATURE OF CONCESSION	STATUS
ACTION 1: CONCESSIONAIRE BENEFITS	RHD / MoF	Traffic Count: Minimum traffic volume guarantees	Pending
		Land Acquisition: To be underway prior to issue of the RFP and to be completed prior to financial close	Survey shows land along alignment owned by RHD; additional land required for interchanges
	PPP Office	PPP Policy passed by government	Completed (legal opinion may be required)
	MRTB / RHD	Toll Policy approved	Completed (legal opinion may be required)
	Planning Commission / MRTB / RHD	Permits & Approvals: Process to be put in place to facilitate approvals required by law	Pending
ACTION 2: CONTRACTOR BENEFITS	MRTB / NBR	Tax: Income tax exemption	Pending
		VAT: Exemption on VAT re: labour & materials	Pending
ACTION 3: LENDER/BANK BENEFITS	NBR / CBB / BB	Tax: Income tax relief on income from loans to PPP projects	Pending
		Loan capital repatriation guarantees	In place
		Foreign exchange rate guarantees	Requires further discussion

Table 0-2: Enabling Concessions (Actions 1, 2, and 3)

Given the generally limited level of PPP knowledge and experience in Bangladesh, and in order to enhance the probability of success of this as a PPP project, it t is very important that the PPP Office carry out the following tasks:

- Dialogue: Continue with open dialogue and consultation with Bangladeshi developers, concessionaries and financing institutions;
- Request for Registration of Interest (ROI): Proceed with the issue of a ROI to expand the list of prospective bidders, support the partnering efforts of Bangladesh contractors, and advertise the opportunity for international and regional concessionaires and contractors that have the capacity and interest in investing in Bangladesh;
- Marketing Material: Develop printed material/brochures for mailing and distribution at sector specific conferences, trade shows, public information centres, and to send to foreign diplomatic missions in Bangladesh;
- Road Shows: Hold a series of PICs for Bangladesh contractors and concessionaires, and follow up with similar sessions in strategic regional/international centres.

FINANCIAL

The financial analysis was completed to provide the RHD with a preliminary analysis of the procurement options available for the development of the toll road project. As part of the assessment, a Value for Money (VfM) analysis was undertaken to compare the total risk adjusted life cycle cost of delivering the project under a PPP delivery model (i.e. Design-Build-Operate-Finance-Maintain) and the Traditional approach (i.e. Design-Bid-Build where RHD finances the entire project costs). A detailed set of assumptions and information provided by the RHD and the Transaction Advisor were relied upon to conduct the financial analysis. These results were further tested for financial feasibility under different growth and cost scenarios. It should be noted that the Transaction Advisor forecasts long term traffic growth to be considerably faster than RHD-supported traffic model. This difference yields significant variation in the long term revenue and overall performance of the project.

The financial analysis demonstrates that the project delivers the highest VfM under a PPP delivery model and is financially feasible. That is, when all planning-level capital, operating, financing costs estimates and net toll revenues are considered, the project would generate sufficient income to cover the investor's debt servicing and generate a reasonable return on equity.

Conclusions based on these financial analyses include:

- Value for Money - The PPP (DBFOM) model was estimated to be 13% less costly ($398.4M versus $457.7M) than the Traditional model.
- Risk – Involving the private sector can contribute to significant risk transference potential ($26.7M vs. $127.4M Traditional).
- Return on Equity (ROE) – under the conservative and medium growth scenarios (based on RHD supported assumptions) the results achieved a 20% and 74% ROE, respectively. As noted above, the Transaction Advisor's traffic growth forecast was materially higher than the figures developed with RHD national average data. Given the strong economic growth that Bangladesh has experienced, we are of the opinion that the forecasts based on RHD's nation-wide data are conservative. Using the Transaction Advisors traffic growth forecast would yield a materially higher ROE.

REPORT OUTLINE

This report will begin with a brief introduction on the project and the role of the Transaction Advisor. Section 2 will address the technical aspects of the feasibility study; this includes the engineering analysis, and summarizes the economic viability, the environmental impact assessment, and the socio-economic impact assessment. The latter three draw from separate reports, Volumes II, III and IV. Section 3, will summarize the commercial and financial viability of the Dhaka By-Pass Road; a full version of this section can be found as a separate report (Volume IV). The Procurement Plan and Heads of Terms make up the last of the five volumes that constitute the feasibility study for the Dhaka By-Pass Road. Based on the outlined analysis, this feasibility study will close with some broad conclusions regarding the viability of the project and present some considerations for going forward.

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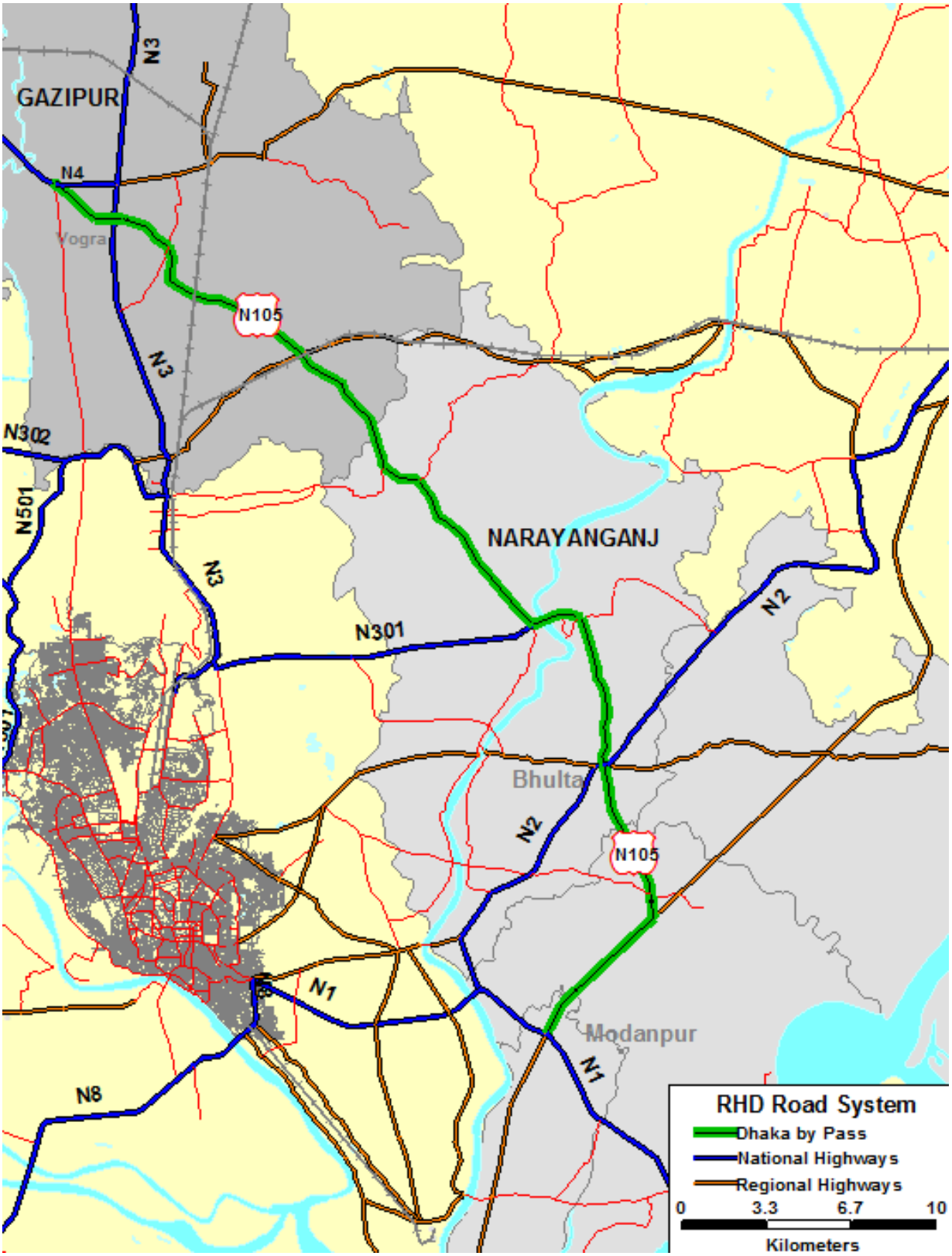
ACRONYMS

AADT	Annual Average Daily Traffic
ADB	Asian Development Bank
ADT	Average Daily Traffic
BCR	Benefit Cost Ratio
BDT	Bangladesh Taka
BM	Benchmark
BOT	Build Operate Transfer
BPDB	Bangladesh Power Development Board
BREB	Bangladesh Rural Electrification Board
BRT	Bus Rapid Transit
BRTA	Bangladesh Road Transport Authority
BTCL	Bangladesh Telecommunication Company Limited
BUET	Bangladesh University of Engineering and Technology
CAC	Critical Air Contaminant
CAPEX	Capital Expenditure
CBB or BB	Central Bank of Bangladesh or Bangladesh Bank
CC	Collision Cost
DBB	Design-Bid-Build
DBFOM	Design-Build-Finance-Operate-Maintain
DESCO	Dhaka Electric Supply Company Limited
DPHE	Department of Public Health and Engineering
DTL	Deputy Team Leader
DWASA	Dhaka Water and Sewerage Authority
EMP	Environmental Management Plan
ERR	Economic Rate of Return
FIRR	Financial Internal Rate of Return
GHG	Green House Gas
GOB	Government of the People's Republic of Bangladesh
GPS	Global Positioning System
GTCL	Gas Transmission Company Limited
IEE and EIA	Initial Environmental Assessment and Environmental Impact Assessment

IFC	Investment Finance Corporation
IRR	Internal Rate of Return
km	Kilometre
LGED	Local Government Engineering Department
LOS	Level of Service
MRTB	Ministry of Road Transport and Bridges
MoF	Ministry of Finance
NBR	National Board of Revenue
NPV	Net Present Value
PIC	Public Information Centers
PMO	Prime Minister's Office
PPP (or P3)	Public Private Partnership
PSC	Public Sector Comparator
RAP	Resettlement Action Plan
RHD	Roads and Highways Department
ROE	Return on Equity
ROI	Request for Registration of Interest
ROW	Right of Way
RCC	Reinforced Cement Concrete
SASEC	South Asian Strategic Economic Corridor
TA	Transaction Advisory
TDM	Traffic Demand Model
TIS	Traffic Impact Study
TL	Team Leader
TSCW	Transport Sector Co-ordination Wing
TTS	Travel Time Savings
UDD	Urban Development Directories
USD	U.S. Dollars
VAT	Value Added Tax
VfM	Value for Money
VGF	Viability Gap Financing
VOC	Vehicle Operating Costs
WDB	Water Development Board

PROJECT LOCATION MAP

MAP OF THE DHAKA BY-PASS ROAD



1. INTRODUCTION

This Feasibility Report has been prepared by MMM Group Limited as the Transaction Advisory Services consultant for the four-laning of the Joydevpur-Debogram-Bhulta-Madanpur (Dhaka By-Pass) Road under a Public-Private-Partnership (PPP) model and follows an initial deliverable, the Inception Report (January 2014), as well as a Preliminary Findings Report (April 2014). The Inception Report set out the consultants initial observations, and clarified scope of work and work plan for our assistance to the PPP Office. The second report presented the preliminary findings that were identified out of our work over the 3 month period from commencement through to mid-March 2014. The findings were presented to the PPP Office and key stakeholders at the Ministries of Communication and Finance and to the Roads and Highways Department, on March 25th, 2014, and a report was produced for April 2014. The Feasibility Report builds upon many of those observations described in the January Inception Report and Preliminary Findings Report, and also includes both economic and financial viability analyses.

With the support of the PPP Office the Roads and Highways Department (RHD), of the Ministry of Road Transport and Bridges, is intent on implementing the four-laning of the approximately 48 Km long Joydevpur-Debogram-Bhulta-Madanpur Road, colloquially referred to as the Dhaka By-Pass Road, under a Public-Private-Partnership (PPP or P3, as may be referred to interchangeably) model. The project connects National Highways N4 (in the North) to the N1 (in the South), traversing the N2 and N3, numerous regional highways and zilla roads. The proposed toll road will provide for a major arterial connection between the industrial zones of the North and North East with the port connection to Chittagong in the South (see maps on pages XVIII and XIX). Upon completion the Dhaka By-Pass Road is expected to alleviate a major bottleneck in transport and further spur economic growth.

The stated objective of the four-laning project is:

> *"... to provide alternate route for road users with high level of travel time reliability, reduced journey times and reduce vehicle operating cost in National Highway 105. The upgrading of the existing road will also enhance the connectivity of the road network to meet the forecast economic and traffic growth targets."*

The PPP Office has engaged the MMM Group Limited, Canada to evaluate project feasibility (Phase 1) and to develop and implement a procurement strategy (Phase 2). The objectives of the Transaction Advisory (TA) Consulting services, as further stated in the terms of reference (TOR) are:

a) To assess technical, financial, social, environmental and commercial viability of upgrading the Dhaka By-Pass Road to 4 lanes on the basis of a PPP Structure.

b) (Subject to a positive confirmation of the viability of the project as set out in paragraph (a) above) To assist the Government in delivering, designing, and implementing the upgrading of the Dhaka By-Pass Road Project on the basis of a PPP structure.

c) To develop a revenue model and assist in the bidding process and award of the project in a manner which ensures:

- Participating of best available companies in the bidding process;
- Financing of the capital cost by concessionaire; and
- Optimizing the revenue potential of the project.

The project, as outlined in the Terms of Reference, is to be undertaken in two phases. Phase 1 of the TA services primarily consists of a feasibility analysis involving (a) techno-economic assessment together with safeguard compliance, (b) commercial assessment including financial analysis and market interest, and (c) drafting an appropriate concession structure and a procurement plan. Phase 1 is targeted to be complete by July 2014. Subject to a successful outcome of the feasibility exercise, Phase 2 of the TA services will be carried out to prepare the procurement documents for the PPP, assist the GOB with the procurement process and closing of the concession agreements.

The work presented in this report includes Task Groups two to six (2-6), including the Engineering, Economic, Environmental, Socio-Economic, and PPP Development studies, as outlined in the project kick-off presentation, and included Figure 1-1.

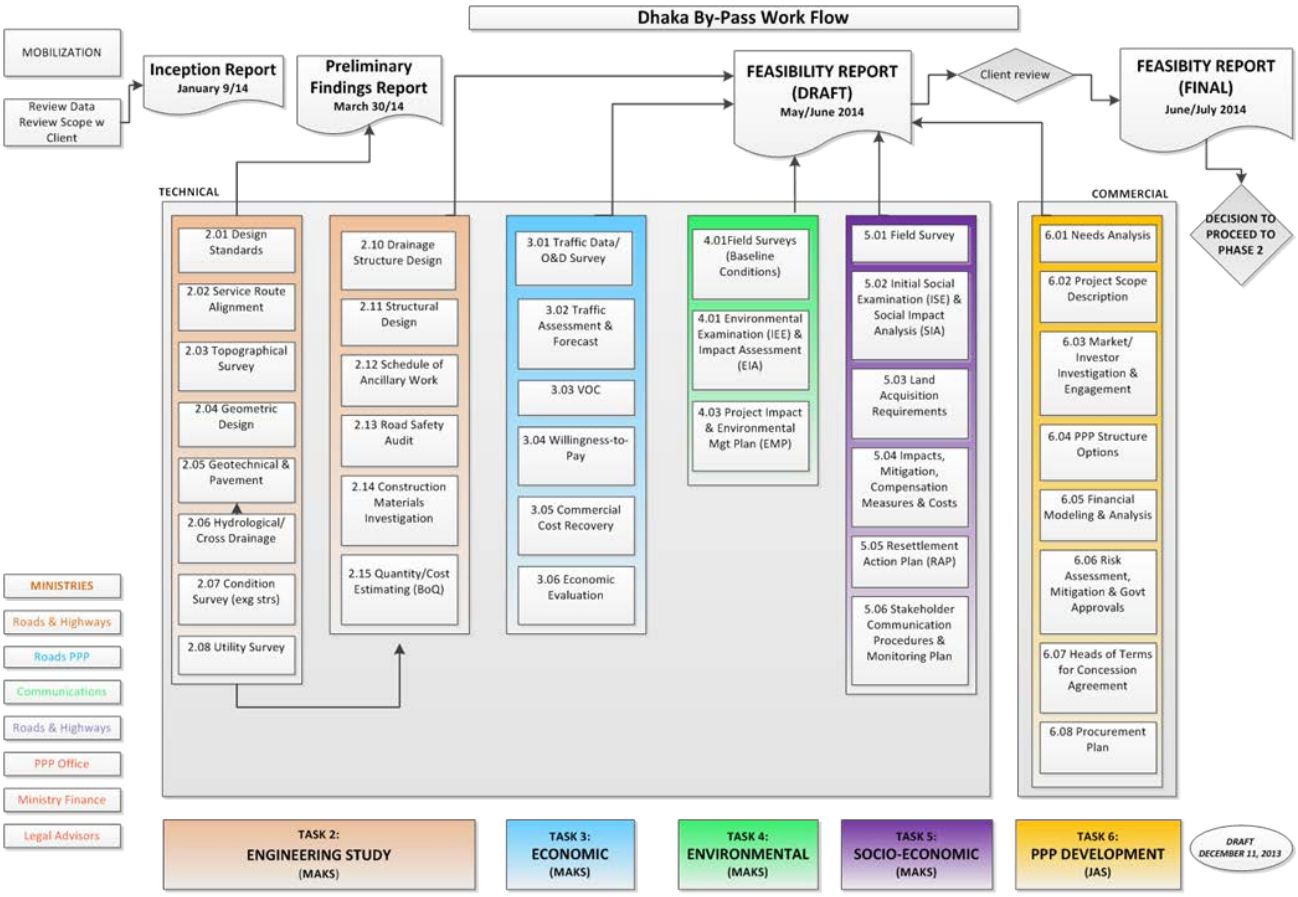


Figure 1-1: Work Flow Diagram

At this time, the project is being evaluated for its viability as a PPP initiative – one that presents an attractive investment opportunity for private market participants – as well as to ensure that the interests of the GOB are adequately protected. Market consultations are being carried out as part of this feasibility phase of the work - including developers and contractors, concessionaires, and lenders (commercial banks and multi-lateral/development banks). The input from these consultations has informed the development of the transactional structure and financing considerations discussed herein, and recommendations that the Consultant believes are necessary in order to make this initiative a success.

Currently, there are a number of issues that need to be resolved as the project moves forward into Phase 2. The following is a snag list that outlines these issues, in no particular order:

- Incentives: In order to enhance the success or desirability of PPP infrastructure projects for bidders and induce earlier private investment, it is recommended that a number of fiscal and monetary incentives be put in place. This issue is to be taken up and finalized by the Government of Bangladesh.
- Debt guarantees are to be discussed with MIGA.
- Lawyers are to draft legal agreements.
- Land acquisition:
    - Mouza maps are to be provided to the TA Consultant in order to begin the process of developing a Land Acquisition Plan (LAP). The amount of land to be acquired will be finalized in Phase II of the project.
    - The government must implement the LAP: it is to begin the land acquisition process in Phase II, and complete the process prior to the project's financial close.
- The government must engage an NGO to finalize and implement the resettlement action plan (outlined in this document).
- Utilities:
    - The government must address the utility relocation issue (e.g. for identified gas pits).
    - The government is to issue letters to non-responsive agencies for feedback.
- The mosque and graveyard relocation issue is to be addressed, as required, according to the Law.
- Commercial and other encroachments are to be addressed.
- The proposed transaction structure is to be reviewed and refined.
- The fill materials issue to be more clearly defined.

2. TECHNICAL FEASIBILITY

2.1. ENGINEERING ANALYSIS (TASK GROUP 2)

2.1.1. METHODOLOGY

The TA Consultant followed the detailed methodology as contained in the contract for services with appropriate enhancements to it in consultation with the Client and from the outcome of the interim preliminary finding report. These task activities have been further illustrated in the logical Task Flow Diagram included in Section 1 of this report. The output of this technical analysis will include:

- Feasibility Stage Survey
- Baseline design that is compliant with GOB Codes and Specifications
- Economic Analysis
- Assessment of environmental and social impacts and recommended mitigation measures
- Cost estimate and BOQ

It is noteworthy that the purpose of the feasibility engineering under the TA services is to allow for the conducting of a reasonable cost estimate for input into the financial modeling. The Constructor appointed by the Concessionaire will eventually prepare its own detailed design for whatever final design scheme the concessionaire decides to undertake. Therefore, the project actual cost will be guided by the detail design adopted the constructor consultant and approved by the executive agency. The methodological approach for the technical analysis adopted by the TA Consultant Team is described here below.

- Feasibility Stage Survey: All surveys shall be computed in the National Grid System for the purpose of determining relative closure accuracy to National Reference Marks. GPS derived points will be transformed from WGS84 into the National System. The establishment of a project datum (Plane System), with corresponding national grid values, is required for construction. The intent is to minimize distortions inherent in larger scale map systems, and consequently minimize the application of corrections to observed values during the construction stage. Total Survey work will be carried out using the Electronic Total Station, Auto Level equipment and Data Process by Auto CAD Civil 3D, Auto CAD Land Desktop, and Auto CAD-2014 software package.
- Baseline Design: The baseline (feasibility stage) design for the Dhaka By-Pass Road will follow standards as outlined in: RHD Geometric Design Standards Manual (Revised) 2005, Bangladesh Road Transport Authority (BRTA) Traffic Signs Manual 2004, AASHTO Geometric Design of Highways and Streets 2004/2014. However, since the project is also part of the SASEC road, the design adopted for the Jaydevpur and Tangail portion of SASEC road – which provides direct connectivity to the north-west of Bangladesh – will also b'e considered for design consistency.

- Traffic Forecasting: The traffic forecast is developed using a combination of historical traffic data maintained by RHD, GDP growth and import/export growth of major commodities such as textile and clothing, and traffic demand modeling using the Origin-Destination (O-D) data developed by the TSC Wing of Bangladesh Planning Commission (2012).
- Travel Demand Modelling: During a meeting with RHD held on December 17th, 2013, stakeholders expressed their interest in the feasibility of a multi-modal travel demand model to quantify the viability of most of the proposed PPP road projects and suggested to allow multimodal travel demand modeling as part of the economic analysis. Therefore, a modified 3-step travel demand modeling approach is carried out using the national network and a 431 by 431 O-D matrix obtained from the TSC Wing of the Planning Commission.
- Traffic Simulation: In addition to travel demand modeling, traffic simulation modeling was also carried out, using TrasModeler software. The purpose of the simulation model was to visualize the behavior of complex traffic systems for the toll road in a 2-dimensional or 3-dimensional GIS environment to illustrate and evaluate traffic flow dynamics, traffic signal, interchange, flyover, underpass operations, and overall network performance. It also allowed for the evaluations of pre and post scenario network congestion using the recently planned intersection improvements for the N2 and N3 in Dhaka City as well as the construction of 4 lanes on the Dhaka-Chittagong Highway with or without interchange at N105/N2 location.
- Assessment of Environmental and Social Impacts: The EIA and SIA studies were carried out according to the RHD agency guidelines as well as guidelines recommended by donor agencies (mainly ADB and WB).
- Cost Estimate and BOQ: The cost estimates have been prepared on the basis of current prices of locally available materials, plant & equipment, labour. Market prices of imported materials were also taken into account, where required, as well as RHD schedule rate analysis guidelines. The basis of estimate (BOE) was also developed for each typical structural and ancillary item.

2.1.2. DESIGN STANDARDS

Design standards for national roads are generally clearly defined in Bangladesh (RHD standards cover all aspects of alignment and structures), however, some innovative cross-section design concepts were introduced to minimize the requirement for land acquisition and to create higher safety standards to accommodate high exposure of truck traffic for the corridor, especially regarding the selection of median width and the provision of a service road / NMT facility.

2.1.2.1. HIGHWAY GEOMETRY

Key features to be adopted for the Geometric Design include:

- Improve the horizontal alignment where sub-standard horizontal curves exist, if at all.

- Address and provide safe sight distance to improve the visibility at at-grade intersections, service roads, horizontal curvatures and bridge locations.
- Improve lane configurations at a number of interchanges and flyovers, in order to allow full access control facility and free flow traffic. These design features are proposed to be located at:

    i. Vogra- flyover with left-turn storage lanes[6]
    ii. Dhirasrom - rail crossing overpass
    iii. Mirer Bazar rail crossing overpass
    iv. Purbachal trumpet interchange[7]
    v. Bhulta underpasses to allow right-turn/u-turn for traffic that is presently crossing the Dhaka-By Pass. The N2 through-traffic will be facilitated by a flyover presently under construction by RHD
    vi. Madanpur left-turn/right turn storage lanes (N105 and N1 intersection)

Other key design features considered during the feasibility stage design include:

- One-way pair dedicated service roads (at either side of the Dhaka By-Pass alignment)
- Construction of bus-bays for the service road
- Creation of pedestrian crossings (overpass, underpass, etc.)
- Improvement of intersections for the service road with LGED minor roads by providing appropriate channelization
- Emergency lanes for the toll road
- Shoulder rumble strips to warn driver (for improved safety)
- Lighting for entire corridor
- Jersey barrier median
- Service and toll road separation with appropriate fencing
- Retaining wall where service road toe slopes crosses the ROW (where applicable)
- Development of a toll plaza

The key geometric design criteria followed are listed in Table 2-1.[8]

[6] The consultant proposed the N105 flyover based on the decision made by ADB and RHD. However, on July 17, the consultant was advised that the N2 portion of the BRT project will utilize a 6-lane flyover and the N105 will be at grade. The consultant will keep this option open in case any last moment changes.
[7] Subject to availability of land from RAZUK who will be the ultimate beneficiary to provide access to and from Purbachal Land Developments.
[8] RHD design criteria for National Highway System.

Serial	Design Criteria	Description	Design value
01.	Speed	**Design Permissible**	80 Km/h 70 Km/h
02.	Stopping Control	Driver's Eye height	1.2 m
		Target (Object) Height-Vehicle	0.6 m
		Target (Object) height-Pavement	0.0 m
		Stopping Sight distance	120 m
03.	Horizontal Control	**Controlling Curve**	
		Maximum Super Elevation	0.06 m/m
		Maximum Curve Radius	500 m
		Minimum Spiral	70 A value
		Design speed	40 Km / h
		Maximum Super Elevation	6 %
		Minimum Radius	80 m
04.	Vertical Control	**Gradient**	
		Maximum	3 %
		Minimum	0 %
		Crest Curves	
		Minimum	70 K value
		Sag curves	
		Minimum (headlight control)	30 K value
		Clearances	
		Major Road crossings	5.1 m
		LGED Road crossings	4.0 m
		Pedestrian/NMT Crossings	3.0 m
		Rail Crossings	
05.	Cross Section Elements	Travelled Lane	3.65 m
		Cross fall	3-2.5 %

Table 2-1: Geometric Design Criteria

2.1.2.2. PAVEMENT

The objective of pavement design is to select the most economical pavement thickness and layer composition that will provide a satisfactory level of service for the designed period. The feasibility stage pavement design is based on a survey of the existing road conditions, traffic analysis, geotechnical and pavement investigation (such as: sub-grade strength assessment), available sources of construction materials, the feasibility study for the Priority Roads Project (by MMM Group), and soil investigation data for the existing road (N 105). Notes on the pavement design are outlined below:

- Design procedure followed “AASHTO Guide for Design of Pavement Structures, 1993” and the design pavement thickness compared with the Indian Roads Congress (IRC) “Guidelines for the Design of Flexible Pavements” (IRC: 37-2001).
- Overlay thickness is estimated in accordance with the guidelines of IRC: 81-1997 and compared with the SASEC portion of the road connecting at the Vogra intersection with N3.
- The use of recycled materials from the existing road pavements is proposed for the service road pavement.
- Provision of effective drainage is followed in pavement design of this project.
- Stabilized base and sub-base are considered as an alternative to conventional granular bases in this project.
- The uses of rubberized or otherwise modified bituminous binders are considered.
- The pavement design for the Dhaka By-Pass are kept consistent (as minimum design standard requirement) with the RHD design standard for the National Highway System.
- The pavement design standard for regional highways is proposed for the service road pavement.

The minimum pavement design criteria used are listed in Table 2-2, below.

Serial	Layers	Description	Thickness (mm)
01.	Wearing Course		50
02.	Binder Course		60
03.	Bituminous Base Course		80
04.	Aggregate Base Type I	100% MDD CBR > 100%	150
05.	Aggregate Base Type II	98% MDD CBR > 80%	200
06.	Sub-base	98% MDD CBR > 40%	250
07.	Improved Sub-grade	98% MDD CBR > 8%	300
08.	Sand Sub-grade	95% MDD CBR > 8%	300

Table 2-2: Pavement Design Criteria

2.1.3. TOPOGRAPHIC SURVEY

The details of the topographic surveys are consistent with the requirements for the feasibility study and preliminary geometric design. The work was carried out using Total Station, GPS and Auto Leveling equipment. Horizontal control was established with reference to GPS coordinates. Vertical control was carried out with reference to the PWD data. The works carried out under this task are described below.

2.1.3.1. ESTABLISHING BENCHMARKS (BM)

Permanent Benchmarks are constructed where required and in addition to permanent ground markers (normally one per 5 km). Permanent Benchmarks consist of RCC Pillars with an appropriate base foundation, and are constructed in such a way that they can remain stable for a minimum period of 5 years, including the construction period. In total, 10 permanent BM's were established, and in accordance with the following guidelines:

- BMs will be established in solid ground (not in swamp or paddy land).
- Their location should be at minimum of 10 metres from the edge of roads, embankments, canals or drains, and in areas not subject to change.
- BMs will be located within the project area.

All RCC BMs are fully marked for future identification and are described at the time of installation. The marking includes:

- A dimensional sketch of the BM, as constructed.
- Two photographs of the BM. One clearly shows the identification number and reference bolt, and the other shows a full view including its location as background.
- A location sketch by showing minimum three adjacent prominent features and names with distance.
- A general location sketch and a description of the approach to the vicinity of the BM.
- Elevation and co-ordinates will be added when computations are complete.

Additional stations other than the BMs are also marked on permanent structures, if available, in order to facilitate the survey works. Detailed information on each BM is provided in Appendix-A1.

2.1.3.2. HORIZONTAL CONTROL

Horizontal Control is provided with reference to existing control points available near the project area. In some instances, arbitrary co-ordinates will be taken from the center of existing adjacent roads for horizontal control. Closed circuit operation will be done by traverse network for the entire area.

2.1.3.3. VERTICAL CONTROL

Vertical Control is carried out with reference to existing BMs available near the area and close to the same BM. If they are not available, arbitrary heights are taken from nearby permanent objects. All horizontal control points are then connected so that each control point can be treated as BM vertical control points. Vertical control will be carried out using the Auto Level machine.

2.1.3.4. TOPOGRAPHICAL SURVEY

A detailed topographical survey was carried out on the basis of previously established control points. The topographical survey was undertaken within 45m of either side of the existing road alignment. Positions

of market boundaries, drainage structures and channels, canals, abnormal features, visible ROW markers, trees, pond, ditch, mosques, temples and graveyards were recorded. The river and channel cross-section culverts are also recorded to facilitate the hydrological study and for the widening of the existing bridges.

Where ascertainable, High Flood Levels (HFL) were recorded with the year of occurrence noted. All details will be picked up including the boundary of the area, structures, all service lines, all trees, plants, road and pavement, ponds, ditches, drains and determine as follows:

- Showing the existing physical features and locations of structures and utilities.
- Determination of property line of the project.
- Flood level determination- the highest flood level and design flood level.
- Determination of water label
- Fixing of datum level of the plant, internal roads, drains etc.
- Recording all the changes of angles of the property line.
- Spot GPS reading for all adjacent proposed developments

The spot height is to be taken in the entire project area at an interval of approximately 05m ~ 10m. A closer spot height is to be taken in the case of rapid undulation. The entire spot height survey will be done using Total Station.

2.1.3.5. CROSS-SECTION SURVEY

Cross-sections are taken at 20m intervals along the route. The width of the cross-sections is 90m wide, with 45m on each side of the existing road center line. The detailed survey includes a complete inventory and condition report of all visible components. Photographs are taken for each bridge and culvert in sufficient number with close-up detail as required providing a comprehensive and descriptive report. The cross section is taken 150m wide for areas in which culverts, bridges, and proposed flyovers are located as well as at the sites of proposed flyovers, and where the existing road has a radius of less than 500m. For structure sites, cross sections are surveyed at 10m intervals. Additional cross-sections are also taken at points of sudden change in the ground levels.

Based on the Detailed Topographical and Feature Survey, the following observations can be made:

- RHD ROW width varies from 27m to 90m. The ROW markers at the vicinity of Purbachal area have already been covered by the land developer. Often the RHD ROW marker is pushed 3 to 4 meters inside the ROW property line.
- Partial and full ROW encroachments are observed either by permanent, semi-permanent or temporary structures. The density of encroachment within the chainage 41+960 to 48+00 is the highest. The encroachments are mostly religious or commercial establishments. The number of features that fully or partially encroach the existing ROW are:

  - 53 permanent (buildings) ranges from 6 to 1 story structures, and eight buildings under construction;
  - 9 permanent structures (1 to 4 story), two temporary, and one under construction (4-story) mosques, two madrasah, one mazar and one Shaheed Minar;
  - 123 small temporary shops and 229 tin-shed type shops.
- There are a total of 13 graveyards and one grave on the ROW.
- The existing road intersects with two major rail lines that also run parallel to an adjacent highway, crossing the N105.
- There are heavily built up areas at all places where the N105 intersects with other National or Regional Highways with high volume of non-motorized traffic (NMT). There is not enough ROW to build an interchange at any of these locations. Additional land acquisition is required at all intersections where an interchange is proposed.
- There are more than 250 borrow pit/ponds of various sizes within the ROW. These are being presently used for fish farming.

Figure 2-1, below, illustrates the thematic map of various critical features within the existing ROW. Survey data were processed with the use of Auto CAD Civil 3D software.

The detailed topographical survey outputs and topo features strip map are included in Appendix A2 and Appendix A3, respectively.

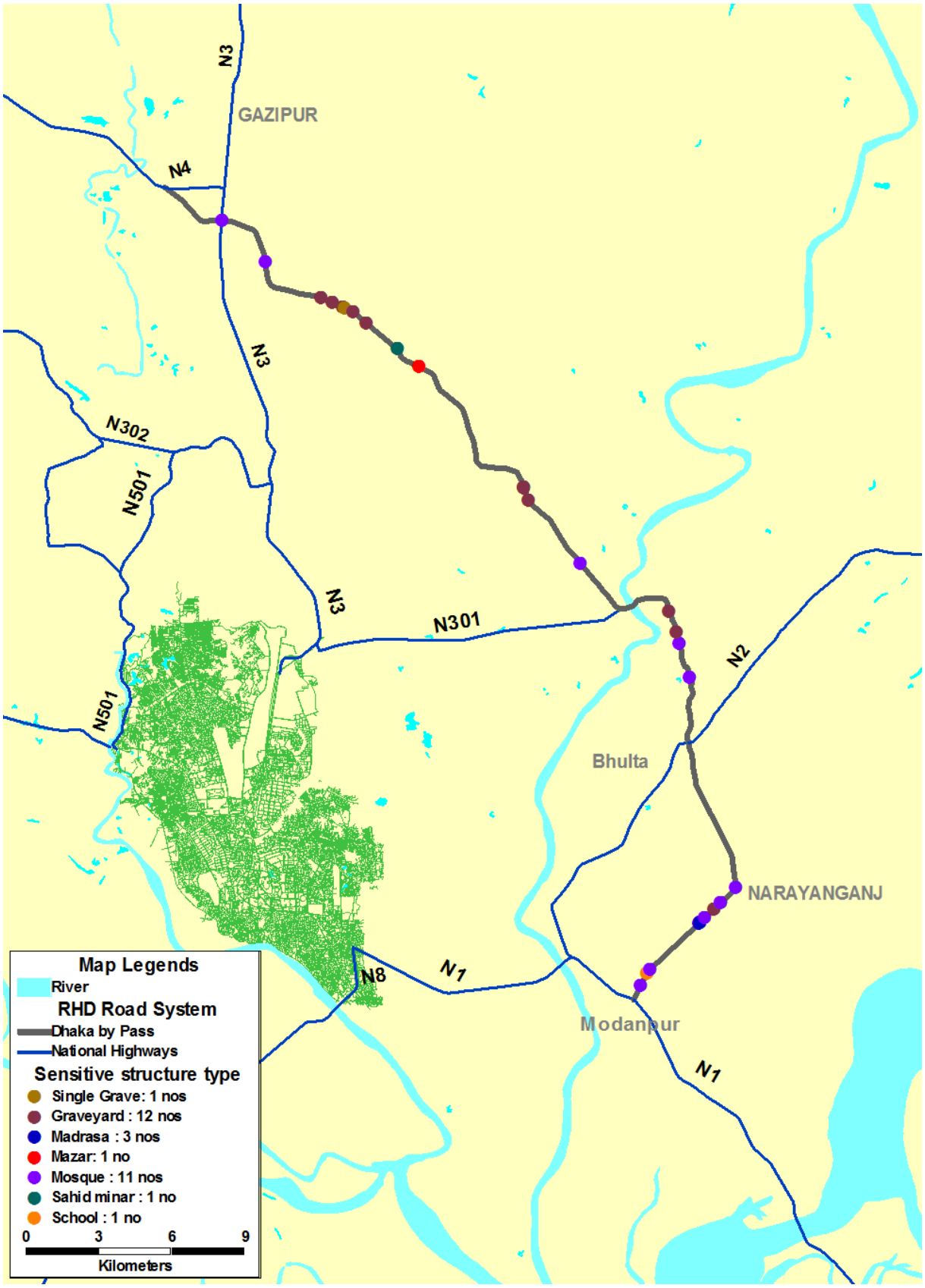


Figure 2-1: Critical Features in the N105 ROW

2.1.4. GEOMETRIC DESIGN

The geometric design for the Dhaka By-Pass is developed based on the detailed topographic survey, and accommodates the existing road structure features where possible. The key existing roadway features considered during the feasibility stage of the project are described below, while the detailed feasibility stage geometric design is included in Appendix A4.

2.1.4.1. EXISTING ROADWAY GEOMETRY

Based on the topographic survey as well as design engineer field visit, the following observations can be made for the existing road geometry:

- The road is a standard two lane highway (two 3.65m lanes) with a soft shoulder;
- In general, the alignment conforms to the design horizontal and vertical alignment (with Design Speed of 80 km/hr), however, there are some sections (Km 9-10, Km 16-17, Km 24-29) where improvement to the existing horizontal alignment is required to improve the sight distance;
- The horizontal alignment is often offset by 16m to 20m from the existing ROW centreline;
- There are 38 different as-build cross-sections along the existing road that mostly varies by pavement and base/sub-base thickness and shoulder width; and
- The existing horizontal alignment has no defined geometry that can be used to establish the existing geometry. Therefore, a measured centreline from the pavement edge is used to establish the existing horizontal geometry.

2.1.4.2. CROSS-ROAD AND DRIVEWAY

Based on the detailed topographic survey, numerous driveway type approach roads connect the Dhaka By-Pass to provide local access mostly by NMT and small motorized (CNG type) vehicles. In addition, a number of driveway access points from commercial facilities including industry and markets are observed. The following observations can be made for the local access to the existing N105 road:

- There are 40 LGED or local roads crossing the N105.
- On average LGED local roads connect with the Dhaka By-Pass existing alignment at points less than 1.5 km apart.
- More than 62 driveway access points were observed from the mainline to:
- Roadside industries;
- Roadside service stations and resort facilities.
- There are more than 102 local roadway approaches connecting only one side (either left or right side) of the Dhaka By-Pass Road having functionality similar to a driveway approach.
- Other than major highway crossings (regional and Zilla roads), the traffic volume for most of the local access is very low and mostly used by the NMT vehicles.

There are too many unplanned driveway and side road approaches connecting with the existing road alignment. Most of these driveway and side road approaches will be serviced by proposed service roads with occasional crossings that connect either side of the service roads. Figure 2-2, below, illustrates the approximate locations of cross roads and driveways along the corridor.

2.1.4.3. RAIL-CROSSINGS

There are two rail crossings along the N105 National Highway. The general findings for these rail crossings are:

- Both rail-crossings have supervised manual gates with an average frequency of 40 trains/day for the Dhaka-Chittagong mainline, which is in the process of being double tracked;
- The rail crossings at Mirer Bazar run parallel to a regional highway within 200m and a flyover that includes both rail-crossings and the regional highway is thus necessary;
- The 2nd rail crossing also runs parallel to a local LGED road and must be included with the rail overpass; and
- The rail guard-rooms are located on a common ROW for both RHD and Rail that need to be replaced to allow for the proposed toll road cross-section.
- Minimum vertical clearance used for the rail-over is 7.2 m and consistent with Bangladesh Railway specification.

2.1.4.4. BRIDGES AND DRAINAGE STRUCTURES

There are six bridges along the Dhaka By-Pass Road, ranging from single to multiple spans. There are 56 box culverts with one to two vents that provide cross-drainage. These are in addition to 49 RCC pipe culverts with vent diameter ranges from 1.0 to 2.0 meters (double barrel). Figure 2-3 illustrates the approximate locations of the cross drainage. The design team also identified three small-scale regulators and one u-drain along the existing roadway. During the geometric design process, the relative locations of these existing structures are considered, with the objective of retaining the structure within the horizontal alignment and maintaining the existing structure invert-level that is consistent with the vertical profile.

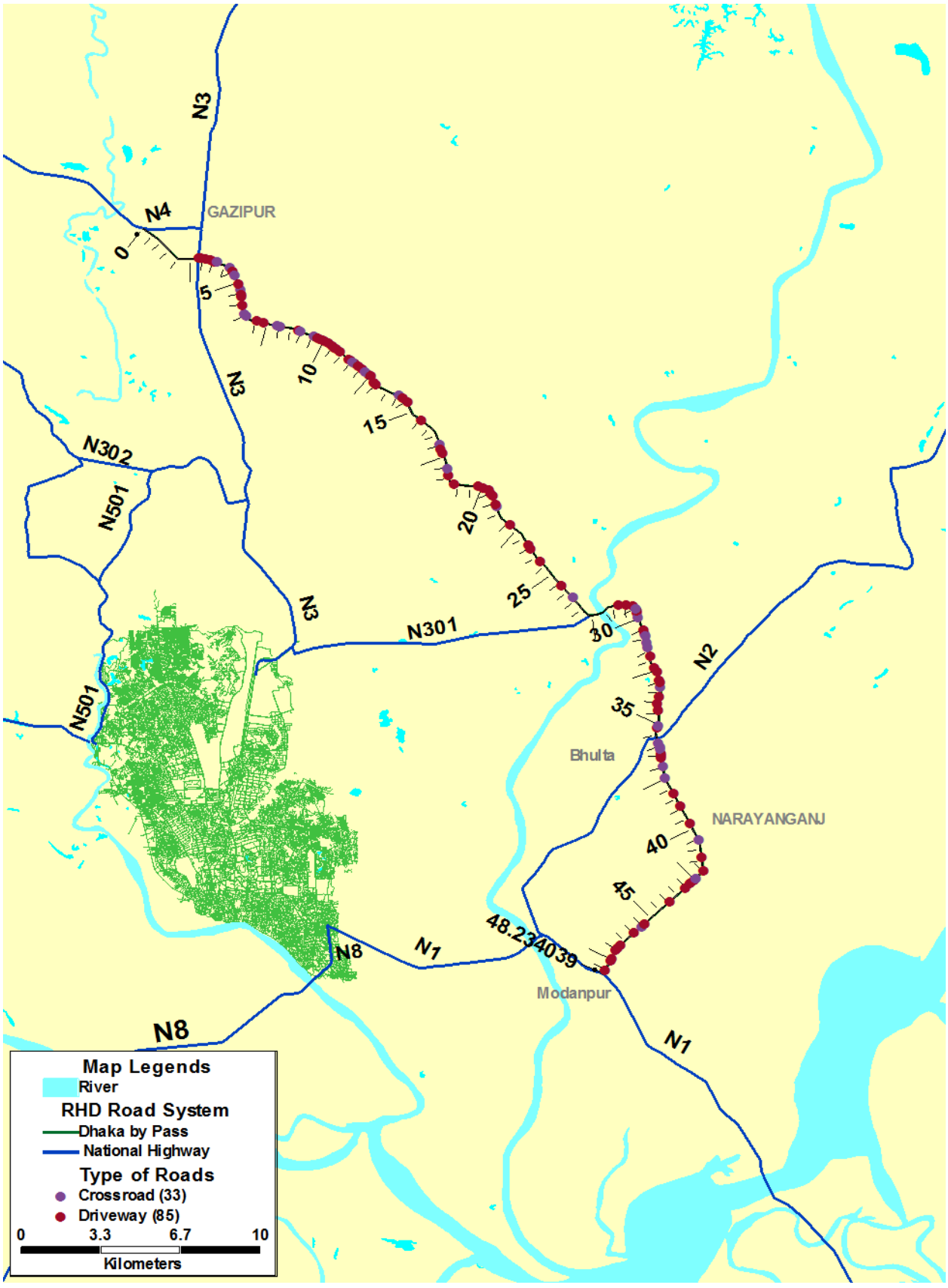


Figure 2-2: Driveways and Side-Road Approaches onto the Dhaka By-Pass Road

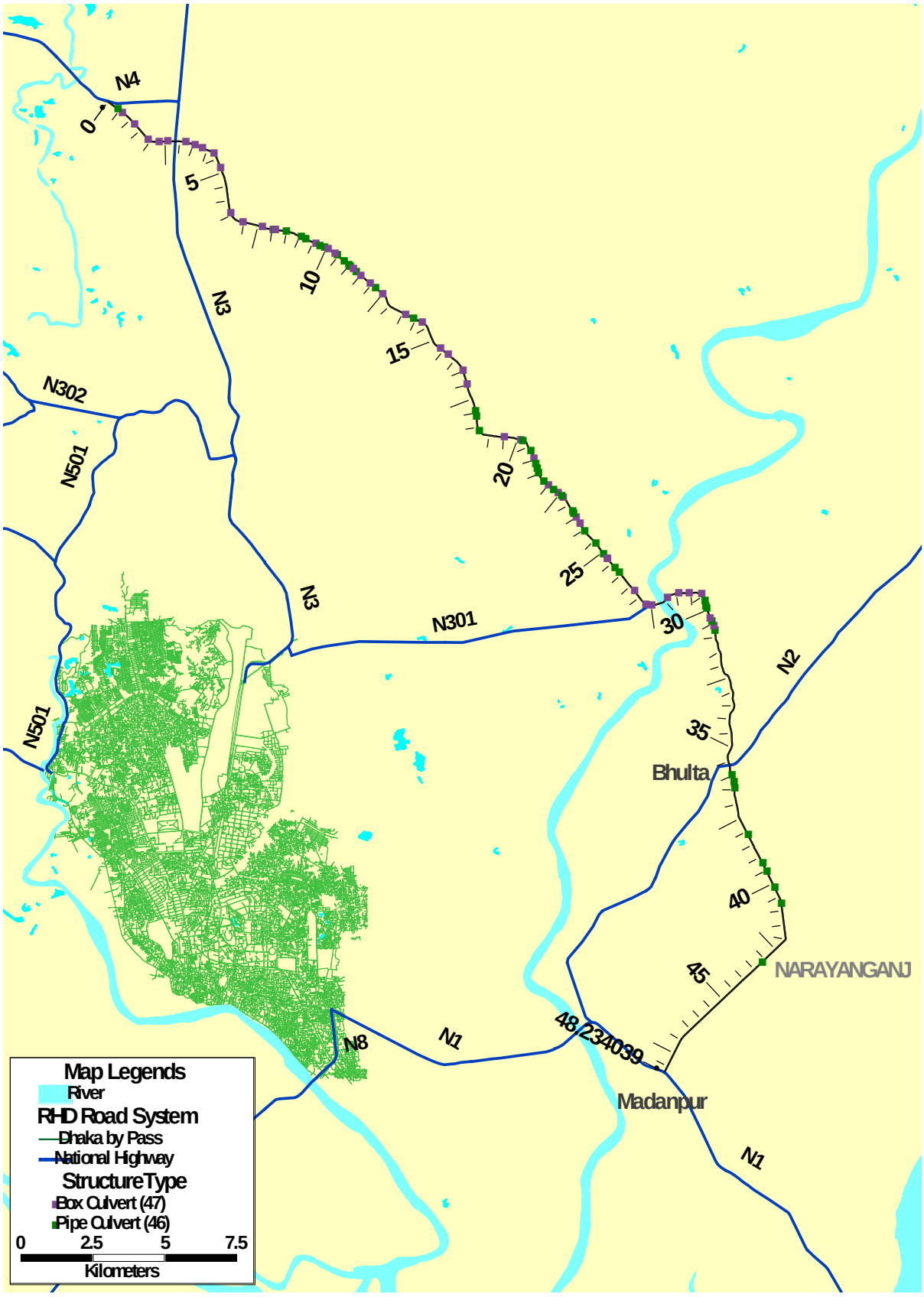


Figure 2-3: Cross Drainage along the Dhaka By-Pass Road

2.1.4.5. ROAD SIGNS AND WARNING

There is hardly any road signage for speed limits, traffic warnings, or traffic delineation at the curve or approaching bridge structures.

2.1.4.6. PROPOSED ROADWAY GEOMETRY

Given the existing status of the N105 geometry and cross-section, as described under the above sub-sections, the following decision was made and confirmed with the executive agency for the development of the feasibility-stage design vertical, horizontal and cross-section. In addition to RHD roadway geometry design guidelines, the following design elements are also considered for the feasibility level roadway geometry design:

- Interchange locations including possible exits and access points;
- The number of pedestrian crossings, as controlled by dual purpose flyovers or underpasses;
- Livestock crossings;
- The alignment of new bridge structures for service roads;
- Horizontal alignment (for safety purposes);
- A one-way service road on either side of the main toll road for accessibility. However, safety considerations were given for selecting the service road pavement width assuming that some NMT may use one-way as two-way road;
- The timing of the BRT/ SASEC (design harmonizing for strategic highway corridor) as well as the interchange at Bhulta and Modonpur;
- Special cross-sections at populated areas, emergency lanes as well as bus-bays for service lanes and at the toll plaza location; and
- A functional cross-section that can fit within a constraint ROW.

2.1.4.6.1. HORIZONTAL CONTROL (ROAD ALIGNMENT)

The existing road centerline is moved to the ROW centerline, where possible, and the alignment is upgraded where existing curves do not conform to the RHD design standard. At locations where the curve radii need to be compromised due to ROW constraints, appropriate road safety treatments are provided in order to compensate for any deviation from the design standard.

2.1.4.6.2. VERTICAL CONTROL (PROFILE)

Since the existing RL of the N105 is above the HFL with a 0.9 m freeboard, it is proposed to design the vertical profile so that the impact on the bridge and culvert RL is minimal. In addition, the maximum grade is kept below 3% at flyovers or overpass to allow for small motorized vehicles.

2.1.4.6.3. CROSS-SECTIONS

The typical cross-section for the proposed toll road is illustrated in Figure 2-4 below. The cross-section assumed a minimum ROW width of 32.2m. Where the ROW is constrained by the ROW width, retaining walls are proposed to compensate for the additional land require for the side slope. Several other cross-sections are also developed at the toll plaza, semi-urban locations, service road bus-bays, and the emergency lanes for toll road.

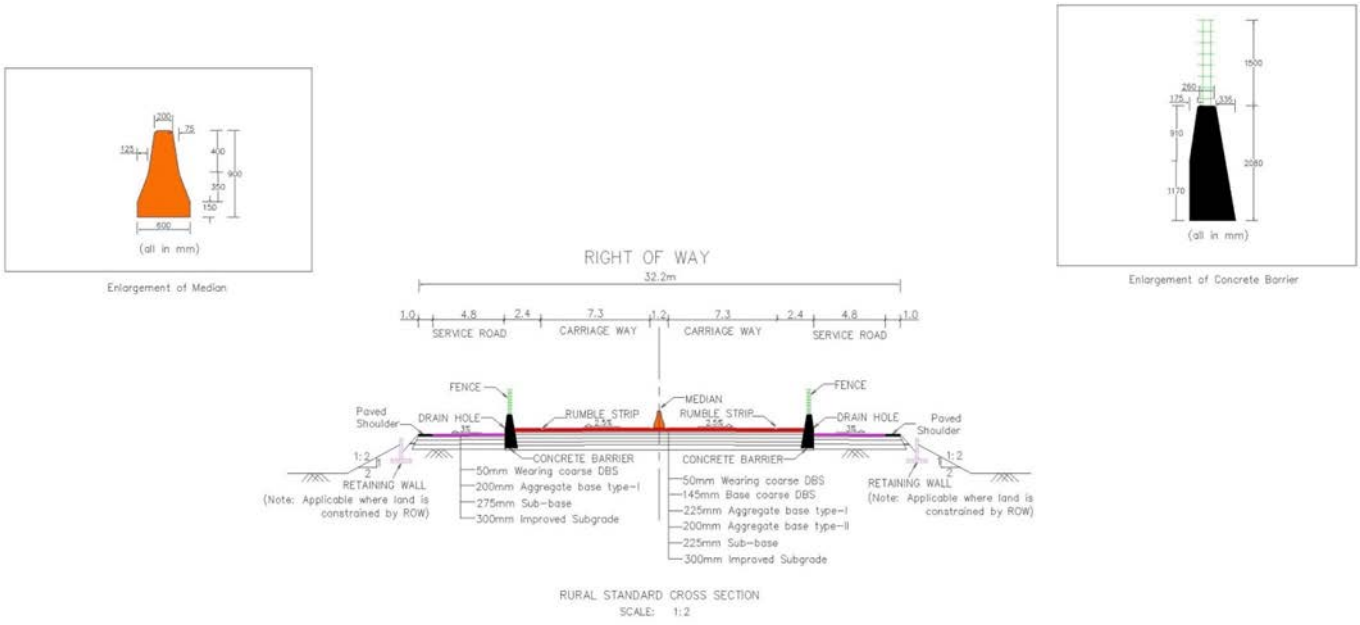


Figure 2-4: Typical Road Cross-Section

Mainline Carriageway: The total width of the mainline line carriageway is 20.6 m. The cross-section includes a 7.3 m carriageway/per direction with 2.4 m of paved shoulder and 0.3 m shy distance from the median barrier. Each shoulder has 0.30 m rumble strip for safety. The mainline is protected from the service lanes by a combination of concrete retaining wall plus fence, as shown in Figure 2-4.

Service Lanes: One-way pair service lanes are proposed on the either side of the mainline carriageway. Out of the proposed 4.8 m width, the effective width of the service lane is 4.5 m with one additional meter of paved shoulder. Depending on the existing development and locations of markets, the vertical profile of the service-lane can vary from 0 m to 0.6 m from the shoulder edge of the main carriageway. The width of the service lane is determined in such a way as to allow the passing of two vehicles at a slower speed plus the incidental presence of non-motorized traffic coming from the opposite direction in a one-way designated service road. The purpose of the one-way service road is to allow maximum accessibility for local traffic. The design standard for the regional highway is assumed for the service road so as to discourage and limit mainline through-traffic to use service road to avoid tolls.

2.1.5. GEOTECHNICAL STUDY AND PAVEMENT DESIGN

2.1.5.1. EXISTING GEOLOGY AND GEOMORPHOLOGY

The existing condition survey was carried out on March 14th, 2014. A team of engineers drove through the project area from Highway N4 in the North to Highway N1 in the South. In addition to visual drive-through inspections, the team carefully inspected the apparently critical locations. All the structures and the area in the vicinity of the structure have been visually investigated. The pavement defects, cracking, rutting, edge breaks, depression, and raveling areas were investigated to assess the road condition. The condition of shoulders and embankments were also monitored. Test pits were excavated along the edge of the existing roadway to assess the soil type. Field tests were performed to determine the soil type.

The native material appears to be sandy silt with traces of clay. The embankment fill is composed of sandy silt. The existing pavement condition varies from good to very bad. The overall length of the roadway is in good condition except localized complete deterioration, potholes and damage. The existing soft shoulder has been damaged nearly everywhere. No major slope stability failure was observed. All structures were found to be in fairly good condition. There were no major cracks or settlements observed in the superstructure and substructure. The investigation team learned from officials at RHD that serious deterioration of road pavement forced complete repair and repaving of the entire roadway within two years of opening of the existing road. Therefore, during the detail design phase, reasons for failure need to be evaluated. The general soil distribution within the proposed alignment is illustrated in Figure 2-5, below.

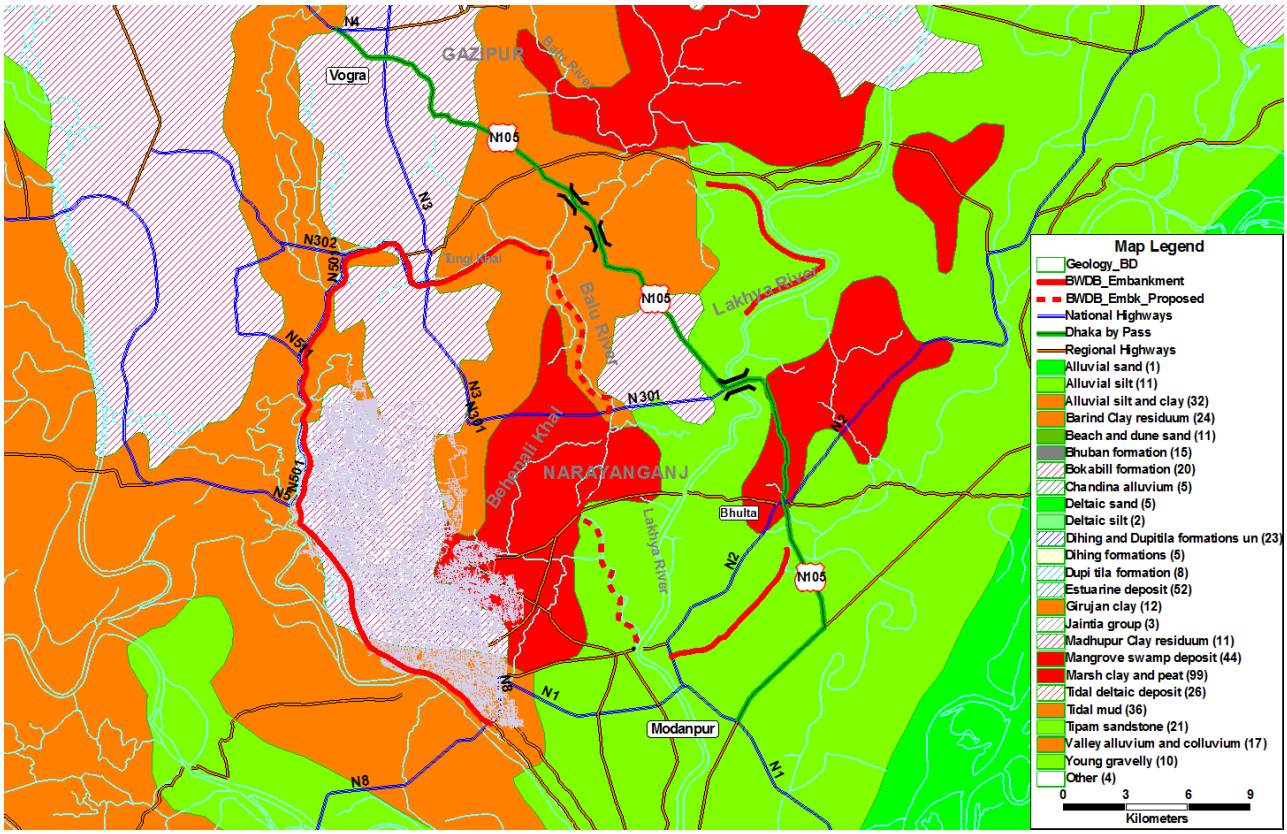


Figure 2-5: Soil Distribution

The roadway will be widened to accommodate the proposed four-lane toll road and two additional service road lanes on either side of the toll lanes. An existing two-lane roadway will be located approximately along the construction centerline of the ROW. There will be embankment fill on both sides of the existing road, which will settle inconsistently depending upon the total depth of fill. The existing roadway embankment has been settled over time since construction in 2006. The new embankment fill is required to be engineered to ensure maximum compaction. The depth of fill is estimated to be up to 8000 mm. Each lift will not be more than 250 mm in thickness, and each layer will be compacted to 98% of proctor value. The burrow material shall be free of any organic material and / or cohesive material. Granular material is recommended for the fill.

During field visits, in some locations, driveways have been constructed to provide access to and from commercial and residential developments. In other locations, the lower valley area between private properties and the existing roadway has been filled within the right-of–way. These fills are assumed to be uncontrolled. It is recommended to excavate these fill to original native ground surface. These excavated areas will be backfilled as controlled fill along with the surrounding area. This will minimize the pavement failure due to settlement of unrolled fill.

There will be several long fly-overs on major highways and railroad crossings. The approach ramps to the fly-over bridge structure may be built-up with embankments flanked by MSE retaining walls, which will reduce the structure length. Optimized height of bridge abutment will reduce the construction cost of the structure. If such approaches are elected to be built, the embankment fill shall be engineered. Again,

each lift will not be more than 250 mm in thickness, and each layer will be compacted to 98% of proctor value. The burrow material shall be free of any organic material and /or cohesive material. Granular material is recommended for the fill.

General Findings:

- No visible soil subgrade related failure or settlement was observed.
- Soil type and gradation appears to be suitable for widening the roadway.
- The new embankment fill is required to be engineered to ensure maximum compaction.
- Uncontrolled embankment filled for driveways by private land owners to the existing road may result in major settlement while widening the road.
- Too many LGERD side-roads and cross-roads are observed whose embankment fill is not within the RHD design standard and must be removed from the widened section of the proposed road.
- The road was reported to have been built in 2006; however no design data is available.

2.1.5.2. EXISTING PAVEMENT

The existing pavement is a 2-lane carriageway with AC dense graded hot mix surface. The asphalt thickness ranges from 50 to 95 mm. The exiting pavement base, sub-base, and sub-grade thickness also varies considerably from one pavement section to another pavement. For example, the base course thickness as reported by RHD (HDM data collected in year 2011) ranges from 90 to 277 mm. Given the existing pavement cross section reported by the RHD HDM circle, it can be concluded that no standard design was applied for the existing pavement and there is therefore a need to newly reconstruct for the toll road. The following observations are made based on the visual inspection of the existing pavement:

- The existing pavement condition rating varies from very good to bad.
- Overall the roadway is in good condition except localized potholes and distresses.
- The existing soft shoulder has been damaged nearly everywhere.
- No major slope stability failure was observed.

2.1.5.3. PAVEMENT DESIGN

The objective of pavement design is to select the most economical pavement thickness and layer composition that will provide a satisfactory level of service for the anticipated traffic for a specified time. This specified time is the design period, after which major maintenance/strengthening will be required. The pavement design on this project is based on the road condition survey, traffic analysis, geotechnical and pavement investigation, weather impact, sub-grade strength assessment and investigation into the sources of construction materials, as described in the relevant sections of this report. Due to higher standard requirements for the access-controlled highway with toll facility, the existing pavement needs to be completely reconstructed to a higher standard.

The pavement design was carried out using the traditional AASHTO method as per the Bangladesh Pavement Design Guide published by RHD in April, 2005. This is based on both the AASHTO design

guidelines from the USA and the corresponding ORN 31 publication by the UK's Transport Research Laboratory. A check was then undertaken using CIRCLY which is a multi-layer, linear elastic design method originating in Australia, but which has worldwide application. Design using Overseas Road Note 31 - A Guide to the Structural Design of Bitumen-Surfaced Roads in Tropical and Sub-tropical Countries (UK Transport Research Laboratory, 1993) is not appropriate for the project road as the validity of that method is limited to roads subject to cumulative traffic loads below 30 million ESALs. Due to higher truck population, the estimated loads of some 149 million ESALs for the main carriageways are well in excess of this value and the method was therefore not applicable. For consistency, MMM Group has used the AASHTO design method for all road carriageways.

Design pavement layers used for the feasibility stage financial analysis is listed in Table 2-3.

Layer & Roadway Section	DBR Main Road	DBR Service Road
10-year Design Loading [ESAL x 10^6]	150.0	2.5
DBS - Wearing Course	50	50
DBS - Base Course	145	-
Aggregate Base Type I [mm]	225	200
Aggregate Base Type II [mm]	200	-
Sub-base [mm]	225	275
Improved Subgrade [mm]	300	300
Fill Height	varies	varies

Table 2-3: Design Pavement Layers

2.1.6. HYDROLOGICAL STUDY/CROSS DRAINAGE DESIGN

2.1.6.1. GENERAL OBSERVATIONS

The proposed study area is situated in the eastern part of the capital city, Dhaka, and falls under the north eastern hydrological region of Bangladesh. The project road lies in a flood plain. The surface water hydrology around Dhaka is complex. The existing road alignment map is shown in Figure 2-6, below. The hydrology of the existing Joydebpur to Madanpur Road (Dhaka By-Pass) is dependent partly on the Balu River to the west and partly on the Lakhya River to the east and west side. The topography of the surrounding area is being been considerably changed due to rapid land filling by land developers and it has been envisaged that the floodplain of the Balu and Lakhya rivers would progressively be encroached by rapid filling. Considering the present land filling trend and future urbanization, the water levels of both Balu and Lakhya will rise. With the rising of the water level of the surrounding rivers and unpredictable local heavy rainfall in a short duration due to climate change, the crest level of the road needs to be determined. Hence, an accurate estimation of high water level design within the study area is a must. The Lakhya River drains surface runoff from a large catchment area lying in the central forest area and flow of the old Brahmaputra River. Additional inflows to the system originate from Balu, which drains a small catchment to the west of Lakhya. The Lakhya River joins the Dhaleswari, downstream of the Buriganga Confluence. The drainage of the surrounding areas is mostly dependent on the water levels of the peripheral rivers.

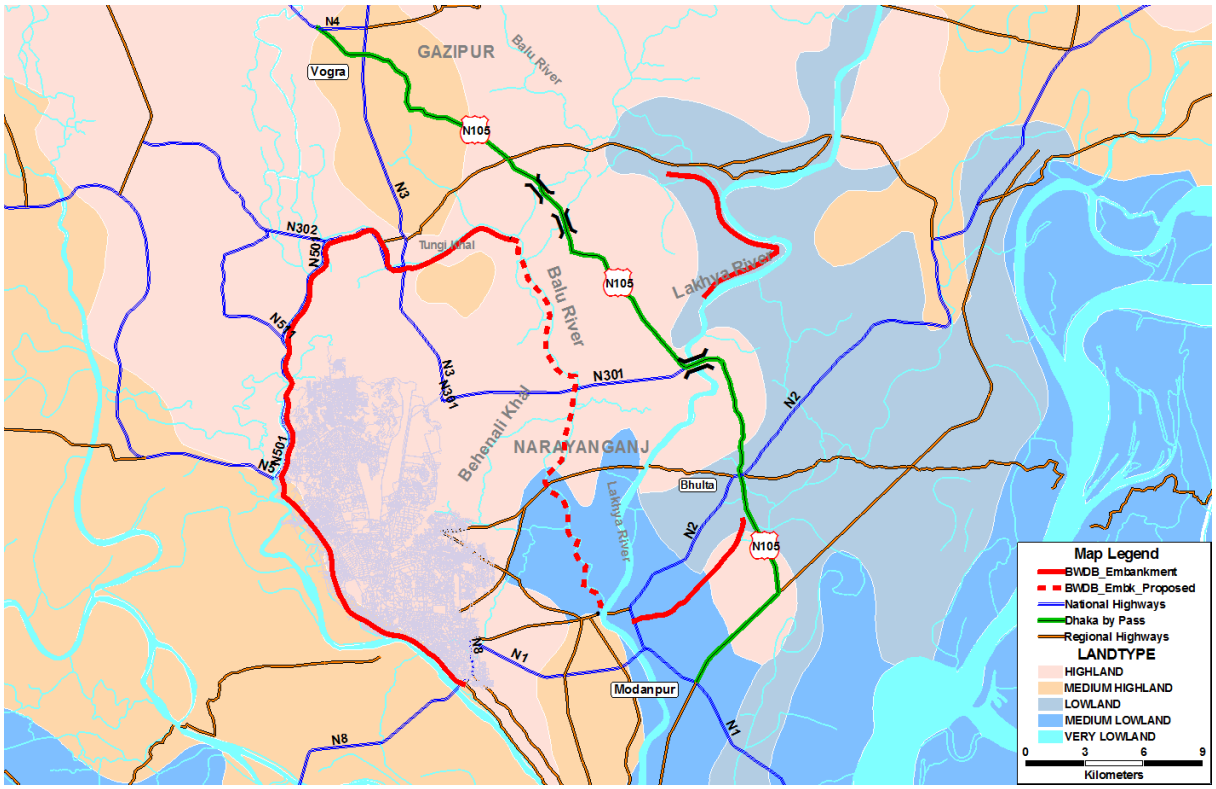


Figure 2-6: Road Alignment, Rivers and Embankment

2.1.6.2. OBJECTIVES OF THE STUDY

The main objectives of the hydrological study are:

- To quantify the adequacy of cross and flood water flow across the Dhaka-bypass given the existing number of box and pipe culverts;
- To establish the adequacy of proposed road level with the available water level data; and
- To provide the extent (in meters) of bed and slope protection works of rivers, if required at different bridge locations.

2.1.6.3. SCOPE OF THE SERVICES

The following activities/works have been carried out for fulfilling the objective of the study:

- Review of the available hydrological and hydrometric data and previous study;
- Field visits/survey to gather sufficient information on local hydrology, existing problems, local topography along the proposed road alignment, existing infrastructures etc.
- Collection of water level data from secondary sources and analysis; and
- Determination of catchment areas for different structures;

2.1.6.4. FIELD INVESTIGATION

A field/site visit was carried out on 14th March, 2014 along the proposed road alignment (from Joydevpur to Madanpur). The main objective of the field visit was to investigate the existing condition of the study area in terms of its topographic condition, drainage etc. The findings of the field investigation are stated below.

It was observed that:

- From 0 km to 15 km the land is high and medium high.
- From 15 km to 28 km (up to Kanchan Bridge over Lakhya River) land is high/low to Medium lowland.
- From km 28 to km 48.4 level is mix of high and low land.

During the field visit, 3 large bridges and 3 small bridges were found on the proposed road alignment, all of which are in good condition and are functioning well. The large bridges include the Nagda Bridge at km 14.920 over the Nagda River (4 span - 37.5 m x 17.6 m), the Ulukhola Bridge at km 17.300 over the Balu River (4 span - 43.75 m x 17.6 m), and the Kanchan Bridge at km 27.960 over Lakhya River (8 span- 4-49.60 m x17.6 m, 2 span - 52.60 m x 17.6 m, 2 span-55.6 m x 17.6 m). The small bridges are located at km 37.4 (single span - 31.5 m x 17.6 m), km 38.620 (single span – 25 m x 18 m), and km 40.480 (single span – 25 m x 17.6 m). Details on these bridges are summarized in Table 2-4, below.

Chainage	Structure Type	Structure name	Full Length (m)	Full Width (m)	Span no. and length (m)	Vent Height (m)
14+920	PC	Nagda Bridge	150	17.6	4@37.5m	10.48
17+300	PC	Ulukhula Bridge	175	17.6	4@43.8m	10.00
27+960	PC	Kanchan Bridge	415	17.6	4@49.6 m 2@52.6 m 2@55.6 m	27.46
37+400	PC	Asian Bridge	31.5	17.6	1@31.5 m	7.66
38+620	PC		25	18.0	1@25.0 m	8.7
40+480	PC		25	17.6	1@25.0 m	10.07

Table 2-4: Bridge Details (as per survey report)

2.1.6.4.1. REGULATORS

There are 4-Regulators (outlined in Table 2-5), all of which are in good condition and are functioning well:

- At km 30.94 (1 vent - 0.9 m x 1.0 m)
- At km 31.71 (1 vent - 1.0 m x 2.6 m)
- At km 32.93 (1 vent - 2.4 m x 1.65 m)
- At km 35.27 (2 vent - 1.65 m x 2.8 m)

Location/ Chainage	Type	Vent Height (m)	Full Length (m)	Full Width (m)	Regulator vent size	Invert Level (CUL)
30+940	U-Drain	1.00	21.30	1.50	1-0.9X1.0	3.335
31+710	Regulator	2.60	19.20	1.60	1-1.0X2.6	2.563
32+930	Regulator	1.65	18.00	3.00	1-2.4X1.65	2.958
35+270	Regulator	2.80	18.00	4.50	2-1.65X2.80	3.484

Table 2-5: Regulators (as per survey report)

In addition to the major structures, there are 56 box culverts and 49 pipe culverts on the alignment. The culverts' openings are sufficient to discharge rainfall runoff of the area. The catchment area of the individual box and pipe culverts has been calculated by empirical formula. In the calculation of water flow, the free flow water level was considered at 2/3rd height of the culvert opening for box culverts and full flow condition for pipe culverts.

2.1.6.5. HYDROLOGICAL ANALYSIS SUMMARY

2.1.6.5.1. FLOOD CATCHMENT AREA (DESIGN RL)

- Land elevations:
  - From Station 0+00 to 0+15 km is high to medium high land;
  - From Station 0+15 to 0+28 km is medium low land; and
  - From Station 0+28 km is mix of high and low land.
- 20 years flood level with 50 years return period for the Balu and Lakhya rivers varies from 7.24 to 7.41 m.
- With 0.9 m freeboard, the high flood level varies from 8.75 to 7.94 m along the existing road alignment.
- Existing road elevations are above the highest flood level of the Balu and Lakhya rivers.

The existing RL level is at or above the 20 years design flood level. Therefore, the proposed design profile can be kept at the same level of existing bridges and culverts RL plus the design asphalt pavement surface.

2.1.6.5.2. DRAINAGE

There are many one and two vent box culverts along single and multiple pipe culverts of 900 mm diameter. Some culverts are chocked or blocked by debris or by property developers, and should be cleaned for proper drainage. Given the number of culverts, the following observations can be made regarding the cross drainage system for the N105:

- Existing box and pipe culverts are sufficient to discharge rainfall runoff across the road alignment;
- Water conveyance at bridge point for the Nagda, Balu and Lakhya rivers show good flow ensuring rapid discharge during flush flood; and

- No additional drainage structure is needed.

2.1.6.5.3. DRAINAGE STRUCTURE

There is no erosion at both banks of the Nagda and Balu rivers at U/S and D/S of the bridges. Both sides of the bridges' abutment walls are protected by brick mattressing works which have been damaged. Abutment wall of these two bridges may be protected by cement concrete blocks of 40 cm x 40 cm x 20 cm sizes which may cost Tk 50 lakhs.

The bridge abutment wall over Lakhya (Kanchan Bridge) is well protected by CC blocks. At left the bank, there is no erosion at U/S and D/S of the bridge. At the right bank, both U/S and D/S of the bridge have been protected by CC blocks.

On the alignment there are 105 (box and pipe) culverts at different locations, of various sizes. Most of the culverts are in good condition and are functioning well. During the visit, local people informed that there is no water congestion in the area and culverts are well capable to drain out local runoff during rainy season.

A detailed hydrological report is prepared for this study and included in Appendix B.

2.1.7. CONDITION SURVEY OF EXISTING STRUCTURES

2.1.7.1. EXISTING BRIDGES

The following observations can be made based on the inspection of each bridge along the Dhaka By-Pass Road:

- There are three major bridges with multiple spans.
- There are three major single span bridges.
- There is an adequate four-lane carriageway with footpath (no room for service lanes).
- Both super and sub structures appear to be in good condition.
- Most bridges have adequate navigation height except at Kanchan Bridge where navigation clearance is restricted during the rainy season for barges carrying cement clinkers to nearby cement factories.
- They are designed and constructed with RHD standard with 100 years design life.

The field inspection and their specific findings by super and sub-structure by each of the bridge is reported below.

Kanchan Bridge: This is a four lane pre-stressed concrete (PC) girder bridge (eight 50 m span) on Shitalakhya River at km 28.3. The super structures consist of nine pre-stressed concrete girder bridges. The sub structures consist of pile foundation in the main river channel with pile cap, pier column and pier cap. The shallow depth section of the river sides are constructed in caisson pile with column and pier cap and the total width of the deck is 17.65 m.

Cast in situ pile and pile cap / pier pile cap: Each Pier pile cap consists of six cast in situ pile foundations with a 1.0 m diameter reinforced concrete pile. All cast in situ piles cover the permanent non corrosion steel casing imbedded into pier pile cap. In dry seasons, the piles and pier pile caps are exposed, and during the monsoon seasons, the entire pile and pier pile cap are submerged in water. No structural damage or cracks were observed in the sub and super structure members of the bridge, which appears to be in good condition.

Vertical column: The vertical column consists of monolithic concrete structures with a Y shape pier cap. The structure appears to be in good condition with no visible cracks or damages.

Pier cap: The super structures rest on a pier cap with nine pre stressed concrete girders and a concrete deck slab. The physical appearance shows no defects.

Elastromic Bearing: The Elastromic rubber bearing is in good condition without any visible deflection.

Pre stressed concrete girder: High strength concrete is used in pc girder. Pre-stressed concrete girder, where the main component is high tensile steel strands and high yield deformed bar (fy = 60 mpa) are used. The member is in good structural condition.

RC deck slab: Traffic on the existing 4-lane carriageway (2 x 7.3 m wide) moves in both directions. The deck slab is in good structural condition without any cracks or potholes and there is no exposed rebar in the deck slab.

Footpath: Both ends of the deck slab have a footpath that is 2 x 1.20 m wide. There is no visible damage or cracks.

Railing and Post: Both ends of the deck slab have a railing and post with standard height but some major repair work will be necessary.

Traffic Barrier: The standard design traffic barrier was adopted and it is in good condition without any damage.

Expansion Joint: Most of the expansion joints are damaged and make a strong noise when traffic moves over them. The deck slabs are deteriorating rapidly and repair will be required urgently.

Bituminous wearing course: The bituminous wearing course is constructed over the top of the deck slab. The top surface does not show any damage, cracks or potholes.

General Findings: Overall, the structure is in good condition and can be retained. However, for service roads with 9.5 m wide carriageways including footpaths, the latter are proposed for the left side of the bridge. Alternatively, bridge retrofitting options can be investigated with managed lane configuration to allow access for the local traffic originated via service road. Under the retrofitting option, RHD can continue to collect bridge tolls from the service road vehicles.

Ulukhola Bridge: This is a four lane PC girder bridge (5 span @ 40 m) at km 17.4. The super and sub-structure elements consist of caisson pile foundation with a pile cap, pier column and pier cap. The

bituminous wearing course is constructed over the top of the deck slab and the total width of the bridge is 17.65 m.

Cast in situ pile and pile cap / pier pile cap: Each pile cap is cast in situ pile caisson foundation. In dry seasons pile and pier pile cap are exposed and during the monsoon seasons the entire pile and pier pile cap submerged under water. No visible damage or cracks were found in the members. Therefore the structures are in good condition

Vertical column: The vertical column consists of monolithic concrete structures with a Y shape pier cap. The structures are in good condition without any visible cracks or damages.

Pier cap: The super structures rest on the pier cap with nine pre-stressed concrete girders and concrete deck slab. The physical appearance of the structures is in good condition.

Elastromic Bearing: The Elastromic rubber bearing is in good condition without any visible deflections.

Pre stressed concrete girder: High strength concrete are used in PC girder. This appears to be in good structural condition.

RC deck slab: The deck slab is adequate for a 4-lane carriageway (2 x 7.3 m wide). The deck slab is in good structural condition without any cracks or potholes and there is no exposed rebar in the deck slab.

Footpath: Both ends of the deck slab have a 2 x 1.20 m wide footpath. There is no visible damage or cracks.

Railing and Post: Both ends of the deck slab have a railing and post with standard height but some major repair work will be necessary.

Traffic Barrier: The standard design traffic barrier was adopted and it is in good condition without any damage.

Expansion Joint: Most of the expansion joints are damaged and make a strong noise when traffic moves over them. Major repair work is required.

Bituminous wearing course: The bituminous wearing course is constructed over the top of the deck slab. The top wearing surface does not show any damage, cracks or potholes.

General Findings: Overall the structure is in good condition and can be retained subject to ex. However, for service roads with 9.5 m wide carriageways including footpaths, the latter will need to be built on the left side of the bridge. Unlike with Kanchan Bridge, retrofitting options are not feasible due to complexity of separating the toll and non-toll traffic.

Nagda Bridge: This is an existing four lane pre-stressed concrete girder bridge (4 span @ 40 m) at km 15. The structures consist of a pile foundation with pile cap, pier vertical column and pier cap. The bituminous wearing course is constructed over the top of the deck slab and the total width of the deck slab is 17.65 m.

Cast in situ pile and pile cap/ pier pile cap: Each pile cap consists of cast in situ pile foundation. No visible damage or cracks were observed in the members. Therefore, the structures are in good condition.

Vertical column: The vertical column consists of monolithic concrete structures with Y shaped pier cap. The members of the structure are in good condition without any cracks or damages.

Pier cap: The super structures rest on the pier cap with nine pre-stressed concrete girders and concrete deck slab. The physical appearance of the structures is in good condition.

Elastromic Bearing: The Elastromic rubber bearing is in good condition without any visible deflection.

Pre stressed concrete girder: High strength concrete is used in the pre-stressed concrete girders. The structural members appear in good condition and no visible cracks.

RC deck slab: Traffic on the existing 4-lane carriageway (2 x 7.3 m wide) moves in both directions. The deck slab is in good structural condition without any cracks or potholes and there is no exposed rebar in the deck slab.

Footpath: Both ends of the deck slab have a footpath with 2 x 1.20 m wide. There is no visible damage or cracks.

Railing & Post: Both ends of the deck slab have a railing and post with standard height but minor repair work will be necessary.

Traffic Barrier: The standard design traffic barrier was adopted and it is in good condition without any damage.

Expansion Joint: Most of the expansion joints are damaged and make a strong noise when traffic moves over them. Major repair work is required.

Bituminous wearing course: The bituminous wearing course is constructed over the top of the deck slab. No visible damage, cracks and pothole were observed.

General Findings: Overall, the structure is in good condition and can be retained. However, for service roads with 9.5 m wide carriageways including footpaths, the latter will need to be built on the left side of the bridge. Unlike Kanchan Bridge, retrofitting options are not feasible due to the complexity of separating the toll and non-toll traffic.

Single span pre-stressed concrete girder bridges: There are three single span bridges at kilometer points 38.0, 39.2 and 41.1 km. These bridges are 4-lane carriage ways and have different spans that vary from 35 m to 45 m. The structures are constructed pile foundation with pile cap and abutment. Cracks are not found in sub structures and super structures, and only minor repair works are required for the expansion joint and railing.

Findings: Overall the structures are in good condition and can be retained. However, for service roads with 9.5 m wide carriageway including footpath, the latter will need to be built on the left side of the bridges.

2.1.7.2. EXISTING BOX CULVERTS

There are 56 box culverts along the Dhaka By-Pass Road, which range from one to two vents barrel. Almost all these culverts are required to be extended to accommodate the proposed widened roadway. The proposed extension will be on both ends of the culverts. To ensure the structural integrity of the existing structure, it is recommended that the breaking of a part of the culvert barrel is to be avoided. A properly designed expansion joint may be considered in between the existing and new addition to the culvert. This will minimize the possible stress development out of differential settlement and thermal stress developed along approximately 35000 mm length of the culvert.

The following observations can be made based on the inspection of each individual culvert:

- There are 56 box culverts with various vent opening sizes depending upon the rain-water catchment area;
- Out of 56 concrete box culverts, three are 2-vent and 53 are 1-vent box culverts;
- Most of the culverts have no wing-walls that will ease the modification without dismantling the existing structure;
- Some culverts' openings are obstructed by local developments; and
- The sub and super structure of these box culverts appear to be in very good condition and designed and constructed with RHD standard with 100 years design life.

General findings: No new box culverts are required. Since there several land developments in progress and culverts are being filled on both sides, leaving no provision for cross-water flows, some of the culverts need to be discontinued depending upon the hydrological analysis of the project area. The existing culverts are proposed to be widened on both sides to provide adequate pavement width for both main carriageway and the service roads.

2.1.7.3. EXISTING PIPE CULVERTS

There are 49 RCC pipe culverts along the Dhaka By-Pass Road with vent diameter ranges from 1.0 to 2.0 m (double barrel). The following observations can be made based on the inspection of each individual culvert. No new pipe culvert is required since there are several land developments in progress and pipe culverts are being filled on both sides, leaving no provision for cross-water flows. Therefore, some of the pipe culverts need to be discontinued depending upon the hydrological analysis of the project area. The existing pipe culvert can be widened on both sides to provide adequate pavement width for both main carriageway and the service roads.

2.1.7.4. REGULATORS AND U-DRAIN

There are three small scale regulators and one u-drain exists along the existing roadway. One of the regulators has 2-vents each with an opening of 1.65 by 2.8 m. Due to dramatic changes of the land use pattern along the corridor, the general functions of these regulators have ceased to exist. Unless otherwise required by hydrological analysis, these structures need to be discontinued.

2.1.8. DRAINAGE STRUCTURE DESIGN

Unless closed due to land development, all active and functioning drainage structures are proposed to be retained with appropriate widening to align with the design horizontal alignment.

- The 51 existing multi cell box culverts and 49 pipe culverts and 4 regulators will be retained.
- Different types of existing structures are to be extended up to 4-lane with service lane according to requirements.

2.1.9. STRUCTURAL DESIGN: MAJOR STRUCTURES

The Dhaka By-Pass Road will be reconstructed in 4-lane with service lane along both sides. The existing two-lane bridge structures will be retained and new two lane bridge structures will be constructed parallel to the existing structures and different types of existing box culverts / pipe culverts structures to be extended according to the requirements. The 4-lane pre stressed concrete girder rail over / flyover bridge will have to be proposed for new construction. The following design standards have been considered:

- Bridge Design Standard specifications for Roads and Highways
- AASHTO Standard Specification
- AASHTO LRFD Bridge Design Specification
- Indian Road Congress (IRC-2000) Specification
- RHD Bridge designs Hand book (2nd edition)
- BNBC Standard Specification

For the purpose of the feasibility level estimate, typical structural designs are prepared for all major structures and provided in a set of appendices. The typical design and drawing are developed for the following salient features and proposed structures, and are summarized in Table 2-6. The approximate locations of various proposed structures are shown in Figure 2-7.

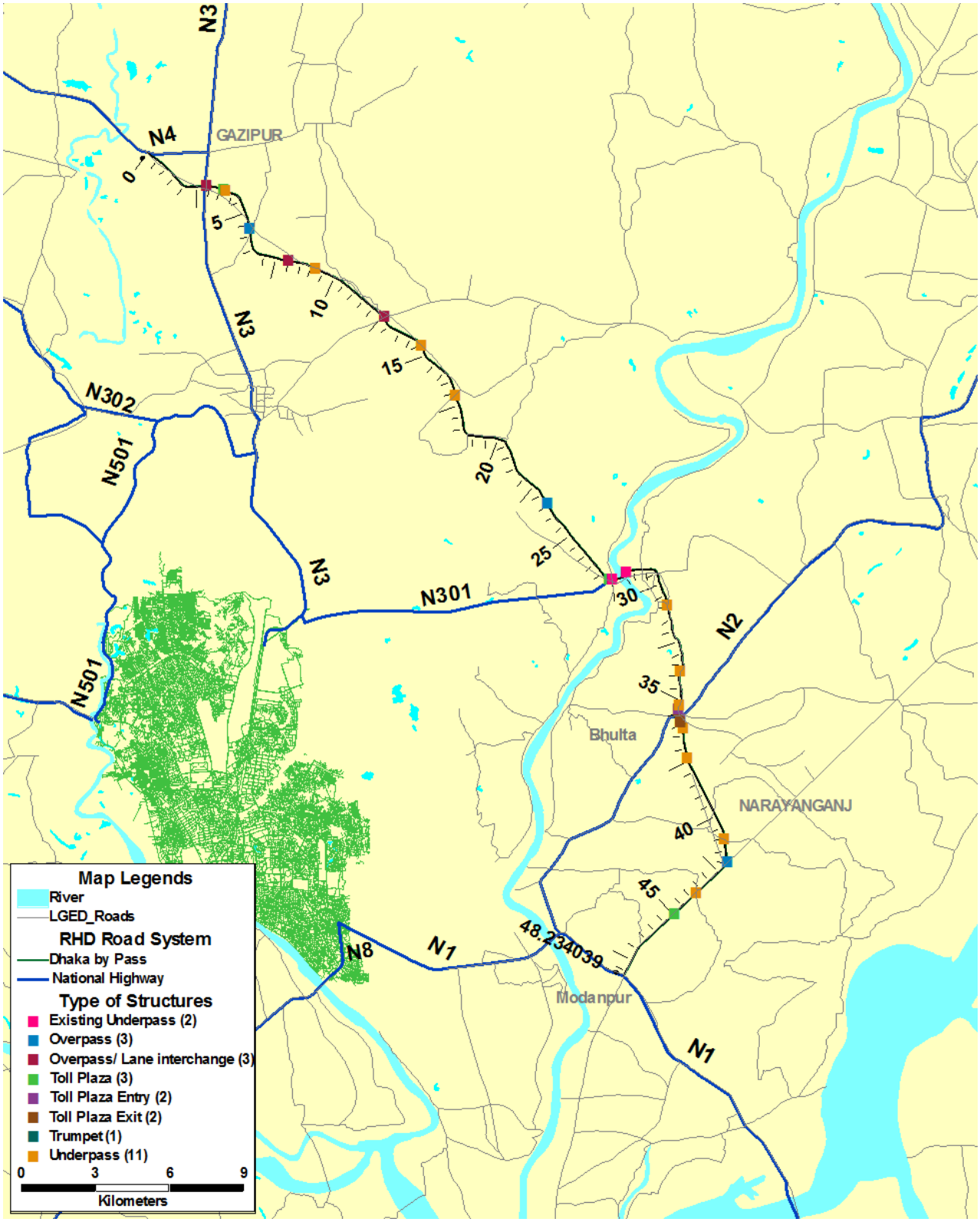


Figure 2-7: Proposed Structure Locations

Sl. #	Chainage	Separation distance(m)	Type of Structures	Size	Total Length (m)	Remarks
1	02+920		Overpass/ Lane interchange	4@40mx 17.65m	160	Vogra/ N105 Fly
2	03+615	695	Full Toll Plaza			
3	03+720	800	Underpass	1x5.0mx3.0m	5.8	SMVT
4	05+660	1940	Overpass	1x25mx17.65m	25	Lane interchange
5	08+020	2360	Overpass/ Lane interchange	3x40mx17.65m	120	Dhirasram rail crossing
6	09+180	1160	Underpass	1x5.0mx3.0m	5.8	SMVT
7	12+600	3420	Overpass/ Lane interchange	12@40mx17.65m	480	Mirerbazar rail crossing
8	14+800	2200	Underpass	1x3.0mx3.0m	3.8	Cattle pass
9	17+200	2400	Underpass	1x3.0mx3.0m	3.8	Cattle pass
10	23+420	6220	Overpass	1x25m x 17.65m	25	Lane interchange
11	27+400	3980	Trumpet	4 x 40m x 17.65m	160	Purbachal Interchange
12	27+400	0	Full Toll Plaza			500m west on N301
13	27+520	120	Existing Underpass	2x5.0mx4.5m	13	Lane interchange
14	28+180	660	Existing Underpass	2x5.0mx4.5m	5	Lane interchange
15	30+940	2760	Underpass	1x5.0mx3.0m	5.8	SMVT Local crossings
16	33+800	2860	Underpass	1x5.0mx3.0m	5.8	SMVT Local crossings
17	35+180	1380	Underpass	2x6.0mx4.5m	13	Lane interchange
18	35+415	235	Entry ramp toll ticket collection booth N2			North bound
19	35+465	50	Exit ramp toll booth at N2			South bound
20	35+600	N2 Flyover by RHD: N105 at grade with 6 lane facilities				
21	35+795	195	Entry ramp toll ticket collection booth, N2			South bound
22	35+925	130	Exit ramp toll booth at N2			North bound
23	36+180	1000	Underpass	2x6.0mx4.5m	13	Lane interchange
24	37+380	1200	Underpass	1x3.0mx3.0m	3.8	Cattle pass
25	41+060	3680	Underpass	1x3.0mx3.0m	3.8	Cattle pass
26	41+950	890	Overpass	12@40mx17.65m	480	Araihazar
27	43+700	1750	Underpass	1x5.0mx3.0m	5.8	SMVT Local crossings
28	44+950	1250	Full Toll Plaza			Araihazar

Table 2-6: Proposed Overpass, Underpass, and Interchange Structures along the Dhaka By-Pass Road

2.1.9.1. BRIDGES

There is a total of 6 4-lane pre stressed concrete girder bridges of different spans (total bridge length =780 m), and which will be retained. A new 2-lane pre-stressed concrete girder bridge (10.225 m wide) will have to be proposed for the service lane.

2.1.9.2. UNDERPASSES

A total of two existing multi-cell underpasses are to be expanded to four lanes, in addition to service lanes, as per requirements. Additionally, 11 new underpasses will have to be proposed in different locations for lane interchange and cattle pass only. The height clearance for the underpass to be used by all vehicle types for service road crossings is proposed to be 4.5 m and the clearance for the underpass for NMT vehicle cattle/pedestrian crossings is proposed to be 3.0 m.

2.1.9.3. RAIL CROSSING OVERPASS / FLYOVER-

Two rail crossing flyover bridges and three major road crossing flyovers at different locations are proposed. A typical design for the flyover was prepared and is included in Appendix A5.

2.1.9.4. INTERCHANGE

One major trumpet interchange at the intersection of N105 and N301 near Kanchan Bridge is proposed. The trumpet interchange will include one split-type bridge style ramp. At the intersection of N2 and N105, a special modified diamond interchange is proposed to accommodate the GOB funded N2 flyover on the N105. The interchange configuration will include two U-turn underpasses at 500m apart from the intersection of N2 and N105 with 4 exist/entry ramp.

A typical layout design (for the proposed trumpet interchange) and the modified diamond interchange configuration is included in Appendix A5.

2.1.9.5. TOLL PLAZA

Three full scale toll plazas are proposed. The proposed two full scale-toll plazas on the main carriageway are located at Chainage 03+615 and Chainage 44+950. The 3rd toll plaza is located on N301 adjacent to proposed trumpet interchange with the Dhaka By-Pass Road near Purbachal. In addition, one exit-only toll collection booth is proposed at the at grade ramp for traffic exiting the N105 at the N105/N2 intersection. The automated toll ticket collection gate is proposed for at grade entry ramp for traffic entering the Dhaka By-Pass from the same intersection.

A list of all structures, along with their chainage and typical design is provided in Table 2-6.

2.1.10. UTILITY SURVEY/CONSULTATION ON RELOCATION (FS & COST)

RHD via its memos dated 10-04-2014 and 28-04-14, requested the relevant agencies to furnish information on their respective existing utility service facilities along the Dhaka By-Pass Road (from Vogra point in Gazipur District to Madanpur in Narayangonj District). These agencies are: *BTCL, BREB, DPHE, DESCO, GP, Banglalink, Airtel, Citycell, Teletalk, GTCL, Titas, Power Grid, BPDB and DWASA. MMM Group, Canada, the Consultants' Dhaka office followed up with RHD's request, however, only a few of them responded with the information with respect to their existing facilities along the DBR. Some agencies had refused to furnish any information and others did not respond at all. However, for the purpose of the estimate, a line item is included for the total cost of all utilities shifting. The position of the agencies, under the circumstance is follows:

Agencies which furnished information include:

Banglalink

This agency has sent a map showing the approximate position of the fiber optic cable (Map enclosed). This agency has their fiber optic cable from Vogra point to Mirer bazar (about 10km). They have no other facility.

Citycell

This agency has sent a route map showing detailed data and information for Optical Fiber Connectivity (OFC) with its exact location and the costs associated with moving 1 km of fiber optic cable (Map enclosed). According to them, shifting 1 km fiber optic cable by HDD will cost approximately Tk. 1,000,000 including other necessary materials.

Airtel

This agency has given a survey drawing of their Optical Fiber Project in Gazipur. According to this, they have their optical fiber connectivity from Vogra point to Mirer bazar (about 10 km).

BREB (Narayangonj)

According to the information given by BREB (Narayangonj) they have 33 km 3 phase HT line and 16 km 33 KV line from Kanchan Bridge to Madanpur. This agency said that it needs layout plan of Dhaka By-Pass to work out the cost of relocating these lines. It is now to be decided whether or not the said layout plan for the DBR is to be given to it.

Agencies which have no utility facilities are:

- DPHE
- DESCO
- TeleTalk

Agencies which did not give any information in spite repeated reminder are:

- BTCL
- GrameenPhone
- GTCL
- Titas Gas Transmission
- Power Grid
- BPDB
- DWASA

Nevertheless, a provisional amount, assessed on a lump sum basis, has been included in this preliminary cost estimate.

However, power grid information and information on gas transmission lines were obtained during the topological survey and following comments can be made.

- Power distribution lines have overhead poles. In total there are 1520 electric poles that need to be relocated.
- No gas transmission pipeline was observed along the road side (no bridge or culvert crossings). However, some gas-pits were observed from chainage 42+460 to 48+00 and need further verification with the Titas Gas Company.
- The existing alignment is mostly within a non-urbanized area and there are no observed underground utilities such as water lines and sewerage lines. However, the consultant is in contact with the respective agencies to identify possible underground utilities.
- There are several deep-tube wells and water pump houses that are located within the ROW and will require relocation.

2.1.11. ROAD SAFETY AUDIT

The following findings are presented based on the field investigation done on March 14th, 2014. During the feasibility study design stage, road safety elements are considered for geometric and structural design. The associated cost for road safety elements is also included. The following deficiencies are considered during the feasibility stage design.

2.1.11.1. ROADWAY GEOMETRY

- Sub-standard geometric elements such as horizontal curves, sight distance, cross slope, shoulder width, lane width, median width and bridge approach exist throughout the project limit.
- Numerous horizontal curves with very small radii create a hazardous condition for the drivers as far as the speed and sight distance.
- Super elevation and super elevation transition are not maintained as per standard in reversing curves at a several locations. It was observed that bus and truck drivers had trouble maneuvering the vehicle along those sections of the roadway.
- There were either substandard or zero cross slopes at many locations of the roadway especially at or near interchanges, hat bazars and built-up commercial areas.
- Bridge and culvert approaches at several locations are not consistent with geometric standards.

2.1.11.2. PHYSICAL SAFETY FEATURES

Cross Sections: The separation of the shoulder from the carriageway is not clearly defined throughout the project limit. This might have occurred as a result of the wearing out of the paint edge. It was found that

the drivers consider the whole paved area as the carriageway which could result in unsafe maneuvering especially at the time of overtaking other vehicles.

Signs and Markings: Signs and markings were found missing in many locations. Even if there were signs/markings, the designs, colors, sizes, positioning, etc. do not follow the RHD standards. There was:

- No pavement delineation separating MVs and NMVs;
- Inadequate signage and marking at the interchanges/intersections, bridge approaches, rail crossings, bus shelters/stops and hat-bazaars;
- No specified parking; the carriageway is being used for parking;
- Missing posted speed limit signs especially at small radii curves and bridge approaches;
- No pavement delineation at entrance and exit points to the local/service roads;
- Unnecessary speed bumps, and rumble strips are missing where they are necessary; and
- Inadequate/missing signs at rail crossings.

Lighting: Bridge lighting was found to be either missing or insufficient on the bridges such as Kanchonpur and Modanpur.

Culvert Railing: Most of the culverts have neither sidewalks nor railings, which encourages pedestrians to share the carriageway with the MVs and NMVs.

Utilities: Numerous utilities are very close to the carriageway which makes the road unsafe.

Median Islands: Median islands on the bridges such as Kanchonpur seem to be unsafe. They can be replaced by safety shape barriers which would make the travel way safe and can add some space to the lane.

Guard Railing: Guard railing at some locations is missing especially at sharp radius curves. Guard railing is required at the junction to channel the pedestrians where buses load and unload passengers, who may gather with NMVs and ultimately congest the junction. The lack of access control, together with the wide circulatory carriageway, will lead to various safety problems. Pedestrians will also walk on the shoulder in the absence of footways and cross the junction using the central island.

Drainage: Roadside masonry drains at least in one location appears to be deeper than 10" and may be hazardous to pedestrians. Existing open drains next to the carriageway are also hazardous for pedestrians and NMVs.

2.1.12. CONSTRUCTION MATERIALS INVESTIGATION

2.1.12.1. EMBANKMENT FILL

To achieve the desired pavement formation level in relation to the maximum height flood level, it is generally necessary to constructs embankments between 2 to 4 m high. These embankments are

constructed with either imported material or roadside borrow pit soil. This can result in large areas of valuable agricultural land being lost when a highway is built through a rural area. Although cohesive soil is less erodible, it is difficult, expensive and time consuming to compact it to the required compaction level.

An alternative material, river sand, is a good fill material with higher CBR value: it is quite abundant in the various river beds in the project area. Extraction by manual collection and transportation is labour intensive, and alternatively, hydraulic dredging and pumping of sand to stockpiles on the river bank to meet large scale demand is possible. Sand is easily compactable to a high degree of compaction but requires protection against erosion by cladding with a layer of cohesive soil.

The GoB has adopted a policy to encourage construction of roadway embankments with river sand rather than clayey agricultural soil. Accordingly the embankments for new carriageways on this project have been designed based on the use of river sand with a CBR value estimated as 10% or greater.

Subsequently the pavement thickness has been designed on the basis of sand sub-grade support CBR values of 10%. The river sands in the project localities are of medium quality with fineness modulus (FM) ranging from 0.3 to 1.3. The laboratory test results on sand from different river sources are given in Appendix A6.

2.1.12.2. IMPROVED SUB-GRADE

Improved sub-grade material is normally river sand with a CBR value greater than 10%. It is a low cost, readily available road material. It has useful drainage properties and provides a capillary barrier between the cohesive sub-grade and the pavement layers. In this project, a layer of 300 mm thick improved sub-grade material has been incorporated into the pavement for these purposes. At the detailed design stage, a minimum CBR value and a minimum FM must be selected and specified, and the pavement design adjusted accordingly. The available locations of good quality river sand together with laboratory test results are shown in Appendix A6.

2.1.12.3. SUB-BASE COURSE

Sub-base material is normally broken brick chips mixed with river sand. Generally 20% to 30% sand content is required to match the desired sub-base grading curve. A well graded and compacted brick sub-base gives a CBR value in excess of 40% with a Los Angeles abrasion (LAA) loss less than 45%. It is an adequate sub-base material despite the high water absorption propensity of brick chips, around 16%. Test results for broken brick aggregates are shown in Appendix A6.

Alternatively, gravel from sources in Punchagarh, Jhenaigati and Sylhet mixed with local sand produce a good quality sub-base with a CBR exceeding 50% and LAA value less than 45%. This material performs better than the brick sub-base because of its lower level of water absorption (typically 2%) and higher durability. Laboratory test results for a typical gravel sample from a Bholagonj source is shown in Appendix A6.

2.1.12.4. BASE COURSE

Base course materials are normally broken stone boulders or selected bricks mixed with local sand. Stone aggregates from Jaflong and Bholagonj sources produce the best quality aggregate: base Type I with a CBR value exceeding 100% and LAA value less than 32%. These stone aggregates are equally suitable for use in cement bound and asphalt concrete layer works. 182. Over-burnt manual and machine made brick aggregates can easily be used to produce aggregate base Type II with CBR value greater than 80% and LAA value less than 40%. The quality of stone from Sylhet sources and imported Indian rock from the neighboring state of Meghalaya are shown in Appendix A6.

2.1.12.5. CONCRETE AGGREGATE

Stone aggregates from Sylhet quarries are commonly used for the manufacturing of normal and high strength concrete. There have been no reports of alkali-silica reaction associated with the use of this aggregate. The major concreting operation for Jamuna Bridge was undertaken using stone aggregate from Sylhet sources.

2.1.12.6. CEMENT AND STEEL REINFORCEMENT

Bangladesh produces different classes of EN and ASTM standard cement and high strength deformed bar of 40, 60 and 75 grades. These materials are readily available in the project area.

2.1.12.7. BITUMEN

The 60-70 and 80-100 penetration grade bitumen are commonly used in the road construction industry in Bangladesh. The 60-70 grade is better suited to Bangladesh temperatures, but the production and supply of this grade is limited: currently this has to be imported.

The 80-100 grade bitumen is produced by the State owned organization, Eastern Refinery, however their production capacity is inadequate for the demand. The product satisfies the various ASTM test requirements but does not perform satisfactorily. The bituminous pavements using the product generally crack due to premature hardening. To achieve high quality pavement performance, it will be necessary to specify an advanced type of bitumen, such as modified bitumen using rubber or polymer. At present these types of bitumen are not produced in Bangladesh.

2.1.12.8. RECYCLED PAVEMENT MATERIALS

The preliminary design envisages recycling pavement materials by milling the existing asphalt concrete and re-using the product. This recycled asphalt concrete mixed with unbound base and sub-base materials should be used in the sub-base or lower base of the service road carriageways. The grading, CBR, LAA values etc. of the existing base course materials have been tested to examine their suitability for reuse in reconstruction. The laboratory test data are shown in Appendix A6. The recycled materials can be modified to a specified grading either by adding new materials or screening out unwanted fractions. These recycled materials are valuable assets, particularly in the conditions of material scarcity in Bangladesh which all too frequently dictate that construction materials have to be imported. These materials must be incorporated in the new construction wherever possible, especially for the service road construction.

2.1.12.9. ROCK SOURCES

A sizeable amount of stones used in the country's construction sector comes from stone quarries, mostly from Sylhet. The collection is made by boats, and every day hundreds of thousands of cubic feet of stones are being extracted from the quarries. In Bangladesh, the main source of sand and gravel is from in-stream quarrying and mining, which come from different parts of the Sylhet division. Figure 2-8 shows the various locations of quarries in Sylhet division.

Figure 2-8: Stone Quarry Locations

<u>Bholaganj stone Quarry:</u>

Bholaganj is the biggest stone quarry in the country. Bholaganj stone quarry is located about 2 km from companiganj and 20 km from Sylhet Sadar. It stands on the bank of the river Dhaolai that separates Bangladesh from India. According to sources, around one lakh people, including women are engaged in different jobs around the Bholaganj quarry. Among them more than 50,000 are involved in stone collection by small country boats locally known as "Barki". Motors (shallow engines) are also put in the operation for collecting stones. Available boulders are also hard and fairly big sized. The supply is unlimited.

Piyan or Jaflong Quarry:

Jaflong is one of the prime zones for both in-stream and off-channel extraction of sand, gravel and stones. It is almost 60 km away from the Sylhet City, at the north-east limit of Bangladesh. Approximately 10,000 people arrive at the Dauki and Piyan rivers every day to collect stone, extracting, on average 35 million cubic feet (cft) of stones every year, from Jaflong. Stones that roll downstream with the river current have been collected and sold by locals for a long time. Earlier, stones were collected manually. Armed with shovels and wicker baskets, labourers load the stones onto small boats. However, the recent use of heavy machinery and systematic excavation advanced this process, and an excavator machine, known as the "Boma" is used for the extraction of stones from under 70-80 feet deep rivers. During the monsoon, river currents wash away precious rocks and pebbles from India, into the Jaflong area. Crushed stone act as a raw material for various development activities such as construction of road, bridge, buildings, canals etc.

Bichanakandi Stone Quarry: Bichanakandi stone quarry at Goainghat Upazila, one of the biggest quarries, supplies stones worth thousand cores of takas annually, to different parts of the country.

Sari River Quarry: Lalakhal is located at Jaintiapur Upazila in Sylhet. The Sari river is renowned for its high quality sand and stone for construction. This quarry is important for its well-graded hard pebbles of smaller size.

Shella and Bhowal Quarries: These are comparatively small quarries located in the beds of streams originating from Khasi Hillsand falling into the Surma River. The sites of collection are 12 and 11 miles respectively from Chhatak and Sunamgonj. The materials are collected throughout the whole year. Though the materials are not of best class and require additional cleaning, and grading.

Chittagong District and Chittagong Hill Tracts: Small quantities of sandstone are quarried at Sitakundu in Chadranath Hill range for local use. Considerable quantities of sandstone, shale laterite and limestone are quarried in Rangamati, Cox's Bazar, and St. Matin Island.

Jalpaiguri: Shingles of 1 to 3 inch size occur as river wash in the bed of rivers Chawai and Karatoa. The supply is quite considerable.

Mymensingh District: Shingles are available as river wash in the beds of Mohadeb and other rivers coming from Garo Hills. The quantity collected is not abundant and cannot satisfy local needs.

Imported Rocks: Indian rock from "Pakur" in Bihar province is extensively used in the western part of Bangladesh. This is a basalt type hard rock with a typical specific gravity of 2.8. The rock is quarried by blasting. The rock has a LAA value of less than 20%. The rock is suitable for pavement and concrete works.

2.1.12.10. SAND

Sand is abundantly available all over Bangladesh. A very good variety of river sand is available in the district of Dhaka, Maymensingh and Sylhet (Savar, Kaliakar, Durgapur, Sunamganj). Both sea sand and river sand of good quality are found in coastal districts like Khulna, Noakhali, and Chittagong. A good

variety of coarse sand is abundantly found in Cox's Bazar. Sand is also available in northern district of Bangladesh but it is not of adequate quality.

2.1.13. QUANTITY/COST ESTIMATES (BOQ)

Cost estimates have been prepared on the basis of current prices of locally available materials, plant and equipment, and labour. Market prices of imported materials were also taken into account where required, as well as RHD schedule rate analysis guidelines.

2.1.13.1. UNIT RATES

The unit rates calculation of work items analysis has been prepared using the Software "Standard Data Book for Roads and Bridges" developed by India Road Congress (IRC) and the RHD analysis guidelines with relevant allowance to cover the contractors profit, overhead, income tax and VAT.

As per the project's TOR, the Consultant is required to prepare the cost estimates based on detailed engineering drawing in the second phase of this project. However, as the first step for the preparation of the cost estimate, unit rates of various items of works related to road and bridge structures were analyzed and established. These rates are based on the current prices of locally available materials, and, where required, plant and equipment obtained from international, national or local sources as applicable, as well as labour inputs of a particular item. Other relevant indirect costs, such as income tax (5%) and VAT (5.5%) with due allowance for contractor's profit at 10% and overhead at 5% have been included in the unit rates.

The cost estimates for the widening and improvement of the carriageways, the construction of new pavement, construction of all associated structures and ancillary works have been prepared on the basis of approximate quantities abstracted from the preliminary design.

Road construction involves earthworks for embankments, pavement construction, related structures such as bridges, culverts, flyovers, rail overpasses and various ancillary works. Preliminary activities include land acquisition and relocation of utility services.

The following major elements have been considered in the preliminary cost estimate:

- Preliminary items and general site facilities
- Earthworks for the embankments
- Structural works
- Pavement works
- Ancillary road works
- Provision of quantity estimate contingency cost

2.1.13.2. PRELIMINARY ITEMS AND GENERAL SITE FACILITIES

The costs allowed under this heading relate to the site supervisory establishment for both the contractor's site management and the consultant's site supervisory staff. Offices (furnished, lighted, air conditioned, guarded and service/maintenance), quality control facilities, workshops, yards, storage, water and sanitation plus allowance for insurances, compliance with EMP etc. need to be covered. It is assumed that the government-owned land can be made available for these facilities, as has been normal practice. Advance payments are normally made to defray establishment costs.

2.1.13.3. EARTHWORKS FOR THE EMBANKMENTS

The volume of earthwork required for the project roads has been calculated based on the preliminary standard cross-section drawings within the ROW. The unit price for earthwork in the embankment has been calculated on the basis of supplying filling materials from the contractor's own sources with allowance for haulage, spreading, watering, compaction and leveling.

2.1.13.4. STRUCTURAL WORKS

Standard drawings have been prepared for the common types of bridge for various spans, with deck width varying according to requirements as a 10.225 m width where there is a need to carry two traffic lanes. The estimation of the construction cost of the structures has been based on quantities calculated from the standard drawings.

Different types of RC box culverts for the extension of existing culverts up to 33 m and costs estimated to drive the unit cost per square meter of deck area. These unit costs have been used for estimation.

Similarly standard drawings for new flyovers and rail overpass structures have been developed, with a deck width of 17.65 m. These drawings have been used to derive unit costs per linear meter length and hence to establish overall costs for each structure.

The following elements were considered in the cost analysis:

- Reinforced Cement Concrete
- Steel Reinforcement
- Pre-stressing stands
- Foundations
- Miscellaneous items

2.1.13.5. PAVEMENT WORKS

Standard typical profiles for the pavement have been developed for the various road sections with 4 lane toll traffic plus 2-lane service roads. The pavement works comprise construction of improved sub-grade, sub-base, aggregate base course, bituminous base course and wearing course. Quantities have been calculated based on these profiles and cost estimates have been made accordingly.

2.1.13.6. ANCILLARY ROAD WORKS

In addition to the paved roads there are several other ancillary items of work which are required to facilitate easy traffic movement on the road and to ensure road safety for the vehicles and pedestrians. A provisional lump sum cost is considered for the following elements.

- Road markings
- Drainage with footpath
- Traffic signs and signals
- Guard posts and safety fence

Relocation of Utilities: The relocation of utility services such as high pressure gas transmission pipelines, electricity transmission towers and posts, fiber optic cables, telephone lines etc. are considered to be the responsibility of the owning authority. However, for the purposes of this report, an estimated lump sum cost item is included in the final cost table.

2.1.13.7. LAND ACQUISITION

The preliminary design has aimed at minimizing the acquisition of land. However, at certain locations, additional land beyond the existing ROW is required for some alignment improvements and toll plaza areas, as well as for road curvature improvements. In total, 10 hectares (4.92 for realignment and 5.08 for Purbachal Interchange) of land are needed to accommodate the interchange including the future interchange at N105/N1, as well as horizontal curvatures for the mainline and the 4.8 m service road on both sides of the main carriageway. The average base cost for the land (as of July 2014) ranges from 55-100 crore/hectares. Table 2-7 shows the approximated land cost within the vicinity of the proposed corridor.

Approximated Land Cost Along the N-105 (Tk)			
Union	Cost/Decimal	Cost/Hectare	Cost/Acre
Basan	232,255	57,403,606	23,225,500
Gachha	393,525	97,262,726	39,352,500
Pubile	219,158	54,166,692	21,915,833
Average Base Costs	281,646	69,611,008	28,164,611
Standard Deviation	79,291	19,597,322	7,929,079
Sub-Total	360,937	89,208,330	36,093,690
Transaction Costs (10%)	36,094	8,920,833	3,609,369
Contingency (10%)	36,094	8,920,833	3,609,369
Total	433,124	107,049,996	43,312,429

Table 2-7: Average Land Cost Along N105[9]

Note: The Contingency accounts for any costs associated with displaced persons resulting from additional land purchases (not currently in the ROW).

[9] Information is provided by the Gazipur Sub-register Office, Gazipur.

No detail land acquisition plan is prepared for Phase I. However, the consultant plans to submit a land acquisition plan (LAP) during Phase 2, with the inception report, subject to the condition that the project moves into to Phase 2.

2.1.13.8. COST ESTIMATION

The purpose of project cost estimation is to evaluate the probable cost from a technical point of view for the commercial feasibility study of the project. Quantities are estimated from preliminary standard designs, field surveys and RHD schedule 2011. Cost estimates use 2014 prices of locally available materials and labor, and plant and equipment purchase prices from the international market or domestic market, as applicable.

Road construction involves embankments, pavements and related structures such as bridges, culverts, interchange, safety, flyovers and overpasses. It also includes other related ancillary works, as well as environmental mitigation cost, social monitoring cost and traffic management cost, which are ongoing across all phases of construction. Unit prices of all work items are based on the current cost of all materials, equipment and labor inputs making up the particular item. A basis of rate analysis was also developed and included in the Appendix C.

The following major engineering cost categories are utilized.

- Preliminary items and general site facilities
- Earthworks for road embankments
- Pavement works
- Structural works
- Road safety work works
- Ancillary works
- Utility relocation
- Environmental management and social monitoring
- Contingencies for quantity estimate error
- Fee for independent engineering cost during the construction; and
- Design fees
- Traffic management during the construction phase

The preliminary engineering cost estimate for major work items are shown in Table 2-8, below.

Sl #	Major Work Items	Amount (Tk)
1	General & Preliminary	320,000,000
2	Embankment Earthworks	1,021,422,360
3	Road Pavement	5,934,086,910
4	Structures, RCC Median &RCC Retaining wall	7,191,864,074
5	Road Safety works	500,000,000
6	Ancillary Works and Road marking	1,405,986,000
7	Utility Relocation Cost	75,000,000
8	EMP & Social Monitoring	15,000,000
9	Provision of Quantity Estimate Contingency Cost (5%)	823,167,967
10	Design Fees (Foreign and Local)	493,900,780
11	Traffic Management During Construction Phase	82,316,797
Total Civil Construction Cost in BDT		**17,862,744,889**
Total Civil Construction Cost in USD		**229,009,550**
Cost in USD per Kilometer		**5,049,825**

Table 2-8: Preliminary Engineering Cost Estimates

Note: Costs are considered on the basis of 2014 prices and include VAT, Taxes and Contractor profit but exclude customs duties. The basis of rate analysis is included in Appendix C.

A number of project management, supervision and development costs must also be included in the total cost to be financed, as shown in Table 2-9. The costs that are to be borne by the government through RHD are shown in Table 2-10. A detailed breakdown of the cost estimate is provided in Appendix C.

Sl #	Major Items	Amount (Tk)
1-11 (see Table 2-8)	Engineering Costs	17,862,744,889
12	Commercial and Pricing Contingency	1,234,751,951
13	Development Contingency	1,317,068,748
14	Design Engineering and Construction Supervision	658,534,374
15	Project Management	329,267,187
Total Construction Cost in BDT		**21,402,367,148**
Total Construction Cost in USD		**274,389,322**
Cost in USD per Kilometer		**6,050,481**

Table 2-9: Total Cost to be Financed

Sl #	Major Items	Amount (Tk)
1	Land Acquisition Costs	1,070,499,958
2	Estimated Compensation to PDPs	403,170,000
3	Cost of Independent Engineer During Construction (Foreign & Local)	390,000,000.00
Total Construction Cost in BDT		**1,863,669,958**
Total Construction Cost in USD		**23,893,205**
Cost in USD per Kilometer		**526,862**

Table 2-10: Total to be Funded by RHD

2.1.14. ENGINEERING ANALYSIS SUMMARY

Preliminary engineering designs have been prepared and are presented in the drawings in Appendix A7. These designs cover the road alignment and cross-sections (detailed in accordance with the guidelines referred to above), the pavement (designed as described to deal with the projected axle loading over the project life), the bridges and culverts, as well as various ancillary works. It is estimated that the upgrading to four lane standards with two wider service lanes will cost approximately US$ 6.58 million per kilometer of road in total. The total to be financed will amount to US$ 6.05 million per kilometer. These costs are high mainly due to the unusual number of flyover, underpasses, one full interchange, and bridges as well as the high standard requirements of road safety elements for a typical toll road facility.

2.2. ECONOMIC ANALYSIS (TASK GROUP 3)

2.2.1. TRAFFIC ANALYSIS

2.2.1.1. INTRODUCTION

The major traffic to be considered for the Dhaka By-Pass Road is the Joydebpur-Debogram-Bhulta-Modonpur Road which connects to five major National Highways - Joydebpur-Tangail (N4), Dhaka-Joydebpur-Mymenshing (N3), Dhaka-Bhulta-Sylhet (N2), Dhaka-Chittagong Highway (N1) and N301.

Transparent and defensible accurate traffic demand forecast for public and private funded highway infrastructure is very critical input for project viability and financial analysis. At the feasibility stage, inaccuracies (overestimation) in traffic forecasts can lead to increase attention from toll road investors, operators, media, financial institutions and governments. Inaccurate traffic forecasts can also threaten the financial viability of PPP highway infrastructure, distort public decisions with respect to risk sharing and resource allocation, and can cause costly negotiations with the potential investor. Given the lack of good quality historical traffic and detailed land use (future and current) planning information, and national traffic O-D data for the proposed Dhaka By-Pass, the following sources and methodology are utilized to develop the traffic forecast:

- Existing traffic counts by consultants
- Historical traffic data from RHD counts from 2004 to 2011 for all highways maintained by RHD
- Background traffic based on the proposed land use planning along and within the vicinity of the corridors
- Impact of Padma Bridge
- Sub-regional and international traffic from SAARC and SASEC countries of India's mainland to the Northeastern states as well as Nepal and Bhutan
- Diverted traffic on the corridor under pre and post toll road scenarios
- Travel demand modeling based on the 2020 traffic O-D developed by the TSCW of Bangladesh Planning Commission in 2012 and adjusted by the consultant O-D counts at major intersections along the corridor.
- Export and import growth
- Projected GDP growth by the Government of Bangladesh

2.2.1.2. TRAFFIC DATA REVIEW AND ORIGIN-DESTINATION SURVEY ZONING

2.2.1.2.1. HISTORICAL TRAFFIC DATA REVIEW

Figure 2-9 and Figure 2-10 show RHD's historical traffic data for 2004 to 2011. Bi-annual RHD traffic data is available since 2004, with latest count from 2011 available at only one highway segment, located

between Debogram to Ulukhula. Based on the historical traffic count by RHD, the following observations can me made:

- The highway experienced highest traffic volume at the time of opening for operation in the late 2007 and exceeded 18,000 AADT for year 2008;
- In 2011, RHD reported more than 10,000 motorized annual traffic, which represents a 25% traffic growth from 2009 but 80% decrease from 2008 (opening day) count;
- More than 70% of AADTs is commercial traffic, consisting of mostly medium to large trucks and containers;
- No traffic O-Ds or long-term traffic count data is available; and
- No historical or existing turning movement counts are available for major intersections along the N105 road.

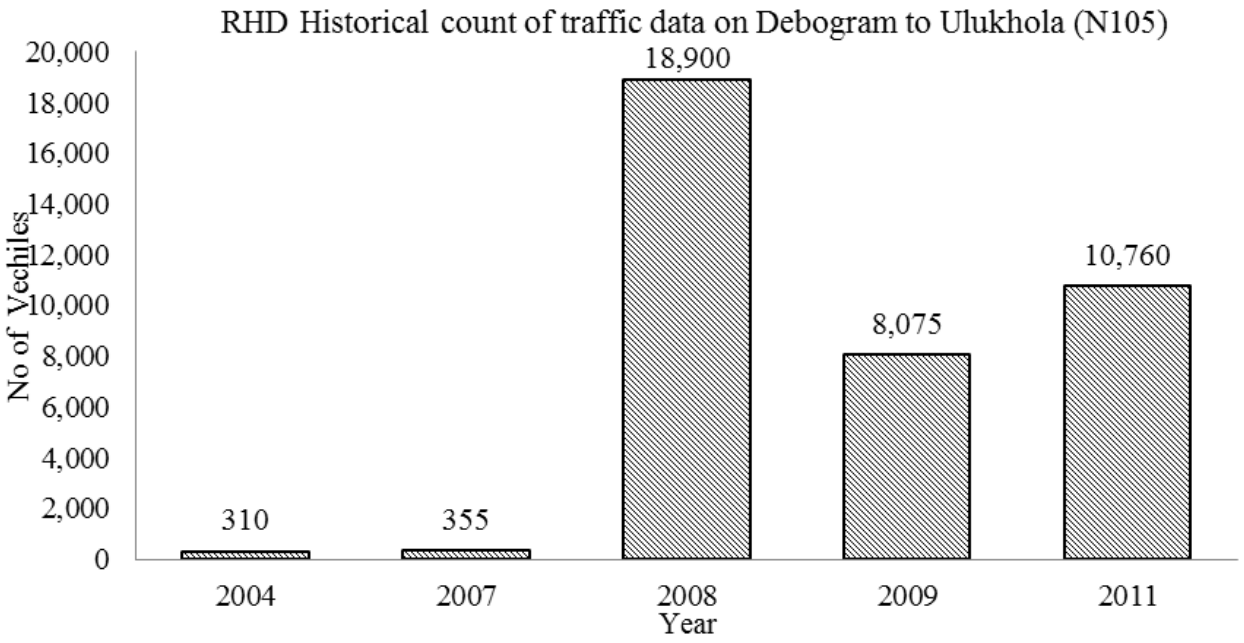


Figure 2-9: RHD Historical Traffic (N105)

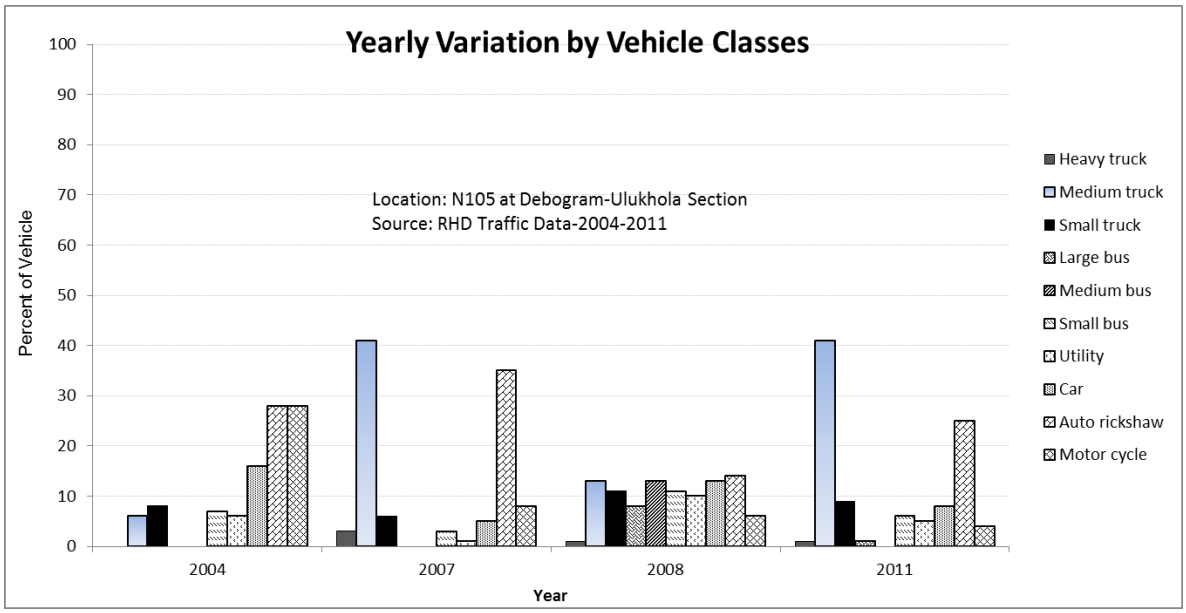


Figure 2-10: Historical Vehicle Class Distribution (N105)

The principal sources of traffic data are (i) annual RHD traffic counts from 2004 to 2011 at only one highway segment located between Debogram to Ulukhola section of the Dhaka By-Pass (ii) Kanchan Bridge Toll Plaza 365 days traffic data for the year 2013 and (iii) Consultant count for different locations in 2014. The project's manual traffic counts took place between January and February in 2014. The Consultant counts included 8-hrs bidirectional short-term classification traffic counts at all major intersections, 24-hrs bi-directional classification count at Kanchan Bridge using the RHD proposed toll vehicle classes. In addition, 2-hrs (AM/PM) intersection turning movement, O-D Survey at N2/N105 intersection and willingness to pay survey were also conducted throughout the project area.

The Consultant's 24-hrs and 8-hrs counts at intersections are then converted to equivalent ADT. Data collected from 24-hrs bi-directional survey was considered as the expansion parameter for converting 8-hrs and 2-hrs data to equivalent 24-hrs volume. The estimation process did not take into account the seasonal variation that also influences the ADT estimate. Only hourly factor is used to estimate the ADT from 2 to 8 hrs count for a given day of the week. An Hourly Expansion Factor (HEF) was estimated by using 24-hrs traffic data. The ADT estimates based on the Consultant's count is found in Table 2-11, below.

$$HEF = \frac{total\ volume\ for\ 24\ hrs\ period}{volume\ for\ perticular\ hour}$$

Location at N105	ADT (vehicle/day)
Modonpur to Araihazar	6,175
Araihazar to N2	13,855
N2 to Purbachal/Kanchan Bridge	9,690
Purbachal/Kanchan Bridge to N3	15,300

Table 2-11: Consultant's Count ADT estimate

The time of day traffic variation on the Dhaka By-Pass is illustrated in Figure 2-11. The figure shows no distinct traffic peak over a 24 hour period. The traffic is uniformly distributed from 9 am to 8 pm over a 12 hours period resulting in a design hourly traffic within 5-6% of AADT.

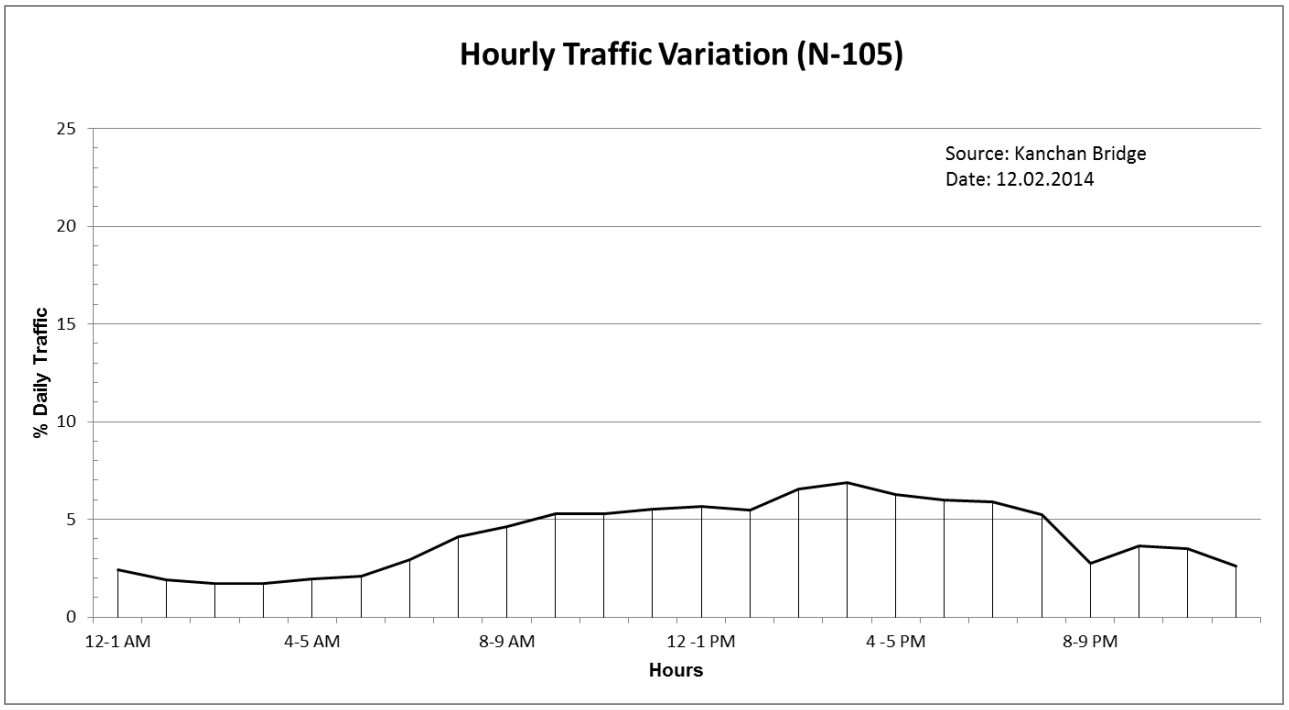


Figure 2-11: Time of Day Traffic Variation

The following two tables illustrate the breakdown of traffic by main vehicle class and the percent distribution by toll vehicle class.

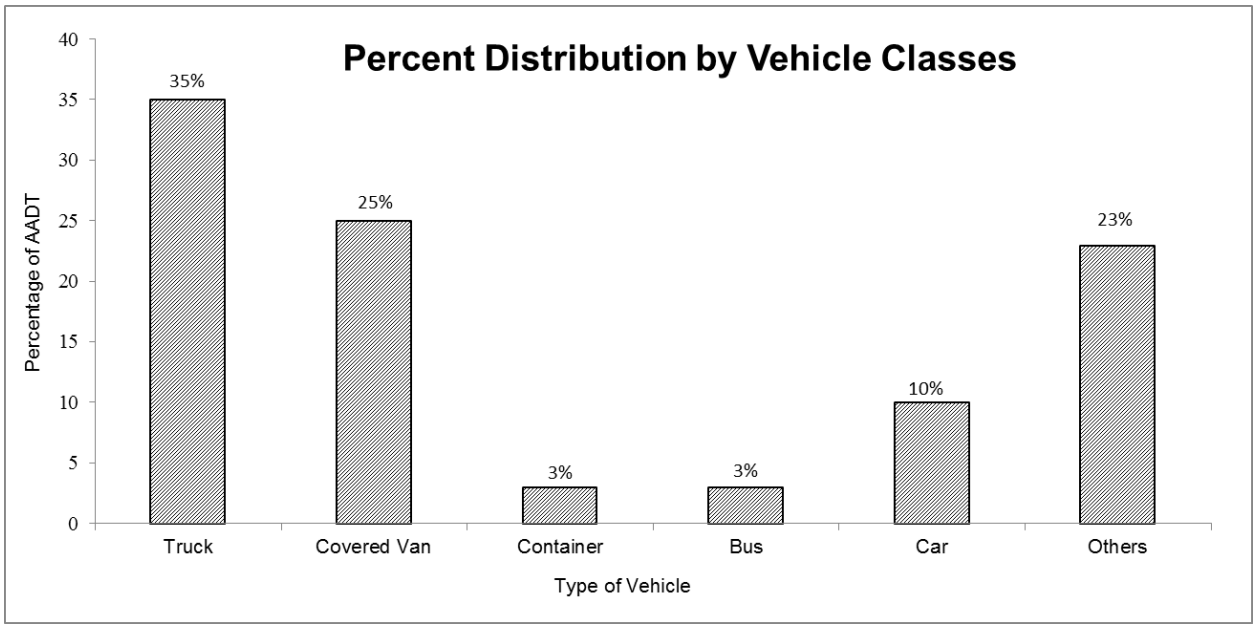


Figure 2-12: Vehicle Class

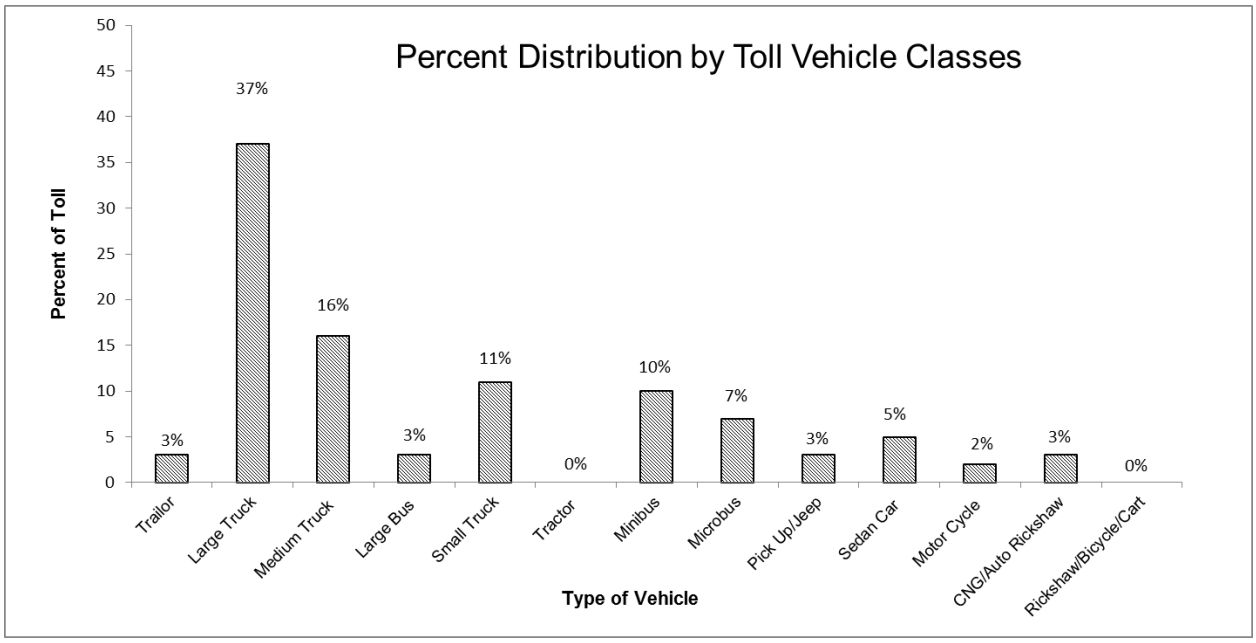


Figure 2-13: Toll Vehicle Class

2.2.1.2.2. TRAFFIC ORIGIN-DESTINATION (O-D) MATRIX ESTIMATION

The traffic O-D matrix obtained from the TSC Wing of Bangladesh Planning Commission for the study was updated using network link-specific traffic volumes from the RHD traffic count, a procedure outlined in the TransCAD (proposed Transport Demand modelling software) Travel Demand Modelling. This attempt to develop a seed O-D matrix will primarily serve as the guideline for the development of a national O-D matrix and then calibrate with relevant demand information as well as consultant O-D survey and spot

traffic count. A 431 by 431 national O-D matrix is calibrated and used for the subsequent analysis of baseline traffic estimate (2020) as well as pre- and post-build scenario analysis of the proposed Dhaka By-Pass Highway upgrade.

2.2.1.3. TRAFFIC ASSESSMENT AND FORECAST

Given the promising outlooks for trades and future GDP growth coupled with macroeconomic stability, political maturity, openness of trade and investment policies, and the quality of education, Bangladesh has a high potential of becoming, along with the BRICS countries (Brazil, Russia, India, China and South Africa), the world's largest economies in the 21st century. The following figure shows the growth trends (base year 2010) in areas that directly demand for efficient transport infrastructure and services; they are continuing and expected to be same in the foreseeable future. Some key observations from RHD 2004-2011 traffic data and other growth trend, as shown in Figure 2-14:

- Both freight and passenger traffic is forecasted to double from the base year, 2010.
- Roads continue to dominate the modal share, creating fierce competition among existing road networks
- Urban sprawl, as at the Purbachal developments, will continue fueling traffic growth
- Double growth for bulk and triple growth for container cargo at Chittagong ports creating additional demand for the Dhaka-Chittagong corridor.
- The modal share is continuing to decline from water and rail transport sectors if travel reliability for these sectors is not improved.

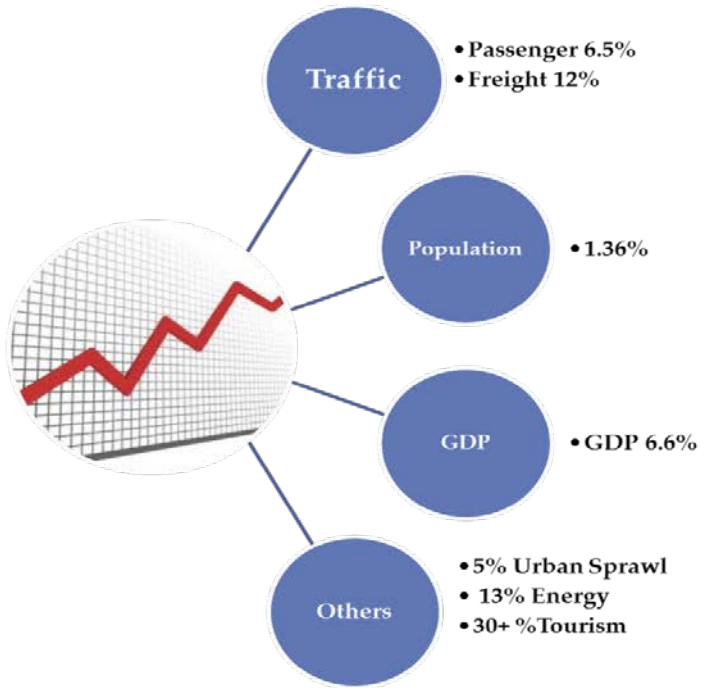


Figure 2-14: Growth in Every Sector Demanding Transport

According to the TOR, mostly inter-district direct traffic will be allowed both for passenger and freight traffic including sea port-bound inter-district freight traffic from north western (Rajshahi-Rangpur) and southwestern regions (Khulna-Jessore-Benapole) to Chittagong travelling across the Bangabandhu Jamuna Bridge, freight traffic from export processing zones (Dhaka, Savar, Gazipur, Bhuluka, Kashimpur, Konabari, Chandra, Tongi, etc) to Chittagong Port. Moreover, the link will serve sub-regional and international traffic from SAARC and SASEC countries of mainland India and to Northeastern States as well as Nepal and Bhutan. The volume of such traffic could be sufficient to accommodate the new facilities. In such a situation, local traffic may be neglected or fighting for a share of the facilities. Traffic forecasts in the corridor will therefore be complex and should consider the private and public sector industrial and export development plans as well as transit traffic demands.

The methods used to produce traffic forecasts for toll road facilities are very complex and data intensive. In addition, they require a wide range of assumptions about future changes in socio-economic, land use variables, willingness to pay for the services and the route alternatives or mandatory requirements to use the services (day-time truck restriction on urban highways). The issue is further complicated by the possible presence of optimism bias and/or strategic misrepresentation in traffic forecasting. Consequently, the potential sources of forecast inaccuracy are many and errors can be compounding.

Forecasting errors can never be eliminated, but they can and should be reduced to a more acceptable level and made more symmetrical. Therefore, cautions are exercised to minimize the traffic forecasting error for the Dhaka By-Pass by disaggregating the various components of traffic forecasting steps first and then aggregating them to estimate the final forecast traffic. A combination of the traffic growth factor, traffic impact due to forecast land use within the vicinity of the Dhaka By-Pass Road, time of day choice or peak spreading and travel demand modeling approaches were undertaken for the study. The disaggregated level of traffic forecasting technique that was used in the study is described below.

2.2.1.3.1. SELECTING THE FORECASTING YEARS AND APPROPRIATE TRAFFIC GROWTH FACTOR

The traffic forecast for the Dhaka By-Pass is based on a 30-year contract period. Since forecasting traffic for such a long design period can lead to enormous error, a five year interval is used. The forecasting years are thus 2020 (opening year), 2025, 2030, 2035, 2040, 2045 and 2050.

In addition to the observations made in the previous section, historical traffic data trends (from year 2004 to year 2011) for all national highways and regional highway intersecting the By-Pass are compared. Figure 2-15 and Figure 2-16 illustrate the historical traffic data for the national and regional highways within the vicinity of N105. The figure shows higher growth in regional highways compared to national highways. Both N1 and N3 show an overall decrease in traffic between 2004 and 2011. However, both N2 and N105 show some consistent traffic growth over the last seven years. Due to considerable anomalies of traffic data counts from year to year, a system-wide traffic growth comprising the average traffic values of all national highways are considered and growth trend line analysis is performed. This analysis result shows a 6.5% growth factor which is comparable with the GDP growth.

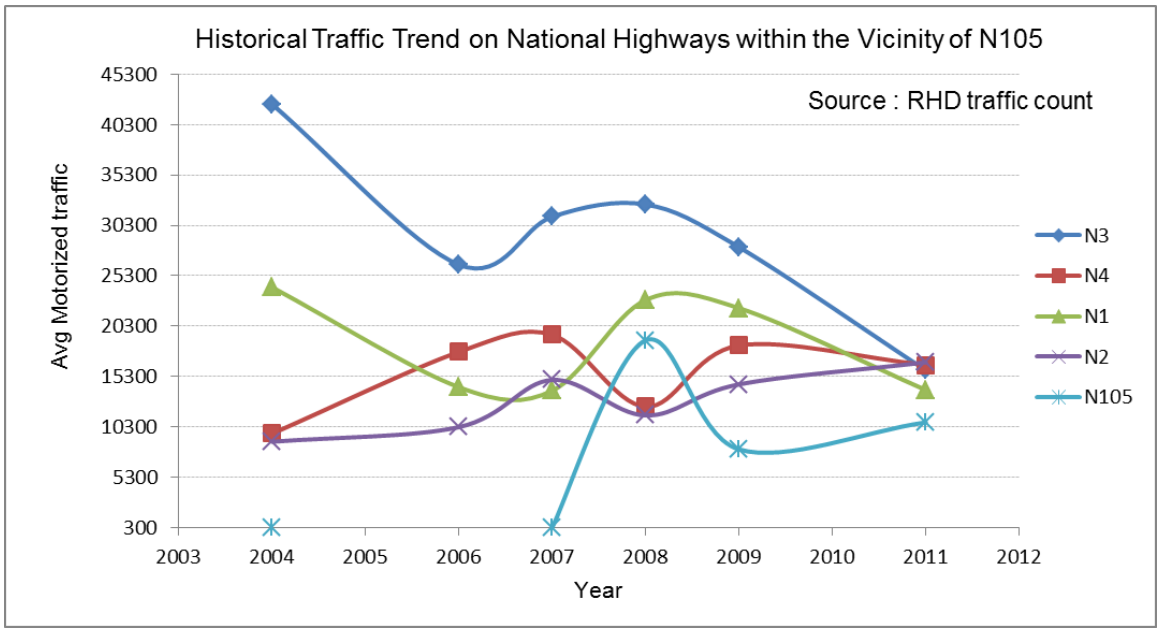


Figure 2-15: Historical Traffic Trends on National Highways

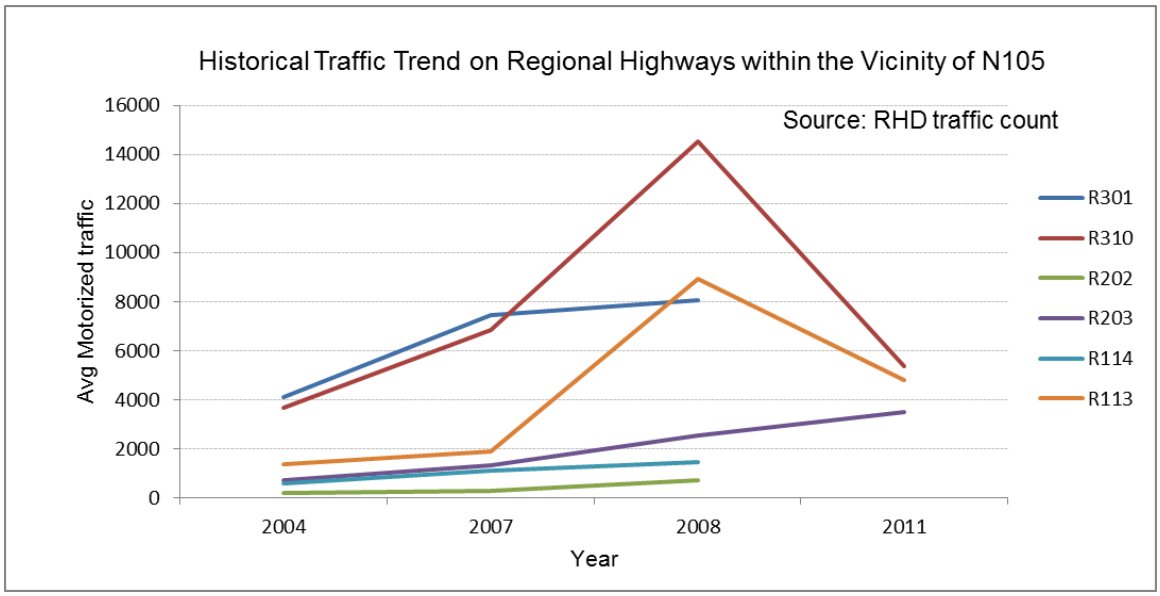


Figure 2-16: Historical Traffic Trends on Regional Highways

2.2.1.3.2. TRAVEL DEMAND MODELING BASED TRAFFIC FORECASTING

Since accurate traffic demand for the project is the most critical item (compared to the preliminary cost estimate) for the overall long-term viability of the PPP road project, the TA consultant developed a single-mode regional travel demand model with a 431 by 431 O-D trips and calibrated using the 24 hour O-D counts at period. This model is used to estimate the traffic diversion and to estimate the 2020 traffic forecast due to system-wide traffic growth. The following figure illustrates the travel demand based model

flows in and within the vicinity of the Dhaka By-Pass Road for the pre- and post-upgrade scenario of the DBR.

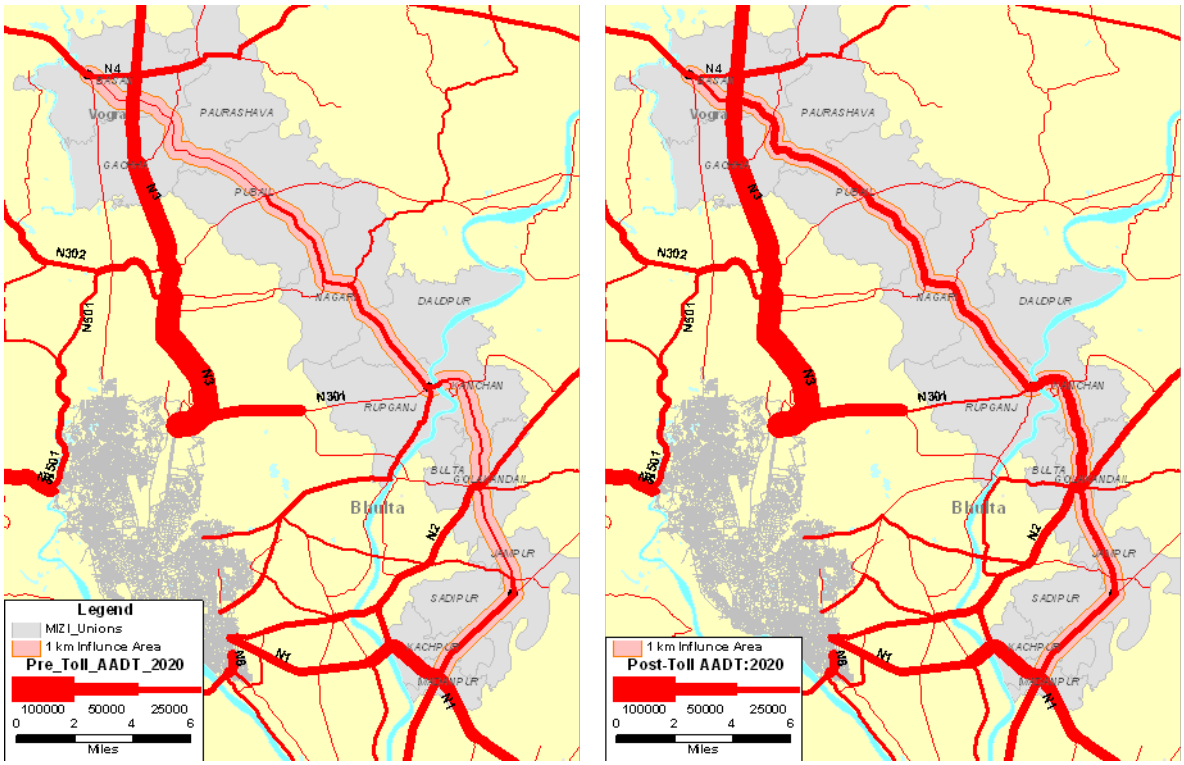


Figure 2-17: Pre- and Post-Toll AADT Flow, 2020

2.2.1.3.3. BACKGROUND TRAFFIC

This is the opening year 2020 forecast traffic based on traffic count conducted in 2014 on the Dhaka By-Pass and the estimated traffic growth rate established earlier. From 2014 to 2025 a higher growth rate of 6.5% per year growth rate is considered. Then a declining rate of 1.25% is assumed from base 2025 to 2045. In addition to the growth factor, a travel demand-based forecasting model is also applied to estimate the 2020 base traffic. The estimated background AADT for various segments of the DBR is listed Table 2-12:

Location	Background AADT							
			Growth Factor Based Future Traffic					
	Count	Model Based	6.50%	5.25%	4%	2.75%	1.50%	1.50%
	2014	2020	2025	2030	2035	2040	2045	2050
Modonpur to Araihazar	6175	25,630	35,115	45,353	55,179	63,195	68,079	73,340
Araihazar to N2	13,855	23,250	31,885	41,142	50,056	57,328	61,759	66,532
N2 to Purbachal	9,690	37,600	51,515	66,534	80,949	92,709	99,874	10,7593
Purbachal interchange to N3	15,300	32,000	43,843	56,625	68,893	78,901	84,999	91,568

Table 2-12: Background Traffic (AADT)

2.2.1.3.4. GENERATED TRAFFIC

Upgrading the Dhaka By-Pass Road will increase vehicle operating speeds and reduce the time cost of travel. Along the entire length of the corridor most of the lands adjacent to the ROW are being acquired or are under acquisition or are being forecast to be acquired for residential, commercial or industrial development, and expected to be built-out within 10 to 15 year horizon. Consequently, a significant increase in population and traffic demand can be expected from this diverse land-use pattern. The following major residential developments are observed along the project area with direct access to N105:

- Probashi Polli;
- Rupayan Developments Ltd;
- Navana Real Estate;
- Rajuk Marine City;
- American Duplex City;
- Rajuk Purbachal residential developments;
- Ashian City;
- Additional 31 land development projects;
- US Bangla;
- Significant building development (shops and market) were also observed along or within the ROW of the N105 corridor; and
- The corridor also provides direct access to several markets, industries and warehouses.

Table 2-13 ilustrates the locations of these future developments that will also contribute traffic for the Dhaka By-Pass Road. For the purpose of generated traffic assignment a build-out scenario is assumed and illustrated in the following table:

Year	Percent land build-out	No. of Dwellings	Generated Traffic: Purbachal Side	No. of Dwellings	Generated Traffic: East Side of Corridors
2020	10%	10,000	5,000	5,000	2,500
2025	25%	25,000	12,500	12,500	6,250
2030	40%	40,000	20,000	20,000	10,000
2035	60%	60,000	30,000	30,000	15,000
2040	75%	75,000	37,500	37,500	18,750
2045	90%	90,000	45,000	45,000	22,500
2050	100%	100,000	50,000	50,000	25,000

Table 2-13: Build-Out Scenario

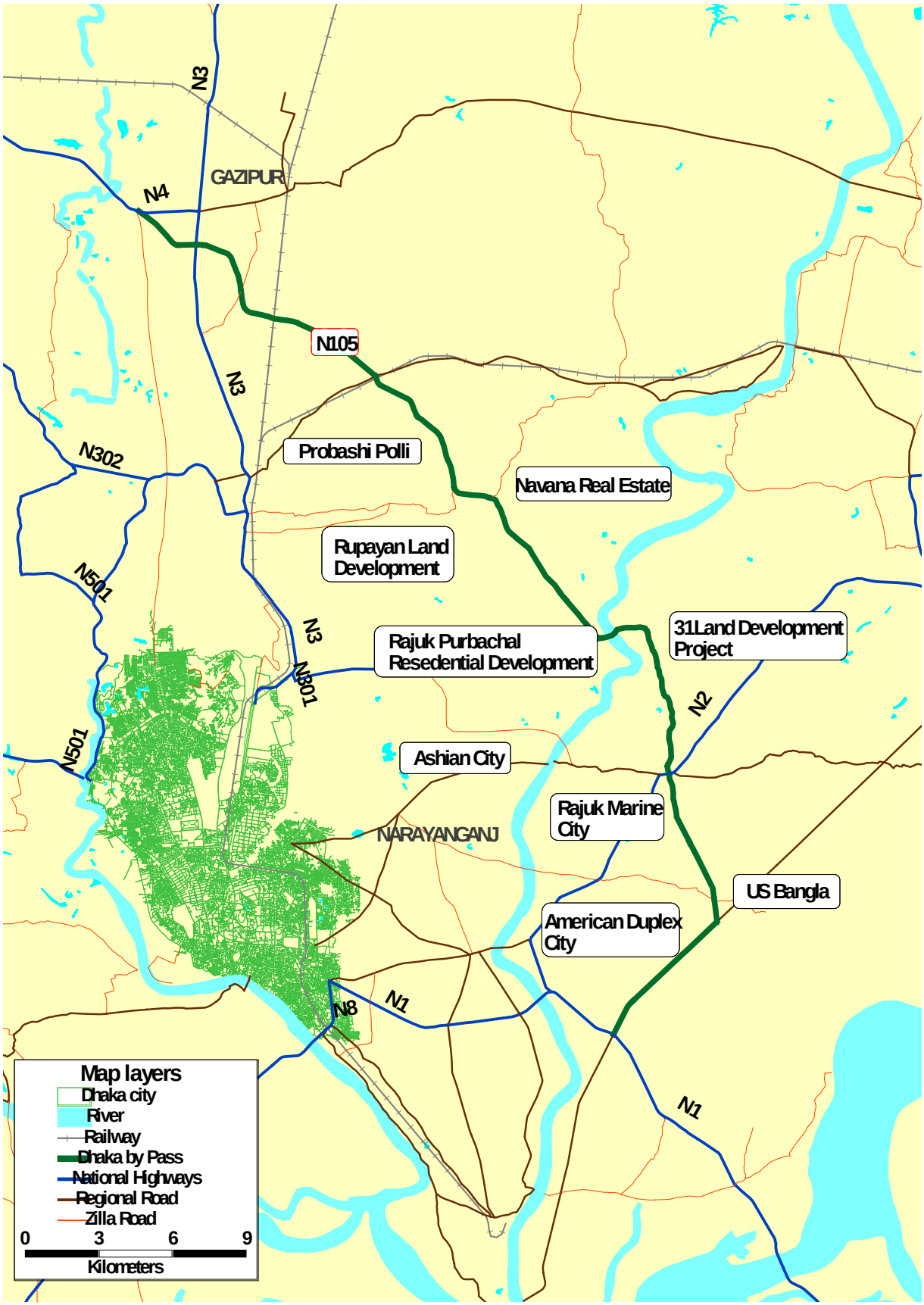


Figure 2-18: Proposed Land Development along the Dhaka By-Pass Road

For generated traffic it is assumed that each dwelling unit will generate 0.5 traffic per day. From OD survey analysis, it can be said that the 75% of the generated traffic will have a destination to/from Dhaka and the remaining traffic to the Joydevpur/Ashulia industrial belt, Mymenshing, Sylhet and Chittagong. Table 2-14 and Table 2-15 show the estimated generated traffic due to these developments.

Location	Generated Traffic Purbachal Area							
	% Generation	Forecast Year						
		2020	2025	2030	2035	2040	2045	2050
Modonpur to Araihazar	12.5	625	1,563	2,500	3,750	4,688	5,625	6,250
Araihazar to N2	15	750	1,875	3,000	4,500	5,625	6,750	7,500
N2 t Purbachal	21.25	1,063	2,656	4,250	6,375	7,969	9,563	10,625
Purbachal interchange to N3	17.5	875	2,188	3,500	5,250	6,563	7,875	8,750

Table 2-14: Generated Traffic Purbachal Area

Location	Generated Traffic Purbachal Area (other 31 land developments)							
	% Generation	Forecast Year						
		2020	2025	2030	2035	2040	2045	2050
Modonpur to Araihazar	28	700	1,750	2,800	4,200	5,250	6,300	7,000
Araihazar to N2	33	825	2,063	3,300	4,950	6,188	7,425	8,250
N2 to Purbachal	48	1,200	3,000	4,800	7,200	9,000	10,800	12,000
Purbachal interchange to N3	40	1,000	2,500	4,000	6,000	7,500	9,000	10,000

Table 2-15: Generated Traffic (31 Developments)

2.2.1.3.5. DIVERTED TRAFFIC

Diverted traffic is traffic that will utilize the proposed toll road from elsewhere. This is not a new traffic but the traffic that will be attracted by the facility due improved travel time. Travel demand modeling is used under pre- and post-opening scenarios to estimate the diverted traffic. The analysis assumes traffic will reach equilibrium stage and no traffic will be diverted to the Dhaka By-Pass after five years from its opening day. Table 2-16 and Table 2-17 list the pre- and post-toll scenario traffic and the estimated diverted traffic to various segments of N105. The highway segment from Araihazar to N2 will primarily experience the highway's diverted traffic.

Location	Diverted Traffic (Based on Travel Demand Analysis		
	% Diversion	2020 Pre Toll	2020 Post Toll
Modonpur to Araihazar	0.05	24,387	25,630
Araihazar to N2	0.29	18,000	23,250
N2 t Purbachal	0.18	32,000	37,600
Purbachal interchange to N3	0.14	28,000	32,000

Table 2-16: Diverted Traffic (Travel Demand Analysis)

Location	Diverted Traffic (Based on Travel Demand Model)						
	Forecast Year						
	2020	2025	2030	2035	2040	2045	2050
Modonpur to Araihazar	459	0	0	0	0	0	0
Araihazar to N2	5,896	0					
N2 to Purbachal	3,610	0	0	0	0	0	0
Purbachal interchanges to N3	4,654	0	0	0	0	0	0

Table 2-17: Diverted Traffic (Travel Demand Model)

2.2.1.3.6. DESIGN TRAFFIC

The design traffic is the estimated traffic that the system can operate with a reasonable speed and travel time. The design traffic for the system is estimated by adding the background traffic, generated traffic and the diverted traffic. Due to the presence of service road, the design traffic for the toll is assumed to be 50% of the total demand for the entire system. It should be noted that at present most of the Dhaka By-Pass traffic is the through-traffic generating from the industrial belt of Gazipur/Ashulia and destined to Chittagong Port. Please refer to the following tables:

Location	Total Traffic (Demand for the Corridor + Service Road)						
	Forecast Year						
	2020	2025	2030	2035	2040	2045	2050
Modonpur to Araihazar	28,261	38,428	50,653	63,129	73,133	80,004	86,590
Araihazar to N2	31,606	35,793	47,442	59,506	69,141	75,934	82,282
N2 to Purbachal	46,443	57,171	75,584	94,524	109,678	120,237	130,218
Purbachal interchanges to N3	38,446	48,531	64,125	80,143	92,964	101,874	110,318

Table 2-18: Total Traffic (Corridor + Service Road)

Location	Total Traffic (Demand for the Corridor)						
	Forecast Year						
	2020	2025	2030	2035	2040	2045	2050
Modonpur to Araihazar	14,131	19,214	25,327	31,565	36,567	40,002	43,295
Araihazar to N2	15,803	17,897	23,721	29,753	34,571	37,967	41,141
N2 to Purbachal	23,222	28,586	37,792	47,262	54,839	60,119	65,109
Purbachal interchanges to N3	19,223	24,266	32,063	40,072	46,482	50,937	55,159

Table 2-19: Total Traffic (Corridor)

Location	Total Hourly Traffic/Peak Direction (Demand for the Corridor)						
	Forecast Year						
	2020	2025	2030	2035	2040	2045	2050
Modonpur to Araihazar	594	807	1,064	1,326	1,536	1,680	1,818
Araihazar to N2	664	752	996	1,250	1,452	1,595	1,728
N2 to Purbachal	975	1,201	1,587	1,985	2,303	2,525	2,735
Purbachal interchanges to N3	807	1,019	1,347	1,683	1,952	2,139	2,317

Table 2-20: Design Hourly Traffic/Peak Direction

2.2.1.3.7. TOLL ROAD PERFORMANCE ANALYSIS

A comprehensive capacity analysis using the HCM 2010 procedure is carried out to understand when the system will break down due to traffic growth. The performance is measured in terms of Level of Service (LOS). The LOS A indicates no traffic travel delay and can travel within the proposed speed limit of 80 km/hr or at free flow speed. Where LOS F indicates traffic delay and overall speed can fall below 40 km/hr. In general, the least desirable LOS is C. Table 2-21 shows that with an AADT value ranges from 35,000-40,000 the system can be operated with a LOS C. This high number of AADT is possible to pass through the system within a 24 hr period due to the extended hourly peak period (5-6% of AADT). Since the capacity is tied to vehicle/hr/lane (flow rate and the density), and the daily peak is less than 6% of the total AADT (compare to typical design volume that often varies 14-11% of AADT), 35,000-40,000 AADT can be assumed for financial analysis and still can maintain the LOS C. This value could be higher if DBR had low percentage of truck traffic. With variable toll rate (time of day) the system will be able to squeeze more traffic for the same 4-lane facility.

Location	Length (KM)	Traffic Performance Statistics (Level of Service)			
		2010	2030	2040	2050
		LOS	LOS	LOS	LOS
Modonpur to Araihazar	6.25	B	C	D	D
Araihazar to N2	6.36	B	C	D	D
N2 to Purbachal	8.22	C	D	E	E
Purbachal interchange to N3	24	B	C	E	E

LOS A indicates no traffic travel delay and can travel within the speed limit of 80km/hr where LOS F indicates travel delay with speed below 45km/hr

Table 2-21: Traffic Performance Statistics

The above traffic data can be found in Appendix D.

2.2.2. WILLINGNESS-TO-PAY ANALYSIS AND SURVEYS

Willingness to pay is defined as “the amount an individual is willing to pay to acquire some good or service”. Willingness to pay for travel depends upon the individual and the route option available to traveler. A willingness to pay survey was conducted by the consultant in the year 2014. The survey was conducted on three major points on the By-Pass Road. The main purpose of this survey was to find out the percentage of the traffic if they are willing to pay the toll appraised by the authority for using the road. The fixed toll varies for different types of vehicles. For the purpose of the survey, the allocated toll for different types of vehicles that was assigned is shown in the following table.

Types of Vehicle	Appraised toll (BDT)
Container	1,000
Truck/Bus/Covverd van	500
Car/Jeep/Microbus	300
Others	50

Table 2-22: Toll for Different Vehicle Types

The survey was conducted on total 297 vehicles traveling along the Dhaka By-Pass Road. Table 2-23 and Figure 2-19 shows the distribution of willingness to pay by vehicle type.

Range of willing to pay	Number of Vehicles
<50 (BDT)	2
>50<100 (BDT)	7
>100<300 (BDT)	20
>300<500 (BDT)	71
>500<1000 (BDT)	179
>1000 (BDT)	18
Total	**297**

Table 2-23: Distribution of Willingness to Pay

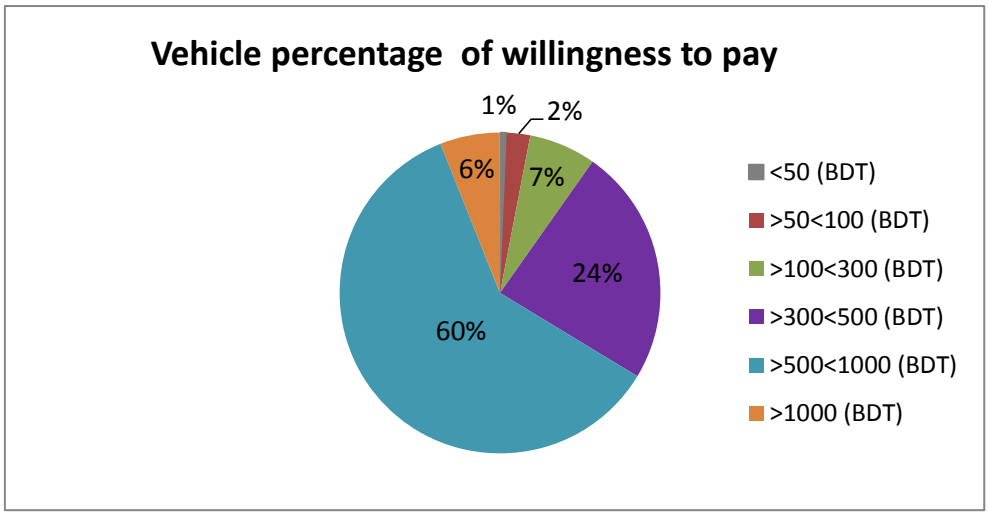


Figure 2-19: Vehicle Percentage of Willingness to Pay

Based on the survey the following observations can be made:

- About 94% of the total traffic uses the By-Pass Road to go their destination.
- Most of the traffic is heavy vehicle traffic.
- About 60% traffic is willing to pay more than 500 BDT but not more than 1000 BDT for use this road on their travel.

From this survey, it can be stated that about 60% vehicles are willing to pay about more than 500 BDT. 24% vehicles are willing to pay more than 300 BDT. Only 1% vehicles are willing to pay less than 50 BDT.

2.2.3.COMMERCIAL COST RECOVERY

Please refer to Section 3 of this report.

2.2.4. ECONOMIC EVALUATION

As part of the feasibility study for the Dhaka By-Pass Road, an economic viability analysis was performed. The report, attached as Appendix E, outlines key considerations for understanding the economic implications of the highway project. It was determined that there is a strong economic case for the execution of the Dhaka By-Pass project, involving the 4-laning of the current N105 (as a toll road) and two service lanes, particularly as a PPP. Based on calculations for Vehicle Operating Cost Savings (VOC), Travel Time Savings and Collision Cost Savings, which would result from improved traffic flow on the toll-way, there is a solid benefit-cost ratio (BCR) and economic rate of return (ERR). The methodology is outlined in Appendix E. The Dhaka By-Pass is an extension of the SASEC Highway; for the sake of consistency, the base figures for calculating the VOC savings and TTS are based on the figures for the SASEC Highway.

Two scenarios were developed; one for a Traditional delivery (Design-Bid-Build) model, and one for an alternative PPP (Design-Build-Finance-Operate-Maintain) delivery model, whereby the government is to provide the difference between the project's total cost and funds put forward by the private sector, which is known as a Viability Gap Fund (VGF). For the economic analysis of this project, the VGF is assumed to be 30%.

The benefit-cost ratios for both scenarios are presented in the table below. For every dollar spent in the PPP scenario, there is 4.52 dollar benefit to the economy, and for the traditional model, spending one dollar will produce a benefit of 3.93 dollars in economic benefit. The net benefit is over US$ 1.3 Billion in each project scenario, with the PPP model slightly higher at US$ 1.4 Billion. The ERR results are equally as encouraging.

Based on the underlying assumptions, the project's economic rate of return has been calculated at 58% through the PPP model, and 47% through the traditional model, both of which could reasonably be considered to be sufficiently high to justify the development of the project. From a sensitivity standpoint, if the expected economic savings attributed to the three factors considered (VOC, travel time and collision cost savings) fall by 25%, the ERR for the PPP model would decrease to 39% and for the traditional model, this figure would drop to 35%, both of which would continue to support proceeding with the project.

It is noteworthy that only three inputs were quantified and computed to determine the ERR and BCR figures; a number of additional benefits, which include generated employment (direct, indirect and induced), increased economic competitiveness, decreases in Greenhouse Gas Emissions (GHGs) and Critical Air Contaminants (CACs), and reducing the societal costs of road-accidents, are likely to further strengthen the case for the project's execution.

BENEFIT-COST RATIO		
Benefit-Cost Ratio (PPP Model)	Benefits	Costs
PV Total Cost (Viability Gap Funding)		-$398,221,516
PV Vehicle Operating Cost Savings	$970,457,084	
PV Travel Time Savings	$825,648,106	
PV Collision Cost Savings	$3,129,695	
Total Benefit	$1,799,234,886	
Net Benefit		$1,401,013,370
EROI		5.52
Benefit-Cost Ratio (BCR)		**4.52**
Benefit-Cost Ratio (Traditional Model)		
PV Life Cycle Costs to RHD		-$457,553,747
PV Vehicle Operating Cost Savings	$970,457,084	
PV Travel Time Savings	$825,648,106	
PV Collision Cost Savings	$3,129,695	
Total Benefit	$1,799,234,886	
Net Benefit		$1,341,681,138
EROI		4.93
Benefit-Cost Ratio (BCR)		**3.93**

Table 2-24: BCR of the PPP and Traditional Model Scenarios

2.3. ENVIRONMENTAL ANALYSIS (TASK GROUP 4)

2.3.1. INTRODUCTION

The upgrading of the Dhaka By-Pass Road may have its associated environmental impacts that require due consideration in project design for its mitigation and management based on detailed environmental assessment. To address the various components such as (i) Field Survey (Baseline Environmental Conditions); (ii) Initial Environmental Assessment (IEE) and Environmental Impact Assessment (EIA); (iii) Project Impact and Environmental Management Plan (EMP), a detailed self-contained report is prepared and included as separate volume. The EIA assessment for the project is based on the following project activities.

2.3.2. PROJECT ACTIVITIES

- Converting the existing 2-lane road to 4-lane road access controlled highway.
- Widening (adding 2-lane) bridges and culverts at their existing location and possible ROW.
- Construction of four major flyovers
- Construction of pedestrian/and animal crossings/under pass at least at least nine locations along the proposed project.
- Construction of parallel service roads along both side of the corridor
- Construction traffic interchanges and Toll Plazas.

Dhaka By-Pass Road upgrading program as observed and/or anticipated during site visits will not involve the following IECs.

- Cultural Heritage site
- Protected Area
- Wet land
- Agriculture Land
- Homestead Land
- Estuarine land
- Buffer Zone
- Biodiversity

Potential impacts of the road upgrading on IECs during implementation stages are nil/minimal on Ecological Resources, Physical and Human Environment as well as on Pollution, because the proposed project passes along the existing road alignment, except at few substandard bend sites.

The impact of the road upgrading on climate, geology, hydro-geology and natural disasters like cyclone and earthquake, flood and sea level rise are nil/ minimal. The environmental resources specific impacts are mentioned below.

2.3.3. IMPACT ON ECOLOGICAL RESOURCES: CONSTRUCTION STAGE

• Encroachment to ecology (sensitive and/or protected)	• Nil /Minimal
• Impact on natural forests/plantations	• Low/Medium
• Impact on Biodiversity and/or vulnerable species	• Nil /Minimal
• Impact on Wet land	• Minimal

2.3.4. IMPACT ON PHYSICAL ENVIRONMENT

• Change of surface water hydrology affecting waterways	• Nil
• Increased sedimentation in channel beds and erosion at construction site.	• Nil / Minimal
• Deterioration and degradation of surface water quality due to run-off, sanitary wastes and other noxious pollutant materials from work sites.	• Minimal

2.3.5. IMPACT ON AIR QUALITY: CONSTRUCTION/OPERATION

• Increased pollution of local air due to rock crushing, dust-blowing, activities involving asphalt, and other noxious chemicals, and movement of land transport.	• Low/Minimal
• Noise pollution due to movement of heavy construction transport, Rock crushing plants, operation of machineries an generator and land transport.	• Low/ Moderate

2.3.6. FILL MATERIAL COLLECTION

Fill materials collection for road embankment construction may be problematic unless the locals offer land voluntarily for digging lake/pond. Dredging of Sitalakkhya bed may be an alternative source for fill material collection but Sitalakkhya bed at present is exhaustively being dredged by both RAJUK and private companies for land filling at Purbachal Residential Area.

The Contractor under no condition shall be permitted to collect fill materials for DBR embankment construction by scrapping topsoil from agriculture land, because this will affect fertility of agriculture land adversely.

2.3.7. ENVIRONMENTAL CLEARANCE CERTIFICATE (ECC)

An ECC from DoE is required to initiate project implementation activities. Prescribed application form (Vide Rule 7.5) and details of other requirements have been stated in BECR (1997). An ECC from DoE can be by-passed during the project's implementation, provided the Social and Environmental Circle of RHD acts like Environmental Circle of LGED. The Environmental Circle of LGED deals with all project-related matters itself with copy to the DoE. The Dhaka By-Pass Road upgrading along the existing road alignment can therefore be done by RHD itself with due information to DoE.

2.3.8. CONCLUSION/RECOMMENDATION

- The environmental impacts related to construction activities will automatically terminate with the completion of project activities.
- The ecology related impacts of the project like felling of roadside trees can be reversed by planting trees as per the Social Forestry Act (2004).
- Design Engineers should design DBR saving the land, wetland homesteads as much possible.

A detail Environment Management Plan (EMP) is developed as part of the detail EIA analysis and included as a separate report as part of the final feasibility report deliverable.

2.4. SOCIO-ECONOMIC ANALYSIS (TASK GROUP 5)

2.4.1. INTRODUCTION

The primary generator of negative socio-economic impact from infrastructure is the acquisition of agricultural and residential lands. These impacts are however limited in the case of the Dhaka By-Pass Road Project initiative, since the up-grading of the Dhaka By-Pass Road will largely be accommodated within the existing right-of-way (ROW) and therefore not require a large scale acquisition of land. While some additional land will likely be required for the construction of interchanges, road geometry, and toll plazas, no impact on agricultural lands have been identified (agricultural and wetlands on both sides of the proposed alignment have already been acquired or purchased by developers including RAJUK). As a result, the project will have minimal socio-economic impact on the adjoining areas. While mosques and graveyards partially or fully located within the ROW may need to be relocated, it is expected that a dislocation of the said structures would be addressed according to established policy in order to avoid negative impacts and, as such their relocation is not expected to negatively impact project implementation

A detailed Socio-economic Assessment report is prepared for the proposed project and included as a separate volume. The following sections summarize the study's key findings.

2.4.2. FIELD SURVEY (BASELINE SOCIO-ECONOMIC CONDITIONS)

Along with other ancillary work, the project was launched with field surveys comprising of engineering, Social Impact Assessment (SIA) and Environmental Impact Assessment (EIA) surveys. A preliminary SIA survey was undertaken within the 1 km influence area along the length of the right-of-way (500m on meter on either side of the ROW). This preliminary survey provided a general overview of the locality, people and their occupation etc. and was followed by an additional SIA survey to provide more accurate overview of essential information such as ethnic group, affected structures, trees, affected household facilities etc. likely to be impacted by the proposed DBR (the engineering survey reveals that parts of the existing 40 m / 130 ft wide ROW is occupied by illegal encroachments. This socio-economic impact assessment provides an overview of the likely socio-economic impact of the DBR on these settlements and is limited to those impacts on the ROW only. In both the SIA surveys about 25% of the whole stretch of 45 km By-Pass Road was taken into consideration for preparation of preliminary feasibility study report of the project. Data and information used in the SIA report have been collected through these field surveys as well as from district wise -15 PD files of population and housing census -2011

Initial Social Examination and Social Impact Assessment

For the purpose of the analysis, one kilometre width along the corridor including the ROW is considered to be the Most Immediate Zone of Influence (MIZI) for this project. Since the ROW was never protected by the Roads and Highways Department (RHD) from encroachment by local businesses, religious institution development and illegal homestead developments, there may be a need to compensate non-land related loss due to displacement from the existing ROW. However, many of these encroachments may also be

addressed through innovative design of the proposed DBR. Notwithstanding, additional lands will in fact, be required in order to accommodate interchanges and road geometry along the alignment.

2.4.3. LAND ACQUISITION REQUIREMENTS

The present TOR described that the 4-lane improvement will be confined within the existing ROW of 120 feet wide. In spite of the assumed sufficiency of the ROW, according to the TOR, land acquisition will be required for following improvements:

2.4.3.1. CURVATURE IMPROVEMENT

There are different sharp curves and bends at several places on the existing N105 road for example at Bostail, Bhulta, Kanchan and the Balu Bridge approach, Dhirasram, etc which need to be improved for maintaining design speed. This may trigger a shift in the alignment beyond the existing alignment and private land may have to be acquired. The detail design of the road based on topographic survey will confirm the land take for curvature improvements.

2.4.3.2. CONSTRUCTION OF 4 FLYOVERS

The TOR suggested the construction of 4 flyovers and overpasses facilitating uninterrupted traffic flows at places such as: (i) Dhaka-Joydebpur, N3 intersection (South of Joydebpur Chowrasta); (ii) Railway overpass at Dirasram near Station; (iii) Mirerbazar intersection with R301 (Tongi-Ghorasal-Panchdona road) and Tongi-Bhairab Railway line; and (iv) the Purbachal Interchange. All the identified places are busy commercial centers with built-up areas, parking places for local transport vehicles, bus stoppages, road side open markets, etc. The construction of flyovers to meet traffic demands for 30-40 years at those places may need adequate designs for alternative options. The construction of flyovers along with other structures, service roads on both sides, separate SMVT lanes, bus stoppages, parking lots, pedestrian footpath, over or underpass, etc. may not be accommodated within the 120 feet ROW. Moreover, a proper radius of the landing ramps and connecting approaches may require much space beyond existing ROW. An example of a recent RHD design study of Madanpur Grade Separated Intersection, 2012 may be highly relevant in this respect – the study estimated land take for 3 design options and showed additional land for Alternative 1 at 52.0 acres, for Alternative 2 at 7.5 acres and Alternative-3 at 54.6 acres. This additional land take requirement was beyond the existing 37 meter of RHD ROW.

2.4.3.3. CONSTRUCTION OF SERVICE ROADS

Although the Dhaka By-Pass was constructed in 2006 through almost non-habitable agricultural area and homestead wood lots, within a few years the road became busy and surrounding areas developed into part of the urbanized agglomeration of the metropolitan city. Housing, business and commercial offices, SME, hat-bazaars, collector markets, transport services, etc., developed along the road. Proposed structures, services roads on both sides NMT lanes, bus stoppages, parking lots, pedestrian footpath etc. may not be accommodated within the 120 ft ROW.

2.4.3.4. PURBACHAL NEW TOWN AND ALLIED DEVELOPMENT

Purbachal New Town is the biggest planned township in the country under RAJUK, which will be traversed and bifurcated by the By-Pass Road along 16 km. The project area covers 6150 acres of land located between the Shitalakhya and Balu Rivers spread over Rupganj Thana of Narayanganj and Kaliganj Thana of Gazipur Districts. The township will be linked by a 10 km long 8-lane expressway with the Dhaka City from Airport/Progati Sarani Road (Kuril Flyover) meeting the By-Pass at the Kanchan Bridge approach area. Purbachal has provision for 26,000 residential plots and 62,000 apartments, accommodating nearly one million people. It is being developed as a self-contained city with all transport infrastructures, roads, urban facilities including administrative offices, commercial centers, industrial park, education, health and sport facilities, green spaces, forest, lakes and canal, etc. As a result of the demonstration effect of the Purbachal Township development, private real estate developers have already purchased all lands on both sides of the road and have completed land development. They will also provide accommodation for another one million people within 20 years. Planning of the service road construction must consider the traffic generated within Purbachal and other private townships.

It is therefore not conclusive that land take will not be necessary. All major roads intersecting with the Dhaka By-Pass are the main arterial highways of the country stemming from the capital. These include the N1 with an AADT of 40,000, the N2 with an AADT of 25,000 AADT, the N3 with an AADT of 45,000, and the R301 with 10,000 AADT. The Dhaka-Purbachal Roads will have an AADT of 30,000 (when paved in 2018).

2.4.3.5. ANOTHER TWO GRADE SEPARATED INTERSECTION

Another 2 important grade-separated intersections will be required to accommodate the projected traffic on the By-Pass Highway Corridor and service road. One is at the Kanchan Bridge approach in the Purbachal Area (largest among the RAJUK projects) where a 300 ft road (8 lanes) joins the By-Pass Road. At present, the road is unpaved but thousands of vehicles have begun to use the road. When paved within next 4-5 years, approximately 25-30 thousand vehicles will use the road joining the Dhaka By-Pass. This huge influx of vehicles/automobiles (both local and inter-district) will create a bottleneck if a grade-separated intersection is not provided. The second grade-separation need is at the intersection at Madanpur, where the Dhaka By-Pass intersects with the Dhaka-Chittagong N1 Highway. Although the Dhaka By-Pass was built in a fairly dispersedly populated area and agricultural land (in 2006), the area has since been subject to rapid and sprawling urbanization, at Madanpur, Bhulta, Kanchan, Mirerbazar and Joydevpur. With the development of the Purbachal Project, it is assumed that the entire area affected by the proposed road will become an agglomeration of the Dhaka Metropolitan Area.

2.4.3.6. LAND ACQUISITION AND RELATED ISSUES

From the above discussion it may be summed up that some land acquisition will be required, however, the land issue should be confirmed during Phase II of the project.

2.4.4. IMPACTS, MITIGATION, COMPENSATION MEASURES AND COSTS

For development partner-assisted projects involving land acquisition in Bangladesh, a compensation package is offered for losses incurred by affected properties and for rehabilitation. Compensation not only covers almost every aspect of loss, but also returns salvageable materials to Project Displaced Persons (PDPs) after full compensation at the current market price. The components of resettlement costs include: compensation paid to recover the loss of affected properties, structures, cost of relocation of common properties, payments made to compensate the loss of business income (5 months profit) and loss of income of employees (for 3 months), payments made to compensate the loss of rental income, special grants to vulnerable households, compensation for loss of trees, cost of land acquisition for resettlement purposes, and all other potential losses. In addition, the administrative costs for implementing the Resettlement Action Plan (RAP) must be taken into account in the project's total cost estimate. A preliminary cost estimate for implementing this plan is shown in Table 2-25.

Heads of cash compensation	District (in million Taka)		Total
	Gazipur	Narayangonj	
Total number of PDPs:	49	56	105
Total for land: Section	Need to be worked during phase 2 inception period		
Total for structures	19.76	28.68	48.44
Total for trees	0.005	0.050	0.055
Total for business & employees	0.9603	2.2541	3.2114
Total for household facilities	1.438	1.438	2.876
Total for rented-out structures	0.0055	0.0218	0.0273
Total for vulnerable	0.075	0.065	0.140
Total for community properties	25.4125	11.4575	36.87
Total amount of compensation	47.66	43.97	91.63
Incl. additional factor to account for increase in PDPs	190.64	175.88	366.52
Total cost for implementing NGO and other miscellaneous costs (10% of total compensation)	19.06	17.59	36.65
Grand total of all	209.70	193.47	403.17

Table 2-25: Head and District-Wise Estimation of Cash Compensation for Resettlement

Following ADB Guidelines (2009) and the prevalent practices in Bangladesh, the total amount of cash compensation (including other costs) has been estimated at Tk.403.17 million. Approximately 90% of this amount is for structures, trees and business losses etc. and the remaining 10% is for the implementing NGO contingency. The amount of compensation for each type of loss will continue increasing with time. Prior to the preparation of preliminary designs, no acquisition of land was anticipated as it was felt that the existing ROW is adequate to accommodate the upgrade of the Dhaka By-Pass to four lanes. However, after the preparation of the preliminary design, it was found that the acquisition of some private land will be required for construction of several lane interchanges and toll plazas. Therefore the amount of compensation for acquired land is to be added to the present total amount of compensation (Tk 403.17).

2.4.5. RESETTLEMENT ACTION PLAN (RAP)

A framework Resettlement Action Plan (RAP) has been prepared by taking into account the data generated from a limited sample survey and meetings with stakeholders. The land take could not be ascertained due to lack of data from road inventory, topographic surveys and design report. However, the amount of land take will be confirmed after (component-wise) project design is completed. Although the TOR has indicated that the design could be accommodated within the existing available ROW, the RAP is prepared with the understanding that significant land acquisition will be required and the owners will be compensated according to the provision of law.

Following the policy guidelines of the Government of Bangladesh and donor agencies, particularly ADB, for payment of compensation in case of involuntary displacement for infrastructure improvement projects, a RAP has been prepared and presented in the following table. The RAP encompasses some basic and essential elements of compensation, nature of possible affected properties, suggested types of compensation, persons entitled, issues to be decided upon at the time of implementation, and concerned implementing agencies.

Types of Loss	Entitled Persons	Proposed Compensation Package	Implementation Issues	Implementing Agencies
1. Homestead and all other types of land, agricultural land, pond, garden, groves, homestead and commercial land.	1.1 Legal owner according to the deed title verified by DC office (Joint Verification Team, JVT) during the process of CCL payment/determined by court	1.1 Cash Compensation by Law (CCL) as per valuation of DC office (this will also include 20 to 50 percent enhancement above the average deed value of similar land) 1.2 Difference between the Maximum Allowable Replacement Value (MARV) i.e. present market value and CCL when CCL is lower than the replacement value 1.3 10% of the present market value should be paid for registration and other expenses in case purchase of land within one year of receiving CCL 1.4 For homestead and commercial land, 10% percent of the MARV may be given to the concerned EP as land development grant 1.5 Transition allowance for loss of crop land, 10 percent of the CCL	1.1 Finalization of the list of Project affected households who have lost land 1.2 Placement of compensations, fund with the DC & NGO offices 1.3 Land owners and other PAP will be informed of the details of RAP contains and implementation 1.4 Considering the factors those influence the land price the PVAC / MVSC will determine the land category-wise current market price of the acquired land 1.5 Payment of compensation under the Cash Compensation by Law (CCL) 1.6 Payment of land price margin between the current market value and CCL 1.7 Payment of Stamp Duty to those who will purchase land within one year of receiving CCL 1.8 Transition allowance for the loss of crop land 1.9 For value of land if the payment takes more than one year for no fault of AP, the amount of MARV may be raised at the rate of 10 percent per annum 1.10 Assistance / help to the Project affected households in problems, especially on determination of land title and maintaining other official formalities 1.11 Advice on receipt of compensation money by so many persons when the land is in the name of late father or grand-father. The advice must cover the situations of including and excluding relocation for loss of homestead 1.12 Payment of compensation for usufruct ownership	1.1 NGO will finalize the list 1.2 RHD will place the fund with DC office for CCL, and NGO for beyond CCL 1.3 The NGO through, circulation of booklets, pottering and meetings etc 1.4 The committee formed by DC-RHD offices for the purpose 1.5 The concerned section of DC's office 1.6 The implementing NGO with the approval of PD, RHD 1.7 The implementing NGO with the approval of PD, RHD 1.8 The NGO with the approval of PD, RHD 1.9 The NGO of PD, RHD 1.10 The NGO with the help of GRC or other committees 1.11 The implementing NGO must explain the easiest process receiving compensation in both the situations 1.12 To be solved by the DC office and compensation within and beyond CCL will be paid within DC and NGO offices respectively

Types of Loss	Entitled Persons	Proposed Compensation Package	Implementation Issues	Implementing Agencies
2. Structures of all types: house, business, etc on private or public land: authorized or unauthorized.	2.1 Legal owner according to the deed title of land on which the structure are constructed, to be identified by the Joint Verification Team (JVT)	2.1 Cash Compensation by Law (CCL) as per valuation of PAVC which must be represented by the Public Works Department (PWD) 2.2 The Project affected households may be allowed to retain the salvageable materials within the time to be specified by RHD. Failure in its implementation by the Project affected households will lead to acceptance of ownership by RHD 2.3 An amount equivalent to 12.5 percent of the CCL under 2.1 may be given to each PAP as Structure Transfer Grant (STG) 2.4 An amount equivalent to 12.5 percent of the CCL under 2.1 may be given to each PAP as Structure Reconstruction Grant (SRG)	2.1 Final numbering of all the affected structures 2.2 Classification of the structures into the categories of thatched, kucha, semi pucca and pucca 2.3 Category wise measurement of floor space of the structures 2.4 Calculation of amount of compensation money 2.5 Fixation of last of carrying out the salvage materials by the Project affected households 2.6 Determination and payment of STG money 2.7 Determination and payment of SRG money	2.1 To be done by the NGO 2.2 DC office with the assistance PAVC and PWD 2.3 DC office with the assistance of PAVC and PWD 2.4 DC office with the help of PAVC and PWD 2.5 RHD and Project affected households 2.6 RHD and appointed NGO 2.7 RHD and appointed NGO ** For the unauthorized structures on others land, if the Project affected households are not entitled to CCL, the total entitled amount may be given to them by RHD through the NGO
3. Loss of trees and other fruit plants including the trees in RHD land occupied by squatters	3.1 Legal owner as identified by the JVT and recognized by DC office	3.1 Cash Compensation by Law as per valuation of the DC office, if necessary representative of the forest department may be included in the JVT 3.2 The owners may be allowed to sellout the trees within the period specified by RHDs and after the expiry of the period RHD will sell them out 3.3 An amount equal to two percent of the CCL for transplanting plants at the relocated area	3.1 Project affected households wise count of number trees under fruits, wood and unclassified in the categories sampling small medium and large 3.2 Counting of fruit plants like banana, papaya and of the type 3.3 Fixation of amount of compensation in accordance with type and size 3.4 Payment of compensation to the Project affected households 3.5 Last date cutting / selling the affected trees 3.6 Payment of 5 percent of CCL for plantation at the relocated places	3.1 To be done by the NGO 3.2 NGO under the guidance of JVT 3.3 To be done by the JVT with the assistance of personnel from forest and horticultures departments 3.4 DC office, JVT and RHD (If the squatters cannot be protected under CCL, an equal amount may be given to them by RHD through NGO) 3.5 RHD, NGO and Project affected households 3.6 RHD through the NGO
4. Income Loss from business on own or others' land: authorized /unauth.	4.1 Legal owner of the business	4.1 An amount equivalent to 6 months net income as recorded against the owner's name. 4.2 Five percent of the operating capital for shifting the goods and materials. 4.3 Net income per month will be determined by the PVAC	4.1 Preparation of final list of business enterprises 4.2 Estimation of the operating capital of each business enterprise 4.3 As assessed in the RAP to be finalized by the NGO with the help of MVSC/PVAC 4.4 NGO with direct participation of RHD 4.5 RHD through the NGO	4.1 To be done by the NGO 4.2 As assessed in the RAP to be finalized by the NGO with the help of MVSC / PVAC 4.3 As assessed in the RAP to be finalized by the NGO with the help of MVSC / PVAC 4.4 NGO with direct participation of RHD 4.5 RHD through the NGO
5. Income Loss from rented out structure	5.1 Actual/Legal owner of the structure	5.1 An amount equivalent to 6 months' rent.	5.1 Identification of rented out structures. 5.2 Rent of structure per month 5.3 Payment of compensation	5.1 To be done by NGO 5.2 To be done by NGO with the help of GRC 5.3 NGO and RHD

Types of Loss	Entitled Persons	Proposed Compensation Package	Implementation Issues	Implementing Agencies
6. Loss of employment excluding the owner or employer	6.1 Employees of business enterprises including the helpers but not the owner	6. Tk. 18,000/- (Tk. 6000x3) considered the equivalent to three months' pay as wage labour: for labourer enterprise-wise number of employees to be determined.	6.1 Finalization of the list of employees/helpers family member on the basis of RAP to be determined by NGO and RHD 6.2 Opening of bank accounts 6.3 Payment of compensation money through account payee cheque	6.1 The NGO with the help of committees formed for RAP implementation 6.2 The RAP with help of RHD-NGO 6.3 All the cheques should be signed by RHD and NGO officers and disbursed by the NGO
7. Loss of household facilities such as tubewells, toilets, electricity, gas, telephone, etc	7.1 Legal owner of the facilities	7.1 Exact value of purchasing a hand tubewell and cost of sinking and constructing a pucca platform as per estimation of the Department of Public Health through including representative in JVT 7.2 The owner may also be allowed to remove the tubewell within the period specified by RHD failure of it will lead to RHD ownership	7.1 Counting of numbers of tubewell under private ownership 7.2 Estimation of cost of pipes and head, sinking and pucca floor, etc 7.3 Payment of compensation to the Project affected households 7.4 Fixation of last date for uplifting the hand tubewell by the owner Project affected households	7.1 To be done by NGO and JVT 7.2 To be done by MVSC/JVT through the Department of Public health 7.3 DC office or RHD through NGO 7.4 RHD – NGO – Project affected households
8. Vulnerable households including indigenous people those will lose homestead and home on RHD/GoVt land.	8.1 Those who will lose homestead squatters and utholies 8.2 All the other households having cronic vulnerability 8.3 Female headed households will get more than male needed 8.4 None will be entitled more than once.	8.1 Tk. 5000 as one time grant for each indicator in additional to other compensations 8.2 Tk. 10000 as one time grant in addition to other compensations for female headed households	8.1 Use of RAP report for identifying the vulnerable households, and collection of data for the missing affected households if any 8.2 Preparation of final list of entitled persons in categories mentioned in column-2 8.3 Placement of budget to RHD by NGO and release of fund by RHD to NGO 8.4 Opening of bank accounts by the vulnerable for encasing the account payee cheques 8.7 Disbursement of cheques to the vulnerable Project affected households	8.1 The implementing NGO 8.2 NGO in consultation with the Rap report 8.3 NGO and RHD 8.4 Vulnerable Project affected households, bank and NGO 8.7 NGO, RHD, Bank and Project affected households
9. Common/ Community Property	9.1 The users i.e. the community	9.1 Relocation at place desired by the community	9.1 Selection of sight location for relocation 9.2 Determination of area and size : 70 – 100 percent larger than the lost one 9.3 Quality construction must be superior to the former one	9.1 RHD and community 9.2 RHD and community 9.3 The RHD

Table 2-26: Resettlement Action Plan (RAP): Project Affected Properties, Proposed Compensation Package and its Implementation Programme

2.4.6.STAKEHOLDER COMMUNICATION PROCEDURES AND MONITORING PLAN

The Dhaka By-Pass Resettlement Action Plan is limited to payment of cash compensation only to project displaced persons for individual cases and replacement of affected common properties by RHD when owned by the community. There will be no need to establish Resettlement Sites as most of the identified PDPs are non-title holders and encroachers.

In general for paying the compensation to individuals the process involves 4 parties:

i. RHD Project Office;
ii. Office of the Deputy Commissioner of respective districts for paying the compensation under CCL;
iii. An NGO appointed by the RHD for paying compensation beyond CCL; and
iv. Project displaced persons popularly known as PDPs.

In case of RHD and DC offices, they have their own government-approved structure for the implementation of RAP's. One experienced NGO is to be appointed for the implementation of the RAP beyond CCL, to be completed before vacating affecting structures and taking over possession of land by the implementation agencies.

The organization structures; manpower requirement, its functions, roles and responsibilities, authorities and power, operation office, etc., will be prepared during the Detailed Design phase.

To facilitate implementation of the RAP, different committees are to be set up under the supervision and control of RHD or the DC. The proposed Committees could include the following:

vii. Resettlement and Rehabilitation Committee
viii. Joint Verification Team (JVT)
ix. Market Survey Committee
x. Grievance Redress Committee (GRC)
xi. RAP Advisory Committee

2.4.6.1. MONITORING OF PROGRESS AND REPORTING

Monitoring is an integral part of project implementation, which must be given due emphasis if the implementation has to proceed according to projected plan and schedule. Evaluation (pre, mid or post) on the other hand, is needed to bring the implementation on the right track towards the attainment of project objectives and, if the situation demands, by rectification of the policies and strategies of the project originally set for.

The RAP normally contains a monitoring and evaluation (M&E) plan, including methods and approaches to be used for such activities. Monitoring involves collection, analysis, reporting and use of information about the progress of different aspects of the resettlement operations, based on the approved RAP.

The objectives of setting a monitoring and evaluation system (MES) are to:

- Collect, analyze, report and use information about progress of resettlement;
- Ensure that inputs are being provided, procedures are being followed and outputs are monitored and verified;
- Ensure timely management action if there appears to be any failure in system due to management IPDPse; and
- Ensure necessary corrective measures at policy level, if it is seen that there is a failure in system due to flaw in the design i.e. wrong theory, hypothesis or assumption, to ensure necessary corrective action at policy level; and to build a benchmark database for the purpose of evaluation; both during course and ex-post facto.

2.4.6.2. FRAMEWORK FOR MONITORING

The implementation of the RAP will be supervised and monitored by the Project Director, RHD, and PPP in coordination with the Deputy Directors, Assistant Directors, Field Officials and staff of the implementing agency/NGO. Monitoring will be done both internally and externally to provide feedback to PD and to assess the effectiveness of the resettlement policy and implementation.

2.4.6.2.1. INTERNAL MONITORING

The internal monitoring by the PD, RHD, and PPP will deal with all aspects of land acquisition and resettlement at the project as well as field levels. The project management particularly, the PD, assisted by the field officers, will be mainly responsible for monitoring the progress of all resettlement activities at the project level, which includes the following:

- Information campaign and consultation with the PDPs
- Status of land acquisition for various components of the project
- Land compensation payment
- Compensation for lost structures and assets
- Relocation of PDPs if necessary (Not applicable for the Dhaka By-Pass Project)
- Land transfer from DCs and handing over to the contractors
- Payment of income/business restoration assistance
- Organizing skill training program for restoration of socio-economic status

The benchmark for project level monitoring will come from land acquisition data and the social impact assessment completed during the feasibility and detail design phases. Further, the implementing agency/NGO will conduct field monitoring and assess the daily operation of land acquisition and resettlement activities.

The mechanisms to be used at the field level monitoring include:

- Review of PDP files
- Informal sample survey of PDPs

- Key informant interviews
- In-depth case studies
- Community participatory meetings

2.4.6.2.2. EXTERNAL MONITORING

The resettlement specialist of the Management Consultant Team (MCT) will conduct external monitoring during the implementation of the project. The MCT may include a Resettlement Specialist and Gender and Social Development Specialist on the team. External monitoring involves a review of resettlement implementation, verification of the results of internal monitoring in the field, and consultation with PDPs, field officials and community leaders for preparing review reports. The specific tasks and methodology for external monitoring shall include:

- Review of pre-project baseline data on PDPs
- Identification and selection of an appropriate set of indicators for gathering and analyzing information of resettlement impact
- Use of various formal and informal surveys for impact analysis
- An assessment of resettlement efficiency, effectiveness, impact and sustainability, drawing lessons as a guide to future resettlement policy making and planning

The external monitoring for resettlement will begin as soon as the Management Consultant Team is mobilized. The Resettlement Consultant is to conduct the monitoring of land acquisition, land schedule, resettlement site development (if any), relocation, implementing NGO activities, etc. External monitoring and supervision of RAP implementation will continue throughout the implementation of the project. The following may be considered as the basis of indicators for monitoring and evaluation of the resettlement project:

- Socio-economic condition of the affected households/business
- Payment of compensations and various entitlements as per RAP
- Changes in housing condition and income level as an impact of the project
- Resettlement of the vulnerable PDPs and businesses
- Rehabilitation of the PDPs and businesses
- Income restoration/social forestry program for vulnerable groups
- Consultation with PDPs, particularly women/vulnerable groups
- Grievance redressal cases
- Level of satisfaction of the PDPs in the post-relocation period
- Overall effectiveness of the resettlement operation

The monitoring report will inform the Project Direct and RHD of the progress in the implementation of the RAP and make appropriate recommendations. RHD will be responsible for undertaking any remedial measures to improve the implementation process.

2.4.6.3. REPORTING REQUIREMENTS

During the implementation phase, the Project Director will prepare quarterly reports on the progress of resettlement activities and forward copies of the report to the GoB and Concessionaire. 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 Mission, will conduct review and report to PD, RHD on the progress of all aspects of land acquisition and resettlement activities for every six months during the implementation stage. A post-resettlement impact evaluation may be carried out by the PPP office to assess whether adverse impacts of the projects have been mitigated adequately and PDPs have been able to restore and/or improve their pre-project standard of living as a result of resettlement and development.

2.4.6.4. COMMUNITY PARTICIPATION IN RAP IMPLEMENTATION

In a land scarce country like Bangladesh, land acquisitions, especially homestead acquisition, is a highly sensitive issue. For reducing the mental shock and tension of project affected persons, the acquisitioning authority with the active participation of demand placing department must organise meetings with the project affected persons as and when needed. Moreover, during the preparation of RAP, the project affected persons should get enough information about the total compensation package and impacts of this land based development project on socio-economic development of the area. All these are done for reducing the mental shock / tension of the project affected persons.

During the RAP implementation stage, the project affected persons should be given sufficient opportunity to voice their opinions / grievances through their representatives in various committees. A list of losses is always completed in the presence of PDPs, which provides them with scope to correct the mistakes, if any, in estimating the losses. Moreover, the project affected persons can know about the RAP thoroughly when the Bangla Booklet is circulated among them by the NGO, whose office is open to the project affected persons. NGOs always encourage PDPs to participate in RAP implementation.

3. COMMERCIAL FEASIBILITY (TASK GROUP 6)

This section summarizes the commercial feasibility and financial analysis undertaken to indicate whether the project generates Value-for-Money (VfM) and supports appropriate delivery under a Build Operate Transfer (BOT)/Public-Private-Partnership (PPP) procurement model.

3.1. NEEDS ANALYSIS

Through resolution of technical design issues and understanding of physical encumbrances and encroachments into the Right of Way (ROW) for the Dhaka By-Pass, the project team has recommended certain refinements to the project scope and objectives for the project. The survey has demonstrated numerous buildings, mosques and graveyards along the proposed alignment that encroach onto RHD lands. Many of these encroachments can be addressed through innovative design; for example, the Technical Lead has proposed extending the Dhaka By-Pass north beyond the Vogra intersection with the N3 and to connect with the N4 SASEC Road, thereby eliminating congestion that would ordinarily be expected at an already busy intersection, as well as avoiding disruption to a mosque located at the intersection.

The Dhaka By-Pass was also found to connect with three other RHD highway initiatives that are being pursued with ADB funding and are currently in design – the N1 interchange at Modanpur, the N2 interchange at Bhulta, the N3 interchange at Vogra and the connection to the N4/north SASEC road. The location and design of these intersections will have financial implications to the viability of the Dhaka By-Pass Road. A meeting of the design consultants was convened by RHD and the Asian Development Bank (ADB) on March 30th, 2014 to address the design complexities at each intersection or flyover. The meeting resulted in establishing design criteria for each of the intersections and a reduction in risk to the Dhaka By-Pass initiative.

3.2. PROJECT SCOPE DESCRIPTION

The Dhaka By-Pass Road is contemplated to include a four lane, controlled access toll road, plus a two-lane service road. Both roads are expected to be constructed by the PPP contractor / concessionaire; however the current plan contemplates that only the toll road will be operated and maintained by the PPP contractor/concessionaire, and only the toll road will generate a revenue stream to the concessionaire. This scope of work raises a number of considerations.

Firstly, the PPP contractor/concessionaire will be expected to finance the construction of both roads, however, it will be expected to recover toll revenue on the toll road component only, as the service road will continue to operate as a free access road servicing local transportation requirements. Secondly, on the basis of the financial analysis, in order to render the project financially viable from the perspective of a private sector partner, a certain amount of viability gap financing (VGF) will be required. As a result of having to finance both roadways, the required gap financing level is likely to be larger than that which is available pursuant to the government's VGF Policy. Since this project involves both a revenue-generating controlled access toll road (the concession road) and a non-revenue generating service road (contemplated to be operated by RHD) – notwithstanding that an Economic Rate of Return (ERR) may be

evident for the entire initiative – an additional source of funding will likely be required to fund the cost of construction of the service road, thereby allowing the PPP contractor/concessionaire to pursue financing for a more financially viable toll road project.

3.3. MARKET/INVESTOR INVESTIGATION & ENGAGEMENT

3.3.1. OVERVIEW

Consultation with developers, contractors and concessionaires[10] was undertaken. Following from these consultations, a number of risks have been identified, which would suggest the need to provide for certain financial and non-financial concessions in order to encourage participation from local/Bangladesh based contractors. Notwithstanding the financial viability demonstrated by the analysis, it is essential that these concerns and risks be appropriately addressed in order to ensure that the project is seen to be viable from the perspective of Bangladesh based contractors, concessionaires and the financial community. We place particular emphasis on this for two key reasons. First, local firms bring with them essential knowledge of local practices and challenges that need be incorporated into bidding teams. And second, this represents an opportunity to contribute to the development of an effective Bangladesh based PPP knowledge base and capacity to be able to respond to this Dhaka By-Pass opportunity as well as the numerous PPP projects that are planned for Bangladesh in the years to come. The following were commonly identified as significant risk factors:

- As a new project delivery model, this is somewhat unique to contractors, and there is no experience among the highway constructors in addressing the risks unique to this delivery model;
- Concern was expressed that this delivery model requires significant investment in the bid phase as well as project delivery, but that there is a risk that government might not follow through on its commitments;
- Concern that the legal authority is not in place (although the PPP Policy was gazetted in 2010);
- Concern that the Toll Policy is not in place (although we have been informed that this has been approved by Cabinet);
- Concern that the private markets (Bangladeshi lenders) have very limited prior experience of closing a transaction of the size contemplated;
- Concern that local interest rates are too high with the result that the project will not be feasible for Bangladesh based bidders;
- Concern that insufficient take out financing is available at the national Bangladesh level;

[10] Banks and Financial Institutions: Dhaka Bank, City Bank, National Credit and Commerce Bank, Infrastructure Development Company Limited (IDCOL), HSBC Bank Bangladesh, Bangladesh Infrastructure Financing Fund Limited (BIFFL), Asian Development Bank (ADB), IDLC. Contractors: Monico, Mir Akhter, Simplex Infrastructure Limited, Reja Construction / Spectra Construction, Ganon, TBL-ACL-JV, Monem, Syno Hyro (expressed no interest in project), and Toma (expressed no interest in project).

- Concern that there are other more lucrative opportunities for developers that will not require equity of the nature contemplated but provide better returns.

Following out of these consultations, a number of "Action" items (including financial and non-financial concessions) have been proposed for further consideration of various levels of government. The primary purpose of these action items is to provide the necessary level of government support to ensure that the PPP structure is financially feasible and, given the risks, will provide sufficient financial returns to justify a long term commitment to the development, operation and maintenance of the Toll Road. These action items have the objective to encourage development of the capacity for PPP delivery by Bangladesh based institutions. They are described in Table 3-1 below, and include:

- Concessionaire benefits such as minimum traffic guarantees (from RHD/Finance);
- Contractor benefits such as developer income tax "holiday" and VAT exemptions on labour and materials;
- Lender benefits such as bank income tax relief on income from loans to PPP projects, repatriation guarantees, foreign exchange rate guarantees and sovereign guarantees (e.g., government backed bond issues).

Many of these GOB benefits and enabling tools hare already been established on other public initiatives or for other industry sectors (e.g., power sector). They are necessary enabling tools both to contribute to reducing risk to the private sector as well as to demonstrate GOB's commitment to ensuring that these PPP structures for project delivery are a success. Additionally since the PPP approach to project delivery in Bangladesh is a relatively new one it is essential that the appropriate structures are put in place to ensure that the interests of international bidders are protected in so far as they are able to repatriate their capital and profits on such ventures, and as importantly to provide such bidders with the level of certainty that they require in connection with investments in foreign jurisdictions.

	Government Agency / Department Action	Nature of Concession	Status
Action 1: Concessionaire Benefitsd	RHD / MoF	Traffic Count: Minimum traffic volume guarantees	Pending
		Land Acquisition: To be fully completed prior to issue of RFP	Survey shows land along alignment owned by RHD; additional land required for interchanges
	PPP Office	PPP Policy passed by government	Completed (legal opinion may be required)
	MRTB / RHD	Toll Policy approved	Completed (legal opinion may be required)
	Planning Commission / MRTB / RHD	Permits & Approvals: Process to be put in place to facilitate approvals required by law	Pending
Action 2: Contractor Benefits	MoF / NBR	Tax: Income tax exemption	Pending
		VAT: Exemption on VAT re: labour & materials	Pending
Action 3: Lender/Bank Benefits	NBR / CBB / BB	Tax: Income tax relief on income from loans to PPP projects	Pending
		Loan capital repatriation guarantees	In place
		Foreign exchange rate guarantees	Requires further discussion

Table 3-1: Enabling Concessions (Actions 1, 2, and 3)

One of the factors complicating a foreign currency loan for a project such as the Dhaka By-Pass, i.e., a PPP toll road, is that the income revenue stream (revenue from tolls) is Taka based. So unless a mechanism can be put in place to provide for debt repayment certainty on foreign equity and debt an additional element of risk is introduced, namely foreign exchange risk, a fact that might well significantly deter foreign bidders (and lenders) from participating in the initiative. One such mechanism is for the GOB to provide foreign exchange guarantees/certainty on foreign investments and debt, and another might be for the GOB to be the toll collection agent and to then distribute to the concessionaire and lenders separately with lender payments in the respective loan currencies, using a similar mechanism as the Power Purchasing Agreement (PPA) of the energy sector.

3.3.2. MARKETING & OUTREACH

Successful delivery of this project requires the support of a strong private sector partner with the experience in developing infrastructure of a similar size, scope and complexity. Given the substantial size of this project and the limited PPP experience in Bangladesh, the PPP Office is strongly advised to proceed with additional and targeted marketing outreach to ensure that prospective regional and international contractors, concessionaries, and financial partners are made aware of the opportunities in Bangladesh and commence with teaming arrangements with Bangladesh partners. A preliminary listing of prospective regional/international Road & Highway contractors and concessionaires has been assembled for further consideration and outreach, and can a draft Request for Registration of Interest (ROI) has been provided to the PPP Office for its consideration and publication.

Given the generally limited level of PPP knowledge and experience in Bangladesh, and in order to enhance the probability of success of this as a PPP project, it is important that the PPP Office carry out the following tasks:

- Dialogue: Continue with open dialogue and consultation with Bangladesh developers, concessionaries and financing institutions.
- Return on Equity (ROE): Proceed with the issue of ROE to expand the list of prospective bidders support the partnering efforts of Bangladesh contractors, and advertise the opportunity for international and regional concessionaires and contractors that have the capacity and interest in investing in Bangladesh.
- Marketing Material: Develop printed material/brochures for mailing and distribution at sector specific conferences, trade shows, and Public Information Centers (PIC).
- Road Shows: Hold a series of PICs for Bangladesh contractors and concessionaires, and follow up with similar sessions in major regional/international centres e.g., Istanbul, Turkey, Seoul, Korea, Beijing, China.

3.4. PPP STRUCTURE OPTIONS

Largely on the basis of consultation with Bangladesh banks and contractors, and our experience with other international PPP structures, the following framework is being considered. On the basis of the information that we have been provided, it would appear that this structure is consistent with the government's PPP Policy. However further input, consideration and discussion will be required with the government's legal advisor upon selection of such.

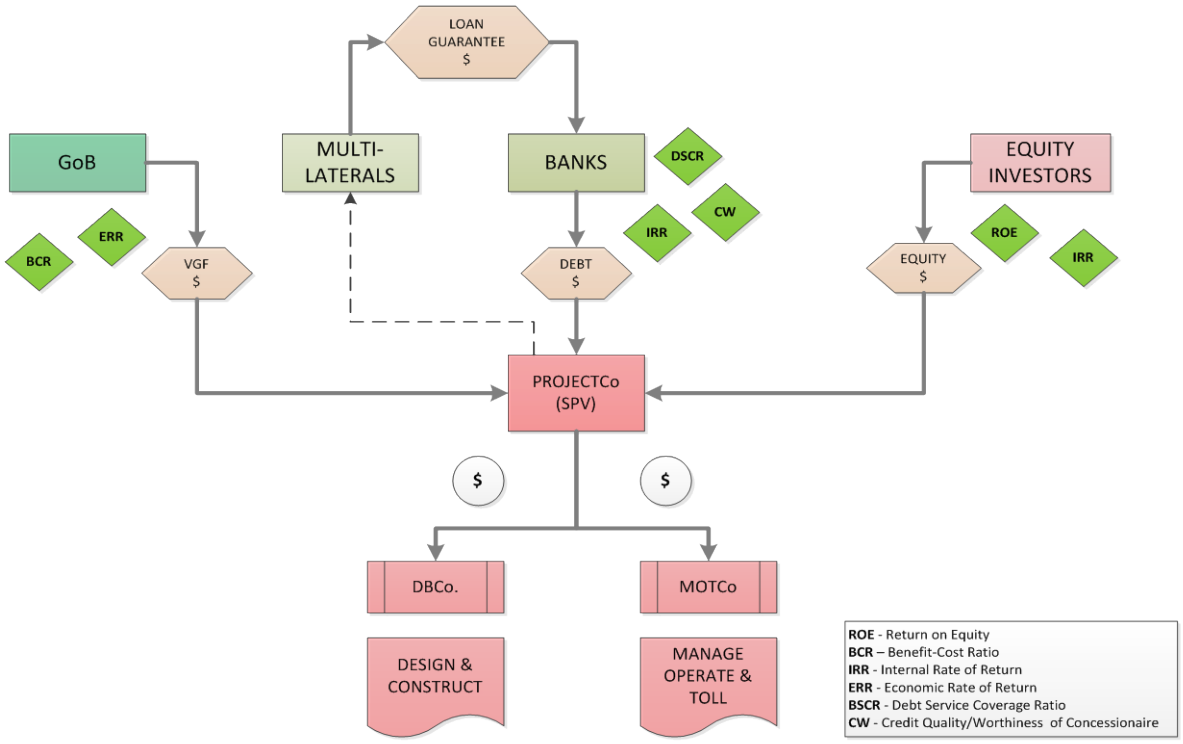


Figure 3-1: Organizational Chart

3.5. FINANCIAL MODELING & ANALYSIS

[THIS SECTION OF THE FEASIBILITY STUDY REPORT (PRESENTED AS A SEPARATE REPORT) AND THE ASSOCIATED ATTACHMENTS ARE TO BE KEPT STRICTLY CONFIDENTIAL. THE INFORMATION AND ANALYSIS PROVIDED HEREIN WAS DEVELOPED SOLELY FOR THE PURPOSE OF INFORMING THE DHAKA BY-PASS STEERING COMMITTEE FOR DECISION MAKING PURPOSES ONLY. IT IS NOT TO BE DISTRIBUTED OUTSIDE OF THE STEERING COMMITTEE FOR THE DHAKA BY-PASS ROAD INITIATIVE, NOR IS IT TO BE COPIED OR DISTRIBUTED TO ANY PROSPECTIVE BIDDER, CONCESSIONAIRE, BANKER OR LENDING INSTITUTION.]

The TA Consultant conducted a financial analysis to determine the feasibility (or infeasibility) and VfM under two different procurement delivery models.

- Traditional Delivery (i.e. Design-Bid-Build): Under this model the government contracts with separate entities for the design and construction of the project. ; and
- Public Private Partnership (i.e. Design-Build-Finance-Operate-Maintain): Under this model, the government enters into a long term concession agreement with a concessionaire to design, build, finance, operate and maintain the toll road.

The purpose of the financial model is to evaluate VfM from the perspective of the GOB and the financial viability of the Dhaka By-Pass initiative as a PPP project under various financial, economic and operating conditions. As such, the financial analysis has been carried out on the basis of a set of assumptions and inputs. The accuracy of the results/output of the financial analysis is fully dependent on the accuracy of the inputs and the assumptions used in the analysis. The financial models were tested under different growth scenarios to determine, annual surpluses (or deficits), level of toll escalations and other performance measures to evaluate the financial feasibility of the toll road project. Traffic demand, toll pricing, annual revenues, capital and operating cost estimates as well as other financial assumptions served as inputs to the above noted procurement models. Consequently, should these assumptions and inputs change; the output will be impacted either positively or negatively.

Growth Scenario	Return for Concessionaire
Conservative Growth	
Achieved Return on Equity	$9,200,000
Achieved Return on Equity (%)	20%
Medium Growth	
Achieved Return on Equity	$34,400,000
Achieved Return on Equity (%)	74%
Transaction Advisor Growth	
Achieved Return on Equity	$431,400,000
Achieved Return on Equity (%)	931%

Table 3-2 below summarizes the achieved Return on Equity (ROE) for the concessionaire under the various growth scenarios analyzed. As shown, the estimated earnings yield a positive return on equity, and these

returns for the concessionaire are deemed to be materially higher to commensurate with the level of risk for this project.

Growth Scenario	Return for Concessionaire
Conservative Growth	
Achieved Return on Equity	$9,200,000
Achieved Return on Equity (%)	20%
Medium Growth	
Achieved Return on Equity	$34,400,000
Achieved Return on Equity (%)	74%
Transaction Advisor Growth	
Achieved Return on Equity	$431,400,000
Achieved Return on Equity (%)	931%

Table 3-2: Return on Equity under Three Cases

3.6. HEADS OF TERMS FOR CONCESSION AGREEMENT

The heads of terms and associated diagram have been prepared solely as a guideline for the preparation of a standard agreement. Since at the time of drafting this report the government's legal advisors had not yet been fully engaged, the heads of terms are put forward exclusively as a draft for discussion. The heads of terms, outlined in Figure 3-2 below, is presented as a separate report, together with the procurement plan.

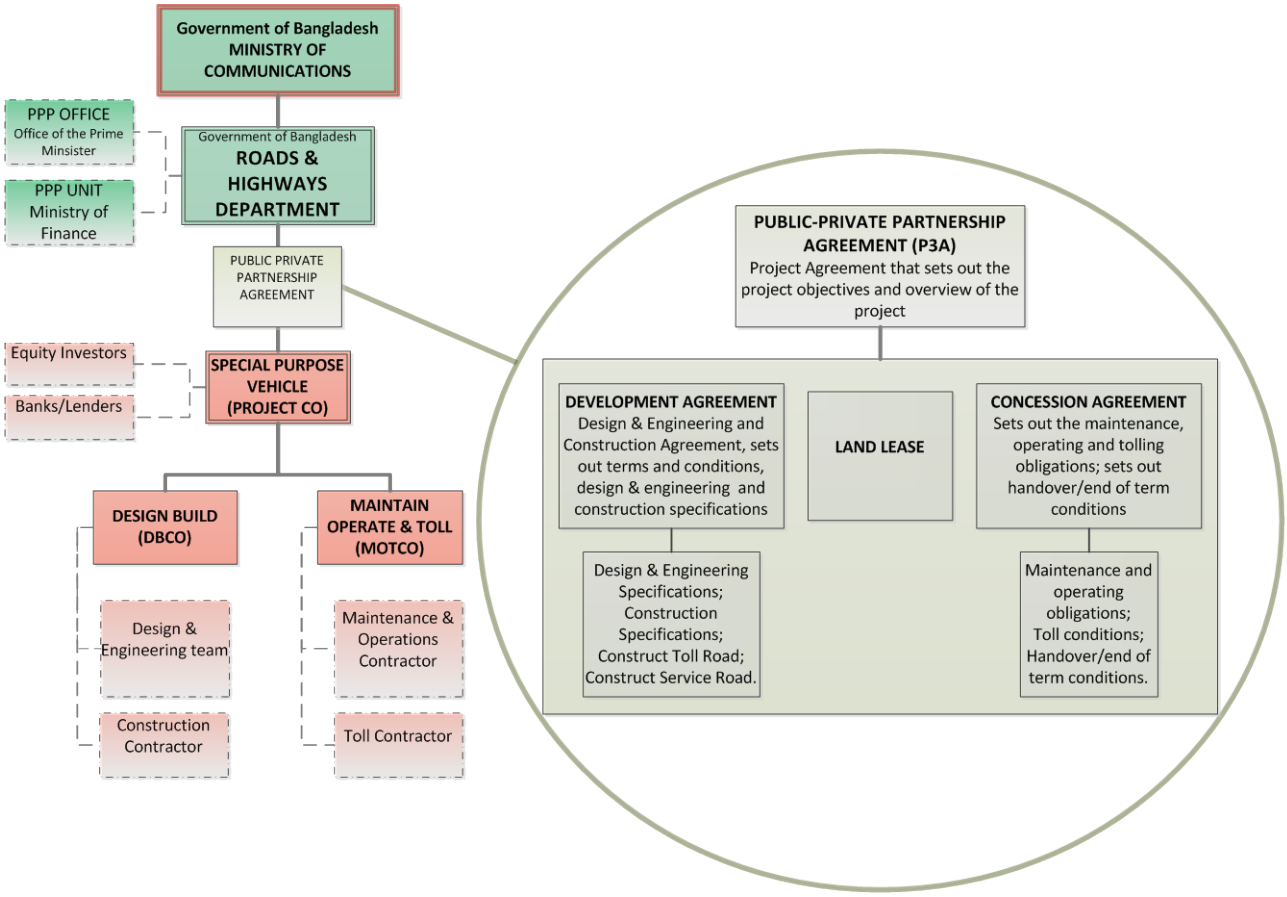


Figure 3-2: Chart of Agreements

3.7. PROCUREMENT PLAN

Figure 3-3 below represents a visual overview of the procurement process. The procurement plan is presented as a separate report with the heads of terms (Volume V).

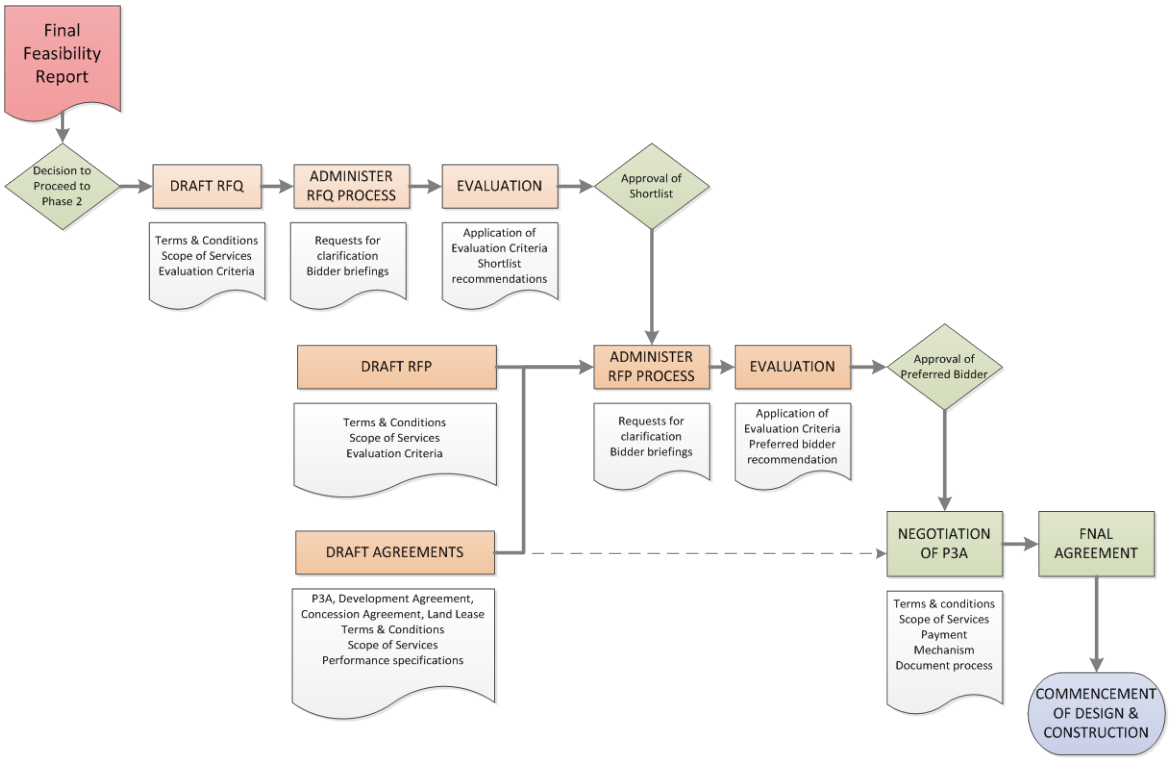


Figure 3-3: Procurement Process

3.8. COMMERCIAL CONCLUSIONS AND CONSIDERATIONS

On the basis of the underlying assumptions, cost estimates and forecasts, the Dhaka By-Pass initiative represents a financially viable initiative. Based on the financial analysis the DBFOM procurement model can be expected to offer cost, schedule, performance and optimal risk transference advantages to the RHD.

Based on the underlying assumptions the financial evaluation of the project under conservative case and medium case scenarios generates an ROE of 20% and 74%. In the Transaction Advisor forecast the revenue and ROE are materially higher. These rates of return are considered more than sufficient to attract private investors and signify that the project is financially viable. These rates of return were calculated under the traffic volume, toll pricing and capital and operating cost assumptions. Going forward, if the present assumptions remain constant and the toll road project continues to remain both economically feasible and financially viable; the RHD may explore the possibility of adjusting the toll price level in order to improve the distribution of returns to both parties. This has been addressed in the Financial Report.

4. CONCLUSIONS

This report takes technical, economic, commercial and financial considerations into account, with the aim of determining the feasibility of the Dhaka By-Pass project. On the basis of various assumptions laid out here within, there is sufficient evidence to suggest that the road upgrading is in fact a viable project, and that benefits can be gained by realizing the project as a Public-Private Partnership. Technically, no barriers have been found to prevent the project's execution. While there are a number of obstacles to be surmounted, these imply some cost impacts as a result of necessary design adjustments, but do not affect the feasibility of the project as a whole.

From an economic standpoint there is value in going forward with the project. Both PPP and DBB models deliver net benefits of well over US$ 1.3 Billion and have positive benefit-cost ratios of 4.52 and 3.93, respectively, where the PPP model fares slightly better overall. The project's NPV is also approximately $66 Million higher in the PPP case (both sitting at approximately $1.3 Billion). In the PPP scenario, the project has an economic rate of return of 58%, while in the traditional delivery scenario, this figure is 47%; both figures could reasonably be considered to be sufficiently high to justify the development of the project. From a sensitivity standpoint, if the expected economic savings attributed to the three factors considered (VOC, travel time and collision cost savings) fall by 25%, the respective ERRs of 39% and 33% would continue to support proceeding with the project.

These calculations are solely based upon three user-benefit inputs: vehicle operating cost savings, travel time savings, and collision cost savings; a number of additional benefits, which include generated employment (direct, indirect and induced), increased economic competitiveness, decreases in Greenhouse Gas (GHG) Emissions and Critical Air Contaminants (CACs), and reducing the societal costs of road-accidents, are likely to further strengthen the case for the project's execution.

The financial assessment incorporates the preliminary information and supporting assumptions developed by the RHD and the Transaction Advisor. Key inputs included estimates for construction costs, operating costs, periodic and routine maintenance, and projected traffic volumes. As noted above, the preliminary inputs and financial outputs generated by the financial model require further independent review and diligence before an ultimate conclusion can be made regarding the optimal delivery model (and contractual arrangement) for the project.

Under the assumptions outlined above, the projected revenue stream does not exceed the life cycle cost for the project in any of the RHD supported models. A projected surplus is only realized under the Transaction Advisor's projections. However, the financial analysis shows that under a PPP model the concessionaire can recover their initial investment and earn an acceptable return, commensurate with the level of risk for this project. Based on these preliminary conclusions, there are both economic gains and financial benefits to be realized by pursuing the Dhaka By-Pass project through a PPP delivery model.

APPENDICES

APPENDIX A: ENGINEERING REPORT

DUE TO THE SIZE OF THE ENGINEERING FILES, THIS WILL BE PROVIDED AS A SEPARATE DOCUMENT.

APPENDIX B: HYDROLOGY REPORT

APPENDIX C: PROJECT COST

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APPENDIX D: TRAFFIC DATA

APPENDIX E: ECONOMIC ANALYSIS