Narayanganj City Corporation

Urban Infrastructure Improvement Preparatory Facility (ADB Funded – NCC Component)

Consultant Services for Preparatory Studies and Procurement Support (PSPS)

Contract No. : UIIPF/NCC/S-01 Project Readiness Financing (TA Loan)

DRAINAGE MASTER PLAN

August 2023

Revision R-1

(updated as on 18Aug 2023)

PADECO IPE GLOBAL NJS In association with BCL dpm

Consultants:

A Joint Venture of

PADECO Co., Ltd.,
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LIST OF ABBREVIATIONS AND ACRONYMS

AAP	:	Action Area Plan
ADB	:	Asian Development Bank
BBS	:	Bangladesh Bureau of Statistics
BIWTA	:	Bangladesh Inland Water Transport Authority
BMD	:	Bangladesh Meteorological Department
BOQ	:	Bill of Quantities
BWDB	:	Bangladesh Water Development Board
DAP	:	Detailed Area Plan
D/D	:	Detailed Engineering Design
DEM	:	Digital Elevation Model
DMA	:	District Metering Area
DMZ	:	District Metering Zone
DTL	:	Deputy Team Leader
DWASA	:	Dhaka Water Supply and Sewerage Authority
DWF	:	Dry Weather Flow
EARF	:	Environmental Assessment Review Framework
EHS	:	Environment Health and Safety
EIA	:	Environmental Impact Assessment
EMP	:	Environmental Management Plan
EQS		Environmental Quality Standard
ESIA	:	Environmental and Social Impact Assessment
ESMP	:	Environmental and Social Management Plan
F/S	:	Feasibility Study
FSM	:	Fecal Sludge Management
GAP	:	Gender Action Plan
GIS	:	Geographic Information System
GoB	:	Government of Bangladesh
IDF	:	Intercity-Duration Frequency
IEE	:	Initial Environmental Examination
IPPF	:	Indigenous Peoples Planning Framework
LAP	:	Land Acquisition Plan
LGD	:	Local Government Division
LGED	:	Local Government Engineering Department
MLD	:	Million Litres per Day
NCC	:	Narayanganj City Corporation
NGO	:	Non-Governmental Organization
NRW	:	Non-Revenue Water
O&M	:	Operations and Maintenance
PMU	:	Project Management Unit
PSPS	:	Preparatory Studies and Procurement Support
RAP	:	Resettlement Action Plan
RF	:	Resettlement Framework
SCADA	:	Supervisory Control and Data Acquisition

SMFM	:	Strengthening Municipal Financial Management
SPS	:	Safeguard Policy Statement
TA	:	Technical Assistance
TAPP	:	Technical Assistance Project Proposal

DRAINAGE MASTER PLAN OF NARAYANGANJ CITY CORPORATION

EXECUTIVE SUMMARY

Background

The Urban Infrastructure Improvement Preparatory Facility (UIIPF) aims to improve urban infrastructure and increase sustainable urban services for the people of Narayanganj, specifically water and drainage services together with a new road and public spaces. The Government of Bangladesh (GoB) and the Asian Development Bank (ADB) agreed to provide a loan for the infrastructure services.

Objectives of the project are: (i) to provide better municipal service delivery and improvement of quality of urban life, (ii) develop institutional capacity of NCC, and (iii) improve efficiency and transparency of municipal finance.

This TA consultancy service includes inputs in the feasibility study, planning, detailed design, cost estimates, and preparation of bid documents for three distinct areas in Narayanganj City Corporation, namely:

- Road on the eastern bank of the Shitalakshya;
- Water supply;
- Drainage works

The drainage component involves the preparation of a comprehensive Drainage Master Plan to address drainage improvements until 2046. Depending on available budgets, priority drainage works will be selected for implementation under this investment project.

Scope of Work

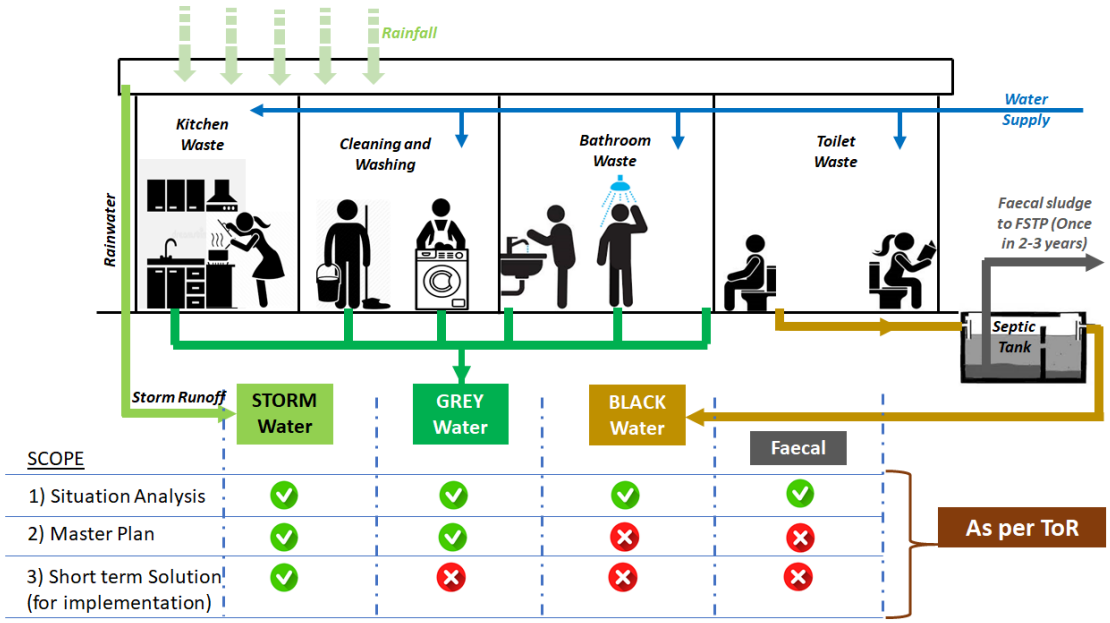
A major output of this project is preparation of a drainage masterplan, which is the subject of this report. The scope of work for the Masterplan as envisaged in the ToR is as follows:

- Investigate drainage water quality and identification of necessary treatment processes for safer disposal
- Prepare environmental audit of existing facilities to be rehabilitated/expanded under the project
- Conduct baseline environmental and social surveys
- Prepare Master Plan to identify priority drainage projects
- Prepare Feasibility Study of Selected Options
- Prepare detailed designs and bidding documents of approved projects
- Improve institutional capacity of NCC to manage the drainage system

Components as per ToR

The Terms of Reference (ToR) expects to conduct a situation analysis of existing sanitation system of Narayanganj city including storm/grey water drainage, wastewater (domestic and industrial wastewater), septage/ fecal sludge management situation, and prepare Drainage Master Plans for storm water/ grey water drainage system for NCC. Thus it interprets the master plan shall include long term solutions for stormwater + greywater, and situation analysis shall include additional black water/foul water/industrial waste//faecal sludge.

Hence this master plan includes a comprehensive study on combined storm and grey water and a situation analysis of blackwater and faecal management.



Understanding the ToR

It is imperative to state that the Consultants suggestion has been considered as the most logical one under the existing circumstances, as agreed both by NCC and ADB. The challenge was on how to satisfy the ToR which clearly stated consideration of storm water and Grey water. Finally it was decided to consider the component of storm water and greywater under the comprehensive master plan study.

NCC and Consequence of Inadequate Drainage

Drainage in Narayanganj has assumed considerable significance of late due to the enormous population growth and the rapid but haphazard urbanization evident in most wards. Failure to provide adequate drainage results in severe waterlogging and this is directly linked to the resurgence of malaria, the spread of diarrhea diseases, damage to housing and property, disrupted communications, lost income and environmental degradation.

An effective drainage network as well as proper management of that system is critical to the future development of Narayanganj and the wellbeing of its residents.

Causes of Ineffectiveness of Drainage System

A review of the existing situation revealed a number of important common factors that reduce the effectiveness of the drainage of surface runoff. These mainly include relatively flat topography and inadequate minimum longitudinal slope of drains, disposal of solid waste directly into drainage channels, little or no enforcement of laws, poorly defined secondary and tertiary drainage channels, absence of an intermediate network of secondary drainage channel, absence of an integrated network of road side drains, underdesigned of drainage channels, lack of coordinated and planned drainage maintenance programs, poor communal awareness, and construction of innumerable culverts and bridges on primary, encroachment of canals by unauthorized land fill and construction of building and other drains and canals without any

regulation in the size and number of vents obstructing. These are dscussed in detail in the following chapters.

Sewage and Household Waste Disposal

From a visual inspection of selected properties, it would appear that a significant proportion of the approx. 30,000 household water connections are discharging their domestic wastewater directly to the stormwater drainage system, instead of to properly constructing septic tanks. Where septic tanks do exist, these are often old and require desludging with the result that they overflow directly to the drainage system during rainfall events. Furthermore, local people regularly dispose of their household water to the drainage channels causing frequent blockages.

Existing Drainage Network

- Roads – 625 km
- Existing Drainage Network -556 km
- Inadequate drains- approx. 10%

Institutional Aspects

Drainage is an important municipal service. However, the service provided by NCC is considered as sub-optimal. There exists substantial scope for improvement in the services provided by NCC. The key constraints are:

- Drainage networks and the drainage infrastructure in the NCC area are not maintained properly, creating “hot spots” of water logging and over spills,
- Lack of O&M machinery, equipment and tools
- Inadequate staff and lack of attention to skill development
- Encroachments of natural canals
- Indiscriminate disposal of solid waste into khals (minor drainage canals) and drains,
- Absence of effective surface drainage system
- Inadequate sewerage network and only one Sewerage Treatment Plant for the whole of NCC area. This creates contamination of drainage flow with untreated sewage.

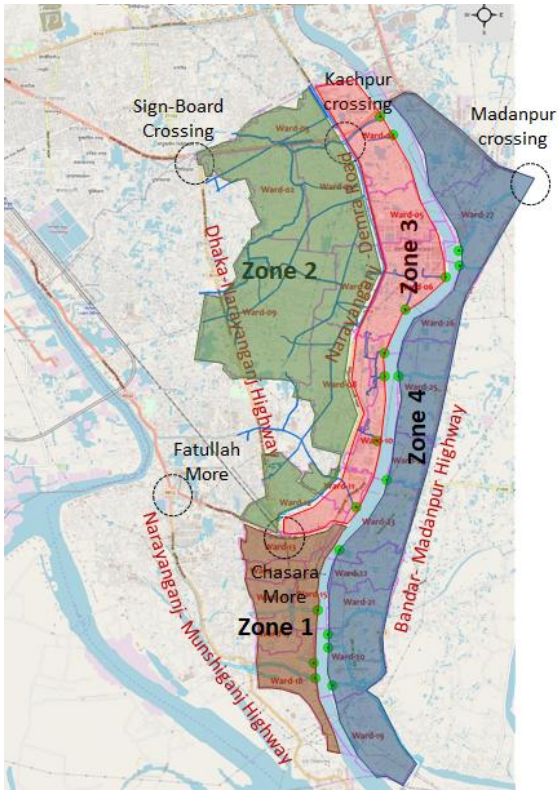
NCC requires a functioning well-resourced drainage section to ensure that any new investment in drainage infrastructure in Narayanganj is properly maintained.

Proposal of Drainage Zones

Narayanganj city is about 16 km southeast of the capital city of Dhaka. With a population of approx.1 million, the city is an important industrial and business center. The Shitalakshya River flows through the city in north-south direction. The city area is divided in 3 administrative zones – Kadam Rasul (eastern part), Sidhhirganj (northern part), Narayanganj (southern part), having 27 wards.

The NCC drainage system into 4 drainage zones for the purposes of this study. Each zone is hydraulically independent and exclusive. The zone boundaries lie along the watershed lines of the total NCC catchment.

Zone 1	Wards - 13, 14, 15, 16, 17, 18
Zone 2	Wards - 1, 2, 3, 17, 8(73%), 9, 11(35%), 12(62%)
Zone 3	Wards - 4, 5, 6, 8(27%), 10, 11(65%), 12(38%)
Zone 4	Wards - 19, 20, 21, 22, 23, 24, 25, 26, 27



Drainage Zone Map

Master Plan Proposals

The Master plan proposal is a comprehensive solution. Main components are:

- Rehabilitation of existing drainage system (presently 625km),
  - renovation of inadequate drains 38km,
  - cleaning of the remaining existing drains 518km
  - proposal of new drains 69km
  - outfall structures, silt & screen chambers;
- Rehabilitation of existing canals of about 55km;
- Landscaping,
- tree planting and
- canal side parks along canals;
- Wetland Integration (Integration of Lakes/Ponds);
- Construction and restoration of Water Bodies;
- Canals Connectivity;
- Increasing height River Embankment (35km on the east side);
- Transformation of Canals/Khals to Navigation Channel;
- Greywater management-

- Interception & diversion (60km),
- pumping facilities (6 nos),
- transmission (40km) and
- treatment of greywater (253 mld at 3 WWTPs).

Phasing of Proposals and Cost

Phase	Components	Costs (in Million USD)[1]
Phase 1 Immediate Phase (Yr. 2024-2027)	Rehabilitation of existing drainage system; Rehabilitation of existing canals; Supply of Equipment (Hugh Pressure Jetters, Trucks, etc)	
2024-2025	Phase 1A (***under ADB's allocated budget***)	27.1
2026-2027	Phase 1B (remaining after Phase 1A)	19.4
Phase 2 Medium Phase (Yr. 2027-2036)	Augmentation of drainage system; Pumping station; Landscaping, tree planting and canal side parks along canals; Wetland Integration; Construction and restoration of Water Bodies; Canals Connectivity; Introduction of Gates at outfalls;	30.1
	Greywater management- Interception & diversion, Pumping stations, Wastewater (Greywater) Treatment Plants	113.1
Phase 3 Long term (Yr. 2036- 2046)	Augmentation of drainage system; Increasing height River Embankment; Transformation of Canals/Khals to Navigation Channel; Augmentation of Wastewater (Greywater) Treatment Plants	7.9
	Greywater management- Augmentation of Wastewater (Greywater) Treatment Plants	12.4
	TOTAL	**210.0**

Table 1 - Summary of Phasing of Proposals and Costs

Climate Change Adaptation

The Bangladesh Climate and Disaster Risk Atlas states that minimal change in the spatial distribution of rainfall is expected throughout the 4-decade period from 2011 to 2050. However, minor changes in precipitation will be experienced by districts in the north-western and eastern parts of Bangladesh, while the rest of the country is unlikely to experience any significant change in annual average rainfall. Accordingly, the annual average rainfall in the project area (Narayanganj) is expected to remain in the range of 3.01 – 5.21 mm/day for the project duration i.e. next 30 years.

The drainage master plan proposals covered climate-resilient urban drainage or stormwater management facilities and are fully aligned with NAP with fully compliance to Climate Change adaptation. The

[1] 1 USD is assumed to be equivalent to 108 BDT

proposals addresses the climate strategy and National adaption plan (NAP) through the interventions as discussed below. These will ensure:

- protection against climate change variability and induces natural disaster,
- climate resilient livelihood and improved urban environment

A range of adaptive measures have been considered in the master plan proposals

- Raising of river embankment
- Planation of tress along canal
- Wetland integration to reduce pumping of storm water
- Construction and restoration of Water Bodies
- Transformation of Canals/Khals to Navigation Channel
- Adopting surface covered drains for storm water

1 PROJECT BACKGROUND

1.1 Introduction

The Urban Infrastructure Improvement Preparatory Facility (UIIPF) aims to improve urban infrastructure and increase sustainable urban services for the people of Narayanganj, Bangladesh, specifically water, drainage, road services and public spaces. The Government of Bangladesh (GoB) and the Asian Development Bank (ADB) agreed to provide a loan for the infrastructure services. The Narayanganj City Corporation (NCC) is the owner of the project in the city of Narayanganj. The proposed infrastructure facilities for the municipal services, as agreed in this project, are in Road, Water and Drainage sectors. NCC has appointed PSPS consultant for feasibility study and detail engineering on the component sectors.

1.2 Objectives of the Project

Objectives of the project are: (i) to provide better municipal service delivery and improvement of quality of urban life, (ii) develop institutional capacity of NCC, and (iii) improve efficiency and transparency of municipal finance.

1.2.1 Objective of Master Plan

The objective of the Master plan is to deliver a comprehensive solution on improved drainage system with flood mitigation, addressing climate change effect and improved management in future. It shall cover climate-resilient urban drainage or stormwater management facilities and shall be fully aligned with NAP with full compliance to Climate Change adaptation measures.

1.3 Project Location

The project location is at Narayanganj, a city in central Bangladesh. It is in the Narayanganj District, about 16 km southeast of the capital city of Dhaka. With a population of approximately 1 million, Narayanganj is an important industrial and business center, particularly for the jute trade and processing plants and textile sector. The Shitalakshya River flows through the city in north-south direction. Earlier, Narayanganj was an important shipping and still at present it serves as an industrial center. Presently it is also a center of business and industry, especially the jute trade and processing plants, and the textile sector of the country and abroad.

Narayanganj City Corporation(NCC) was established on 5 May 2011 unifying three former municipalities: Narayanganj Municipality, Siddhirganj Municipality and Kadam Rasul Municipality. The city is divided in 3 administrative zones – Kadam Rasul (eastern part), Sidhhirganj (northern part), Narayanganj (southern part).

The city's location on the eastern bank of the Shitalakshya River provides good road connectivity and easy access to other major cities in the region. Furthermore, Narayanganj is home to important industrial zones, including the Adamjee Export Processing Zone (EPZ), located in the Siddhirganj area.

1.4 Purpose of this Report

This report focuses on **Master Plan of Drainage Sector**, which is an important component of the project. The project is expected to deliver improved drainage system with flood mitigation, addressing climate change effect and improved management in future. This is important for better municipal service delivery, economic growth, environmental improvement and improvement of the quality of urban life.

In view the above, a 'Briefing Note' on drainage sector was prepared by PSPS Consultant in June 2022. Following to this a first draft 'Drainage Master Plan Report' was prepared and submitted as a deliverable of PSPS in 05Sept 2022. The master plan report addressed a vision for the expansion and upgradation of NCC's drainage system. It would facilitate NCC to have a full understanding of the issues involved with respect to drainage.

The draft drainage Master Plan proposes for phase wise intervention:

- Immediate term – Yr. 2024-2027
- Medium term – Yr. 2027-2036
- Long term – Yr. 2036- 2046

In parallel, a report on detail design for proposed drainage system was prepare. It addresses the Immediate phase intervention, where detail design outputs and recommendations for drainage network system augmentation throughout the entire city have been highlighted.

1.5 Scope of Work

A major output of this project is preparation of a drainage masterplan, which is the subject of this report. The scope of work for the Master plan as envisaged in the ToR is as follows:

- Investigate drainage water quality and identification of necessary treatment processes for safer disposal
- Prepare environmental audit of existing facilities to be rehabilitated/expanded under the project
- Conduct baseline environmental and social surveys
- Prepare Master Plan to identify priority drainage projects
- Prepare Feasibility Study of Selected Options
- Prepare detailed designs and bidding documents of approved projects
- Improve institutional capacity of NCC to manage the drainage system

1.6 Terms of Reference and Compliances

The ToR specifies the following activities as listed below. The requirements of ToR have been addressed in this report as appropriate and applicable. Compliance detail is given below for ready reference. The compliances are complied and complied in separate chapters of the report either directly ir indirectly as suitable for the flow of the report. The consultant felt that a few points in the ToR are not applicable for the purpose of the report, but addressed adequately for the fulfillment of the requirement of the ToR.

Item No.	As specified in ToR	Complied in …
i	Review the existing drainage network along with existing road, canal, land use and other structure plan, also the plan of future expansion of the city in consultation with City corporation;	Chapter 3
ii	Identify the priority area of existing drains required to be rehabilitated or need up gradation;	Chapter 3
iii	Identify the outfalls and proposed layout plan drainage network with alternatives;	Chapter 3
iv	Prepare base map showing existing and proposed drainage network;	Chapter 4
v	Current Situation Analysis. Conduct a situation analysis of existing sanitation system of Narayanganj city including storm/grey water drainage, wastewater (domestic and industrial wastewater), septage/ fecal sludge management situation, assess quality of water conveyed by existing drainage system;	Chapter 7
vi	Strategic Goals and Targets in the Future. Conduct analysis of where the city wishes to be with respect to drainage management with a plan for intervening 5- year intervals with specific performance targets. Particular attention should be given to the vision of the city contained in the various formal planning documents and consultation with relevant government agencies, City level committee, Community Based Organizations (CBOs) and NGOs working in this sector;	Chapter 9, 10
vii	Assessment of indicators for achieving the objectives/targets, such as expansion of areas served, increased population coverage, overall investment, and operation and maintenance (O&M) costs. It should also include other factors including the policy environment, systems and procedures, organizational arrangements, sector governance and broad stakeholder relationships, customer service, planning and budgeting procedures, O&M arrangements, financial management, human resources management, and information systems;	Chapter 10
viii	Identify how this drainage management will be sustained, which covers arrangements in place and planned for monitoring of performance, performance evaluation and the incentives and disincentives to undertake or develop these functions. Most important are indications of government "ownership" of the master plan and the quality of the planning it contains;	Chapter 9, 10
ix	Prepare Drainage Master Plans for storm water/ grey water drainage system for NCC having different suitable options including treatment process with cost involvement including technical, social environmental and institutional aspect consistent with the NCC's policies and acts, identifying potential areas for drainage network and different treatment options before safe disposal;	Chapter 5, 6, 7
x	Design an institutional capacity development plan recommending improvements in policy and regulatory frameworks, organizational arrangements and capability, and human resources as required to establish sustainable storm/grey water drainage system (That means institutional setup including resource requirement for enforcing/cutting out practically as much	Chapter 9

Item No.	As specified in ToR	Complied in …
	as possible the interaction/illegal connection of domestic sewage and industrial wastewater into the storm/grey water drainage system);	
xi	Cost Estimate and phase wise investment plan. Estimate the preliminary cost for physical implementation of proposed drainage master plan and prepare of phase wise investment plan as appropriate	Chapter 8

1.6.1 Compliance Matrix to Draft MP (Sept 2022)

The draft Drainage Master Plan was submitted in September 2022. The report was revised and comments were given by PMU office. The comments are addressed in Final Report. A compliance matrix is given below.

Sl. No.	Comments on Draft Master Plan	Response by PSPS	Remarks
1	The consultants prepared draft DMP for stormwater. The grey water from household's kitchen, shower room etc. was not considered here. In the absence of a sewerage network, this grey water finds its way in drains and natural canals. If this is not considered, proposed drains work for improving drainage system will be inadequate and there will remain risk of waterlogging even after huge investment on drainage. The TOR also demands to include grey water.	Grey water comes under the broader category of 'wastewater'. It is addressed in the chapter – Greywater management.	
2	The present onsite sanitation would continue for a longtime. It will take time to have a sewerage system in NCC. So, grey water needs proper attention until NCC have a sewerage system.	Complied and addressed in the chapter - Greywater Handling and management	
3	In DDMP section 2.3.1 mentioned that the primary data was collected by a topography survey by a selected company. Consultants are requested to state quality control measures were taken?	Consultant confirm it as an acceptable quality for the said purpose.	
4	In para 2.6 it was mentioned that the area of zone was calculated along with present land use classes but no calculation of different classes of land was found in the DDMP.	Discussed in calculation of Coefficient of Runoff	
5	In para 2.10 standard value of run off coefficient of different classes of land was tabulated (Table-19) but runoff coefficient	Coefficient of runoff has been taken based on the landuse pattern as filed in Action Area Plan. Hence, PSPS	

Sl. No.	Comments on Draft Master Plan	Response by PSPS	Remarks
	of study area was not presented. Without actual filed runoff coefficient discharge may not be appropriate. Consultants are requested to present actual filed runoff coefficient of study area	has considered filed runoff coefficient of the study area.	
6	In the DDMP consultants proposed several numbers of floodgates. It is mentioned here that the canals may have connection with other water bodies at another point. In this case floodgates may not be functioned. Besides this floodgate should have pumping provisions as well. Consultants are requested to review the necessity of these floodgates.	Reviewed and recommended for provision of flood gates (flap gates considering zero operation) only at those outfalls where outfall invert is lower than median level of HWL.	
7	In DDMP it was proposed that no drains will be built in roads which have width less than 5 m. NCC does not agree with this approach. Drains should be built in all roads. If any road is found so narrow, in that case drains should be provided in the middle as a part of road in order to remove the water logging.	Revised accordingly. All roads (i.e. 100%) irrespective of its road width are proposed with drainage system.	
8	In the table-5 of DDMP the consultants proposed 30 km of 300mmx300mm new roadside drains. NCC disagree with this proposal as because drains may be crossed by service lines which will affect the capacity of drains and may not be avoided	The length of drainage system is about 625km. The minimum width is proposed to be 600mm for new proposed drains and depth varies with slope having minimum of 600mm invert depth.	
9	NCC does not want to keep any brick-built drains. The consultants are requested to propose for replacing old brick drains by RCC drains.	Revised accordingly. All drains are RCC drains/pipe.	
10	In the DDMP consultants proposed for desilting of existing blocked drains as an immediate term intervention. NCC thinks desilting/dredging of canals are also necessary. The consultants are requested to review this.	Canal rehabilitation are considered under Immediate term investment.	
11	DDMP summarized the existing drainage network by block in the Table-7. It is evident from table-7 that there are no masonry drains in NCC. On the other hand, Tables 11, 12, and 13 shows that	Inconsistencies are addressed as applicable.	

Sl. No.	Comments on Draft Master Plan	Response by PSPS	Remarks
	there are RCC, masonry, and pipe drains are in NCC. Please, check these tables.		
12	From Table-14 of DDMP it was evident that about 50% households in NCC area were affected by flood. Consultants are requested to review this and mention the source of data.	Reviewed and corrected. The source is now based on primary survey i.e. Focus Group Discussion (FGD)	
13	The consultants measured the present size of existing canals. But in reality, the original sizes of the canals would be different from present sizes. The consultants are requested to contact the survey unit of NCC to get land records of these canals. List of Khals in Table-2 should have proper name.	Complied and corrected.	
14	In DMP proposed drains list to be incorporated as i) new drains, ii) drains to be rehabilitated and iii)drains to be cleared.	Complied in this Final report	
15	The proposed drains should have reduced level (RL), ID number and length.	All details of drains, (i.e. new drains, drains to be rehabilitated, and existing drains to be cleaned), not limited to ID, RL, IL, Length, size are shown in Detail Design Report. It is not relevant for master plan having >600km drains.	Refer Detail Design Report
16	In Annex-III of DDMP the consultant listed out a total of 257.057 km drains (Siddhirganj-149.852km, Narayanganj-28.315 and KadamRasul-78.89km) which is presented in the table below. It shows that Narayanganj Zone has less drain than other. As Narayanganj is the Core city of 12.69 skm. area all road of Narayanganj Zone has side drains. This is why there are more road side drains in Narayanganj zone. On the other hand it was a total of 352.829 km drains in Table-7. So the consultants are requested to recheck the drains quantity at Narayanganj as well as at Kadamrasul Zones.	Modified with 4 drainage zones. Details are incorporated, as applicable.	Refer Detail Design Report
17	In DDMP, Highest Flood Level analysis of outfalls were not included but it is essential for a Drainage Master Plan.	Included in this Final report	

Sl. No.	Comments on Draft Master Plan	Response by PSPS	Remarks
18	Preparation of drainage Master plan is a multidisciplinary task which requires input from various areas such as urban planning, policy making, infrastructure management, hydrology, hydraulics, ecology, environment, law, sociology, economy & political support & that would match this in the contents.	Incorporated as far as possible in compliance with the ToR	

1.6.2 Compliance Matrix to Draft Final MP (June 2023)

Sl. no.	Para no.	Observations of NCC dated 07.08.2023	Responses to observations
1	1.6.1	Compliance Matrix to Draft Master Plan at clauses 3 & 6 mentioned below; Clause -3, to be shown the authenticity; Clause -6, Flap Gate is not required as the Drainage is gravity system; If it is requested to make justification.	Section 4.2.1 (Topographic survey) has been rephrased to comply clause 3 of 1.6.1. Flood Gates (Flap gate type) are recommended only at some strategic outfall locations where outfall invert is lower than median level of HWL of river. Consultants gave its professional view for its inclusion in the overall master plan proposal. NCC may consider it in future.
2	1.8	Review of previous study: DAP study is not included;	DAP has been reviewed and its relevant points are included/ referred.
3	1.10	Limitation & Assumption. i) Having drain invert level is challenge but not impossible. In such cases assumption may not be the right solution. The width of top slab is not the width of drain opening. Survey report prepared should be verified physically whether the drain sections data is authenticated. ii) Authentic data for existing culvert to be collected from Roads and Highways Department, Narayanganj.	(i) PSPS is in a view that the data available for existing drains are adequate enough for preparation of master plan. (ii) Existing culvert levels will be required during canal rehabilitation. NCC may get it from RHD.
4	1.11	Abbreviation of DFW + IDF to be included in the table.	DWF – Dry weather flow IDF- Intensity Duration Frequency curve. It has been included.
5	3.2	List of drain in the table to be mentioned in the drawing. (Fig -14, 15, 16, 17, 18) so that alignment of drain could easily understandable.	It has been clarified with additional drawings in A3 with proper references of the figures 14-18. Figures in the report are kept as it is.

Sl. no.	Para no.	Observations of NCC dated 07.08.2023	Responses to observations
6	3.11.5	SL.13,Match with summary of drainage issues and probable solutions may be taken by DAP & RAJUK.	Addressed as appropriate.
7	3.12.2	Runoff co-efficient to be checked.	It is a typographical error and corrected in this revised version.
8	4.1	Table-24, minimum drain bed width may be changed. Drain height should not be less than 750mm.	Drain height for proposed new drain is considered as 750mm where ground situation permits, and 600mm where ground situation does not permit.
9	4.2	Each ward should have at least 3 TBMs. All TBM's details should be provided in a Table in the Master Plan. At least three TBM at each Zone to be physically cheeked & shown by PSPS to PMU thoroughly.	As per the survey report 18 nos. TBMs were established for surveying in all 27 wards. These were well noted in the survey report submitted and presented in September 2022. For details Survey report may be referred.
10	5.2	Table-25, Ward wise contribution of drainage zone (catchment area) to be checked.	Rechecked and the table has been edited.
11	5.12.2	NCC area 43.98 sq.km shown to be checked whether it is authenticated.	Land area which receives rainfall has been calculated from scaled autocad map.
12	5.8	Nomenclature of out fall (374 outfalls) location to be mentioned in a table as well as in the map/drawing.	Included as an additional Annexure.
13	5.14	Specify the drain nomenclature/criteria (Primary, Secondary & Tertiary) (P, S, T) based on the width/depth. Separately all types of drawing to be mentioned in the table-24.	Included, based on width as: Primary - >1500mm Secondary - >900 upto 1500mm Tertiary – 600mm upto 900mm
14	7.10.1	Waste water Collection and Conveyance: In this section only thematic/conceptual diagram has been provided. Besides this, in zone-2 where 91 canals are available. No greywater conveyer has been provided along those canals. Moreover, zone-2 didn't cover with interception and diversion sewer. The gray water conveyer should be addressed in the water plan. The necessary design/drawing would be required for fulfilling the future plan implementation.	In principle the concept has been clearly indicated in Figure 53. Figure 55 has been substantiated by an additional drawing. The master plan conceptualized the components required for greywater conveyance, collection and treatment. NCC may get the detail designs done for master plan components in future.
15	7.10.2	Pumping station details such as capacity, infrastructure, land availability & quantity to be provided.	Capacity, quantities are given in Table 44. Land availability information is included in Table 43.

Sl. no.	Para no.	Observations of NCC dated 07.08.2023	Responses to observations
16	8.2.2	Detail alignment with section of intercepting system to be provided in detail.	Detail alignment will be shown in separate drawings.
17	8.2.3	Design capacity & cost of pumping station to be attached in detail.	Capacity is given in Table 44. Breakup of cost estimate (approximate) will be included.
18	11.1 to 11.2	The phasing and priority investment program table should have the drain segment with its nomenclature.	Each drain segment details under priority investment program are given in Detail design Report, as considered under Phase 1 components and corresponding tender documents. All phasing will be indicated in an additional drawing for better clarity.
19	Tasks not addressed	i) The name of newly proposed drain with necessary design/drawing in detail didn't mention in the Master Plan report; ii) Legislative and Institutional Arrangement; ii) EIA didn't addressed; iii) land use management; iv) desludging of septic tank; v) DAP study; vi) Mitigation measures and sophisticated technique proposed for drainage arrangement other than conventional way from water logged areas; vii) hill shade viii) All Maps and Drawings should be in minimum A2 size paper in folding shape within the report.	i) PSPS viewed that it is not a part of masterplan proposal. It has been addressed in the Detail deign documents. However, a name list has been included as an additional Annexure. ii) Institutional arrangement for Drainage sector has been included in Chapter 9. It has been elaborated by inclusion of relevant legislative aspects as appropriate and applicable. ii) Environmental aspects (also Social aspect) has been included in concise form. iii) Preparation of Landuse management plan in not considered to be a part of Drainage master plan. iv) PSPS restricts its scope to situation analysis of septic tank sludge (faecal shudge). v) DAP has been studied and relevant outcomes are referred as appropriate. vi) Inclusion of sophisticated technique is applicable only if there is water logging problem after implementation of master plan proposal. vii) Hill shade is shown in Figure 4. More clarity will be ensured. vii) All drawings are given in A3 and A0.
20	Annex-I	TOPOGRAPHIC SURVEY REPORTS should be included reduced level (RL), road/drain name (road name are available	Topographical survey report was submitted and presented in September 2022. It was also included in Detailed design report (updated) as submitted in

Sl. no.	Para no.	Observations of NCC dated 07.08.2023	Responses to observations
		in the detailed design reports) as well as important features' name.	June 2023. PSPS request to refer the reports for better understanding of topographic survey data and road names. For detailed information PSPS felt to consult Survey Report.
21	Annex-II	Only main drain list provided in the DETAILS OF EXISTING DRAINS. All drain list should be provided (road name are available in detailed design reports).	Annexure II is the list for existing drains. An additional Annexure has been included for name list of drains for proposed new and renovated drains.
22	Annex-III	EXISTING DRAINAGE SYSTEM EVALUATION report ID of drain should be provided in drawings sheet.	Has been provided in drawing sheet also.
23	Annex-VI	PROPOSED DRAINAGE SYSTEM DESIGN table with drawing sheet no. should be provided.	A table for proposed drainage system will be provided. For detailed purpose Detail Design report shall be referred.
24	Annex-VII	ESTIMATE FOR DRAINAGE WORKS has no section of drawings of drains/ culverts/ khals to be incorporated.	It has been included.

1.7 Strategy and Future Targets of NCC

1.7.1 Vision of NCC

The vision of the Narayanganj City Corporation is to develop Narayanganj City into an environment friendly, clean, healthy, safe and poverty free planned city through of necessary services to its residents.

1.7.2 Mission of NCC

The Mission of Narayanganj City Corporation includes:

- Environmental friendly Infrastructure Area development
- Solid waste management
- Less disaster, crime, traffic and boat accident
- Infrastructure Area that support industry and basic human needs
- Equity in Public service to all wards
- To build an environmentally friendly, clean, health safe and poverty free planned city through providing necessary services to the city dwellers.
    - Build Narayanganj city as a planned green city with construction of planned infrastructures for improvement of communication sustem and mitigation of water logging and drainage congestion problems
    - Ensuring environmental protection and cleanliness of the city through proper waste management;
    - Ensuring health care services
    - Ensuring good governance at all levels of the city corporation.

At present Narayanganj City Corporation provides various types of services to about one million people at different levels. This population could be doubled if the rate of population growth will continue for the next 20 years. So, considering the time limit for the next 20 years, to build a planned, clean, green, environment friendly.

1.8 Review of Previous Studies

Following are the documents consulted in view of preparation of the detail design report.

- Inception Report, prepared by the PSPS Consultant, January 2021;
- Briefing Note on Drainage, project by the PSPS Consultant, June 2022;
- Planning for Expansion for Narayanganj City Corporation Area, prepared by PSPS, Jan 2022;
- Technical Assistance Project Proposal, July 2019;
- Documents/Drawings obtained for DND through NCC;
- NCC Action Area Plan Report;
- Report on 'Drainage Problems in Narayanganj City Corporation Area under Urban Development' prepared by Urban Planner, PSP;
- Bangladesh Climate Change Action Plan;
- Sustainable Development Goals – Bangladesh Progress Report 2022-2026;
- Draft Master Plan on Drainage system in NCC, prepared by PSPS Consultant, September 2022;
- Draft Detailed Design Report of proposed drainage system in NCC;
- Service Level Benck marking System from MoEF, India.
- Detailed Action Plan, prepared under RAJUK, June 2020

1.9 Meetings and Site visits

1.9.1 Meeting with Stakeholders

Several meetings were conducted with NCC and different stakeholders-DND,RHD,WASA,BMD. Site visits were done as and when required. NCC guided the consultant teams on the local prevailing situation on drainage.An important meeting was conducted on 24th Aug 2022 with DND (Dhaka-Narayanganj-Demra) project officials, who is executing canal rehabilitation works within major part of NCC..

Meeting with NCC and DND

Meeting of NCC and PSPS

Fixing of meeting with BIWTA (responsible for constructing embankment road along the bank of Sitalakshaya river) and RHD (responsible for fixing the canal culvert level on Bandar-Madanpur Highway) was under persuasion by NCC.

1.9.2 Site Visit

The design of a drainage system is crucial in ensuring the proper disposal of rainwater and sewage in any urban area. NCC is a densely populated area in Bangladesh, which is prone to flooding during the monsoon season. A comprehensive drainage system is necessary to manage the excess water and minimize the damage caused by floods. As part of preparation of Drainage Masterplan and development and detail engineering activities, frequent site visits were carried out at various stages of design work to achieve the following objectives:

- Monitoring of Survey Work: This phase had been carried out from December 2021. It was to ensure soundness in supervising field survey work and monitor survey output. It ensured the presence of full survey team, checking of values on sample basis, providing necessary instruction in terms of data handling and gap filling etc. are some of the major activities.
- Existing Drainage Scenario Analysis: This part has been carried out in parallel with the survey monitoring work to have brief idea on NCC drainage systems, existing drain and canal outfall conditions, flow direction, major water-logged zones, DND pump activity and their impact over the NCC drainage area.
- Designing Drains: Immediately after the design work, consecutive site visits to the proposed and renovated drains were thoroughly done in order to check that the designed drainage system would work as intended, as well as the possibilities of drain construction throughout the narrow roads. Aside that, the gradient and alignment of the drains had been checked so that they would not be blocked or damaged by any obstructions in the area.
- Landmark: It is always important to properly mark the drains that are to be proposed and renovated. This was done with appropriate landmark such as: road name, mosque, school name, institutions and other popular location in order to ensure convenience of location tracing while construction/ supervision ongoing. Separate site verification was carried out to undergo this activity.

Site Visit and Verification

Verification of Level

The site visits helped in achieving the following outcomes:

- Precision of Data: Survey data contained significant amount of errors in levels and missing drains of existing drainage systems which were later adjusted based on the data obtained from site check.
- Improved Drainage System: The site visit helped in identifying areas where the water was accumulating and assessing the reasons behind it. This helped in designing the drains in such a way that the water would flow smoothly towards the main drainage system.
- Effective Monitoring: Site visits helped monitoring the construction work and ensuring that the drainage system was being built according to the design specifications. This helped in identifying any

deviations from the design and taking corrective actions to ensure that the system would work effectively.

The information gathered during the site visits was used to prepare the master plan and to design an effective drainage system that would minimize the damage caused by floods and ensure the proper disposal of stormwater and sewage in the city. It would also reduce the challenges during construction. All the concept/design modifications were done as per feedbacks from site.

1.10 Limitations and Assumptions

- The existing drainage system has significant deposits of silt, muck and even construction debris. In some cases, getting actual invert level data of these existing drains through survey activity was a challenge. In such cases during survey the section of existing drain was taken from the top as the RCC drain slab cover as it was difficult to remove and reinstated, and then slab thickness was deducted to get the depth of drain. Due to siltation invert data was analysed to have inconsistencies in some cases, where logical assumptions have been prioritized over existing data.
- The proposal part of this document has been done based on the available data, primary topographical survey conducted in 2021-22 and site visits. The Consultant team gave honest effort in the analysis of the ground situation and framing up of the design proposals. During preliminary design validation of all designed data at site level it was observed that NCC has been currently engaged itself in constructing new small drains and extending its drainage system. It can be considered as a continuous process. In such situation it was not possible to validate all tertiary drains which are under continual updation. However, the primary drains were validated by the consultant. It is assumed that validation for all drains shall be conducted at the pre-construction stage.
- The Bandar-Madanpur highway is under maintenance and widening. This project has been taken up by the Roads Department, where several canal culverts are under construction/ rehabilitation. The invert of the culvert is likely to influence the proposed invert of the canal. In absence of authentic data of culvert the designed value for the canal, designed output of canals have been considered. Culvert data (after construction) will be required during canal rehabilitation work.
- Majority of the khals (or canals), mainly under drainage zone-2, belongs to DND. These khals are under rehabilitation project implemented by DND. No official document on proposed khal details were made available to PSPS. The drain design in this drainage zone assumed the khal details which were obtained during several discussions with DND.
- The network design has been done by SewerGems software and Excel spread sheet in parallel. The software has a limitation to accept more than a specified number of stretches. In Zone-2 the design was done by SewerGems which allowed a maximum number of stretches. Hence, a substantial road network (of smaller width) were left out from being included in the software. These left out stretches were taken from survey drawing and put separately in excel output and its size was determined.
- Ward boundary areas as obtained from survey data does not match as given in NCC website. In this case, data of primary survey has been considered.

1.11 Methodology Used in the Preparation of the Drainage Masterplan

Precipitation data for Narayanganj for the period 2003 to 2020 was collected from BMD Dhaka station for 3h continuous interval. This was analyzed using the Least square method to develop Rainfall IDF curves.

A hydrologic model was then developed to predict the volume of flow generated at any point in a drainage basin based on rainfall data. For this purpose, each drainage basin in the study area was sub-divided into sub-catchments at a certain number of nodes. A node represents a location where runoff rates were calculated. Nodes were located at critical drainage facilities and points in the study area. All nodes were be designated based on the drainage sub-catchments contributing to them. Design flow calculations were based upon the assumption that upstream drainage areas (catchment areas) have reached maximum allowable development.

Flow in storm drains was modeled using Manning's equation and the design discharge data generated from the hydrology model. From the hydrologic analysis, runoff flow rates will be computed at each node for the appropriate design storms. The runoff will be assumed to enter the drainage channels at node locations. Within the hydraulic model, the flow that enters at each node location will be assumed to be flowing through the entire upstream length of the channel.

Design discharges obtained were compared with the carrying capacity of the existing drains. Where existing sections were found inadequate, standard drain sections were adopted for discharge purposes.

Analysis of drain invert levels was carried out from upstream to downstream considering outfall invert levels. Level and bed slopes of the drains were fixed as per the level of outfalls, to allow discharges to pass by gravity flow.

Wherever possible, existing drains should be rehabilitated after de-silting. Where the discharge capacity is found to be inadequate, they shall be augmented as indicated by the hydraulic design. Where the drains are damaged, appropriate repairs will be proposed.

The corresponding flow chart is shown in Figure below.

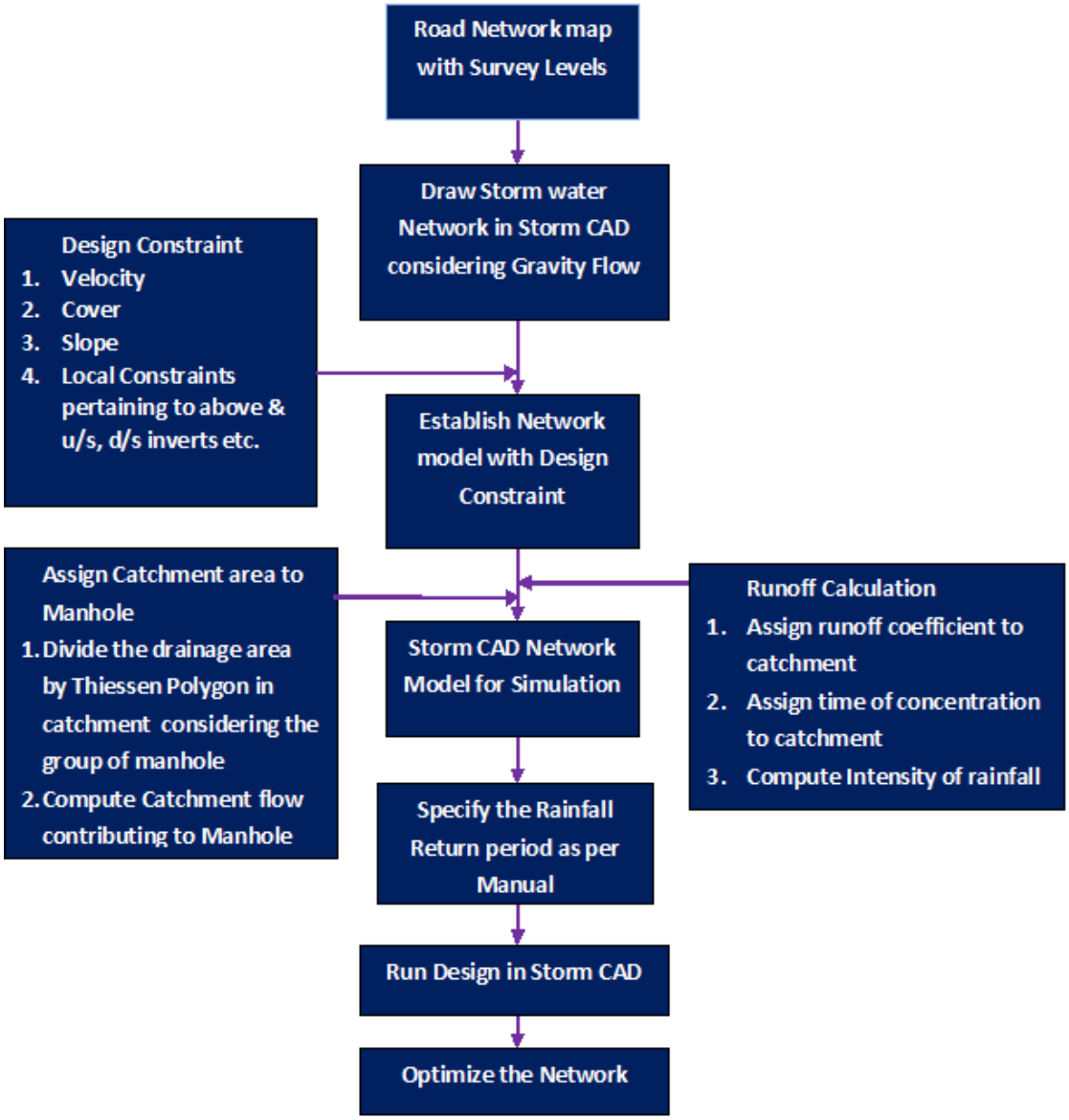


Figure 1 - Flow Chart of Methodology

2 ABOUT NARAYANGANJ CITY CORPORATION

2.1 Evolution of Narayanganj City Corporation

Narayanganj has a rich history dating back to the Mughal era. The city's administrative setup evolved over time, with the establishment of local bodies such as the Municipality Committee in 1876 and the Town Committee in 1901. The city underwent significant changes during the British Raj, with the construction of the first railway line in 1888, linking it to Kolkata. In 1985, Narayanganj was declared a municipality, and in 2011, it was upgraded to a city corporation, becoming the fifth city corporation in the country. The city corporation covers an area of 33.78 square kilometers and is responsible for providing essential services such as waste management, water supply, and road infrastructure. Over the years, the city corporation has faced several challenges, including rapid urbanization, population growth, and inadequate resources. To address these challenges, the city corporation has taken various measures, such as formulating development plans, improving service delivery, and engaging with the community through participation and partnership initiatives. Despite these challenges, Narayanganj City Corporation has made significant progress in promoting sustainable urban development and improving the quality of life for its residents.

2.1.1 Description of the Planning Area

RAJUK's jurisdiction extends over approximately 1528 sq. km. (590 sq. miles) comprising 26 Strategic Planning Zones. For the purpose of preparation of the Detailed Area Plan (DAP), the whole of RAJUK area has been divided into 5 groups (within these 5 groups are included the 11 locations for which initiative to prepare DAP was taken earlier).

The project area of Group B covers about 50663.67 acres of land and includes Strategic Planning Zones Nos. 9.1 (Narayanganj West), 9.2 (Narayanganj Fringe East), 9.3 (Kadam Rasul Paurashava), 10 (Narayanganj), 11.1 (DND: Dhaka-Narayanganj-Demra-Triangle South), 11.2 (DND: Dhaka-Narayanganj-Demra Triangle North) and 19 (RAJUK East).

Group-B has common borders with Groups-A, C and Locations-5 and is separated with Group-D area by the Dhaleswari river. Group-B constitutes the south, south-eastern, south-western border of RAJUK's jurisdiction area[2]. Project location is shown in Figure 1.1

Figure 1.1 – Location of DAP Group B Area (NCC)

[2] Source – Copied from DAP 2010

2.2 NCC Administrative Area

2.2.1 Future Expansion Areas

The Drainage Master Plan covers the period until 2046. However, the extended areas of NCC outside the current city boundaries, much of which lies in DND area, will be addressed in a future phase as hereunder:

If the courses/path of the rivers (i.e. outfall of all drainage systems) around NCC and its neighbouring areas - (i) BuriGanga-Dhaleswari, (ii) Shitalakshya, (iii) Brahmaputra, and (iv) Meghna, are studied, it appears that they are running almost parallel and converging at the southernmost confluence at Meghna. A 'hypothetical watershed line' can be drawn for each catchment area, as shown in Figure below.

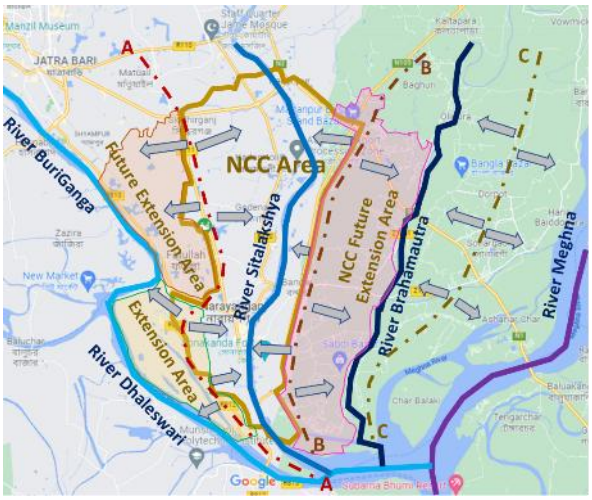


Figure 2 – Watershed line

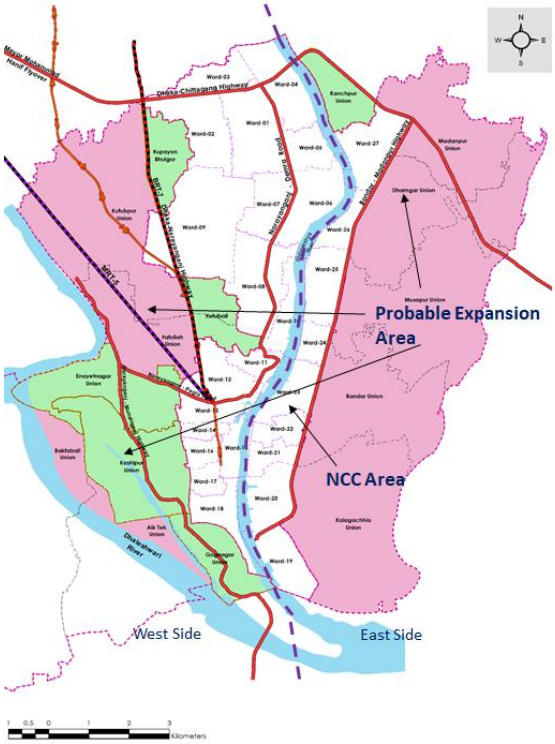


Figure 3 – Probable Expansion of NCC

It can be seen that:

- The watershed line alignment between catchments BuriGanga-Dhaleswari rivers and Sitalakshaya river, i.e. A-A, is more or less matching the western boundary of NCC. Hence it may be assumed that the storm runoff from the eastern side of the watershed line A-A will flow through the NCC area to the Sitalakshaya river. The storm runoff from the western side of the watershed line A-A will flow through the NCC expansion area (future) to the Dhaleswari river.
- In the east of Sitalakshaya river Bandar-Madanpur Road runs parallel to the Sitalakshaya river and makes the eastern boundary of NCC. It is also an embankment road and has a proposal for further widening due to a new bridge over the river at Madanpur. It may be considered as the watershed line B-B.In such case it may be assumed that the storm runoff from the western side of the watershed line B-B will flow through the NCC area to the Sitalakshaya river. The storm runoff from the eastern side of the watershed line A-A will flow through the NCC expansion area (future) to the Buriganga river.

Hence it can concluded that the present NCC area is located in the Shitalakshaya river basin within two parallel well defined watershed lines (A-A and B-B). As such there would be no drainage (storm runoff) influence from the outside NCC (i.e. NCC expansion areas). Regardless, provision of a lump sum amount has been made in the Priority Investment Plan for such future interventions.

As there is currently no development plan for the extension areas, it is not possible at this stage to propose a drainage layout therein.

2.3 Population

Current and projected population of Narayanganj until 2046 are given in Table below

Ward No.	Area (sq.km.)	2021	2026	2031	2036	2041	2046
Ward-01	3.7	49897	58267	67041	79454	92782	108345
Ward-02	3.5	34888	45740	47574	55554	64873	75755
Ward-03	2.1	49018	51240	60841	67054	69146	69435
Ward-04	3.7	31888	37237	44483	50777	62294	73241
Ward-05	2.1	25119	29333	34252	39998	46708	54543
Ward-06	3.2	34227	33333	38253	41999	53708	76543
Ward-07	2.6	29847	34853	40699	47526	55498	64808
Ward-08	3.4	58232	63999	75405	91725	100279	105442
Ward-09	6.1	37006	44213	56461	68926	88810	112352
Siddirganj Administrative Area	30.4	350,122	398,215	465,009	543,013	634,098	740,464
Ward-10	1.6	27939	34625	42098	48988	57451	73165
Ward-11	1.7	33477	40092	47649	57806	67748	85189
Ward-12	1.6	54800	62991	72725	85260	96897	108989
Ward-13	2.2	64198	73966	85541	98225	115372	129396
Ward-14	1.3	40133	45864	52725	60905	70624	77142

Ward No.	Area (sq.km.)	2021	2026	2031	2036	2041	2046
Ward-15	1.6	32858	39369	46805	56820	66597	83845
Ward-16	1.5	47039	53929	62143	70903	83467	92139
Ward-17	1.4	48433	55557	64043	72122	85058	95165
Ward-18	2.1	41568	49541	58683	70691	82794	102759
Narayanganj Administrative Area	15.0	390,445	455,934	532,412	621,720	726,008	847,789
Ward-19	2.7	16,121	18,824	21,982	26,169	30,975	37,003
Ward-20	3.3	24,105	28,147	32,869	38,383	44,821	53,339
Ward-21	2.7	30,240	35,311	41,235	48,151	55,228	63,660
Ward-22	2.6	41,901	46,929	55,137	62,721	74,913	80,982
Ward-23	3.6	41,688	48,681	56,847	66,382	76,517	85,520
Ward-24	2.7	27,692	32,337	37,761	44,095	50,492	59,129
Ward-25	3.0	17,231	20,120	23,996	27,937	32,039	39,413
Ward-26	2.6	9,289	12,847	13,666	16,791	20,272	27,669
Ward-27	3.9	18,467	21,565	25,682	30,406	36,339	45,599
Kadam Rasul Administrative Area	27.0	226,734	264,761	309,175	361,035	421,596	492,314
Total	**72.4**	**967,301**	**1,118,910**	**1,306,596**	**1,525,768**	**1,781,702**	**2,080,567**

Table 2–Population Projection Data of NCC

2.4 Socio-economic Condition

Narayanganj City Corporation (NCC) is a densely populated city, with an estimated population of over 1.5 million people as of 2021. The city is a major industrial hub, with the ready-made garment (RMG) industry being the largest contributor to its economy. According to the Bangladesh Bureau of Statistics (BBS), the RMG sector in Narayanganj employs around 400,000 workers and generates over USD 4 billion in export earnings annually.

Despite the city's economic growth, poverty remains a major issue in NCC. The poverty rate in Narayanganj stands at around 22%, which is higher than the national average of 20.5%. According to the World Bank, the urban poor in Narayanganj face challenges in accessing basic services, such as water and sanitation, health care, and education. In addition, the COVID-19 pandemic has further exacerbated the socio-economic conditions of the city's poor, with many losing their jobs and struggling to make ends meet.

The government of Bangladesh has taken several steps to address poverty and improve the socio-economic conditions of NCC. The government's social safety net programs, such as the Vulnerable Group Development (VGD) program and the Employment Generation Program for the Poorest (EGPP), aim to provide income support and skills training to the poor. The government has also invested in infrastructure development, such as upgrading the city's water supply and sanitation systems and constructing new roads and bridges.

Despite these efforts, more needs to be done to reduce poverty and improve the socio-economic conditions of Narayanganj. The government and development partners can work together to provide more targeted support to the urban poor, improve access to basic services, and promote inclusive economic growth. Through these measures, NCC can continue to develop into a thriving and sustainable city that benefits all of its residents.

2.5 Topography of NCC Area

Narayanganj City Corporation (NCC) is located in the central part of Bangladesh and covers an area of approximately 47 square kilometers. The city's topography is relatively flat, with an average elevation of around 5 meters above sea level. The region is intersected by several rivers, including the Shitalakshya and Dhaleshwari, which are vital sources of water for the city. The NCC area is also characterized by several low-lying areas that are prone to flooding during the monsoon season. According to recent statistics, around 16% of the city's total land area is considered flood-prone. The flat terrain of the city, coupled with its proximity to the rivers, makes it an ideal location for agriculture. However, due to urbanization and population growth, the area devoted to farming has decreased over the years. The topography of the NCC area, combined with its location near the capital city of Dhaka, has made it an essential contributor to the country's economy. Flat terrain and water resources display ample opportunities for future development and growth.

Topography of NCC, to be specific west Shitalakshaya river under NCC area, and its adjoining areas can be described as bowl shaped. It is elevated at the edges near the rivers flowing east and west of NCC and its adjoining unions, and down at the middle portion. The present topography is either natural or due to man-made activities, i.e. construction of embankment roads (Demra-Narayanganj Road, Dhaka-Munsiganj Road). The elevation of NCC area varies from 3.5 m msl to 7.5 msl(average).

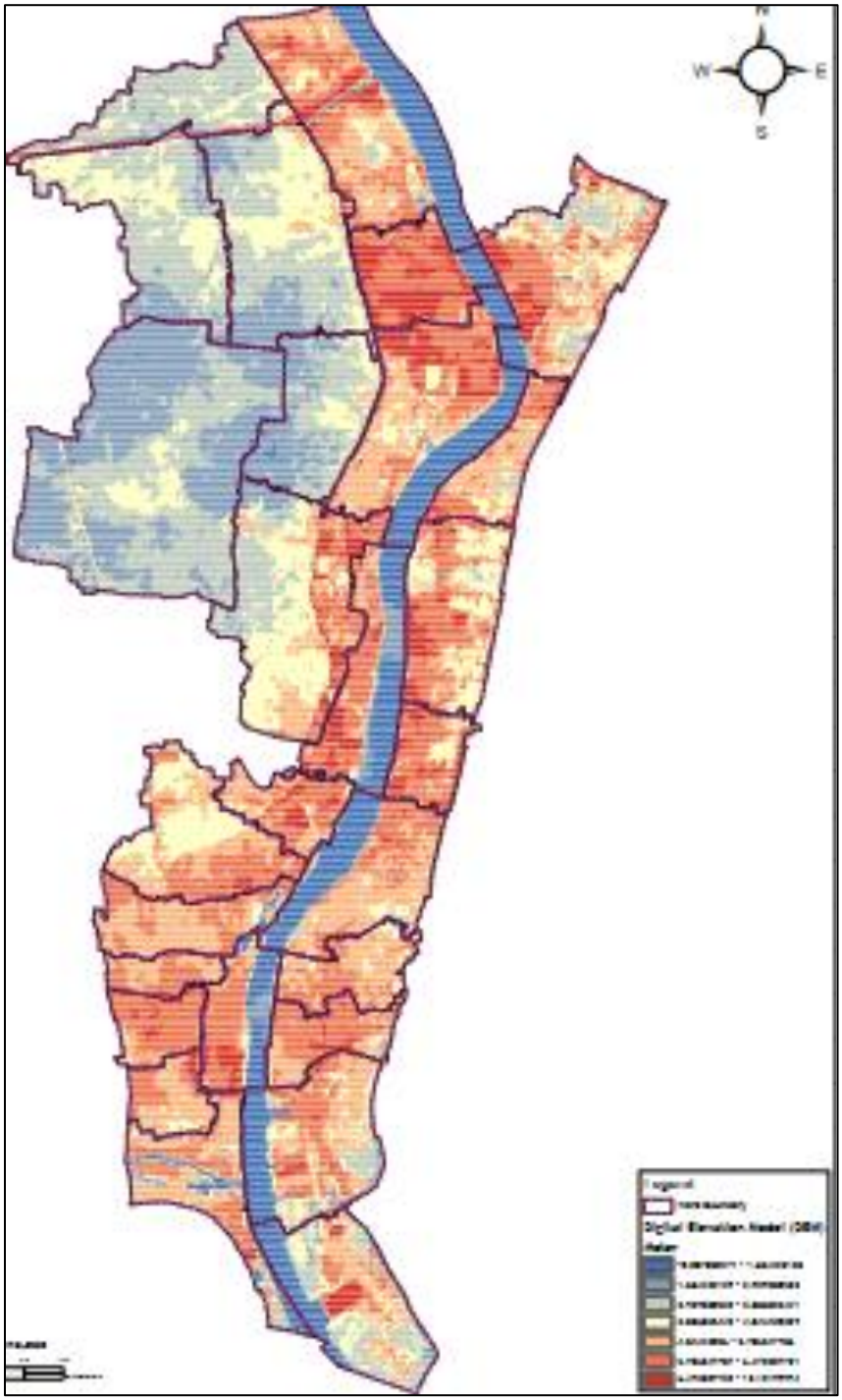


Figure 4 – Cadastral Representation of Topography of NCC

The maps on (i) Physical Feature Survey and (ii) Contour are shown below. These were prepared during preparation of the Action Area Plan for NCC in 2016[3].In the maps, blue lines (deep blue patches) are low elevation areas and yellow/light brown lines are higher elevation areas. This evidence natural slope towards the west and away from the river. From recent survey data it has been validated and found to be in line.

[3] Source – Report on 'DRAINAGE PROBLEMS IN NARAYANGANJ CITY CORPORATION AREA AND URBAN DEVELOPMENT' prepared by Urban Planner PSPS

2.5.1 Contour Map of NCC Area

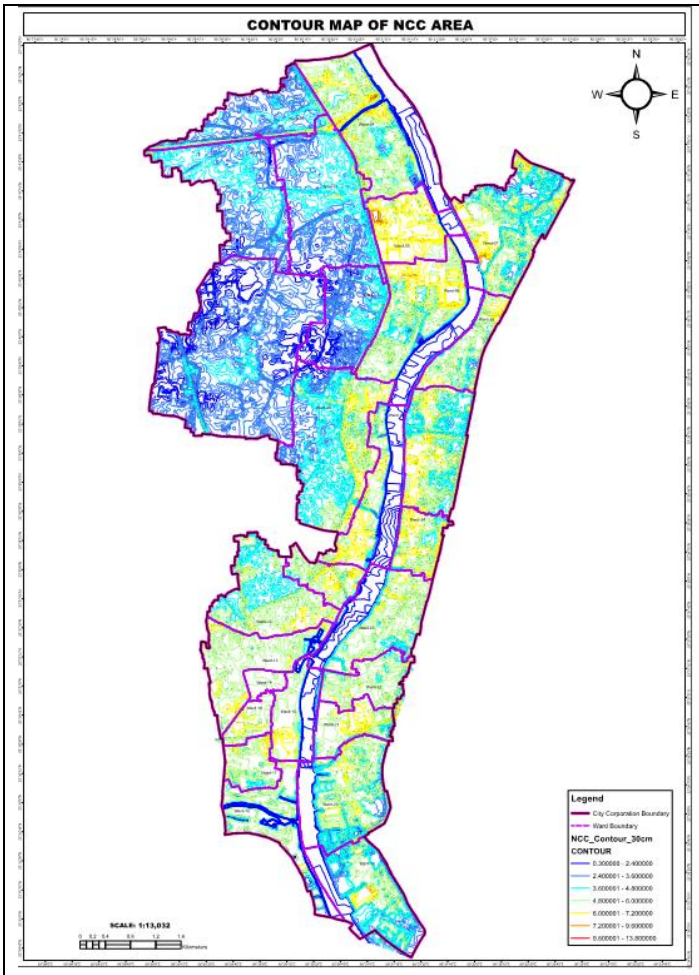


Figure 5 - Topography Nature Map of NCC Area

Figure 6 - Contour Map of NCC Area

2.6 Geology and Ground Water

2.6.1 Geological Features

Narayanganj area boasts a diverse range of geological formations. The region primarily sits on the alluvial plains of the Brahmaputra-Jamuna River system, which is renowned for its rich sedimentary deposits. Additionally, Narayanganj is located on the edge of the Madhupur Tract and the Holocene floodplain deposits from the aquifers, making it a terrace that ranges from one to ten meters above the adjacent floodplains. Although it is of Pleistocene age in its present form, its origin may be in the late Miocene. The Madhupur Tract's soils, which have developed largely on Madhupur Clay, are nutrient poor and somewhat acidic, typically red or brown in color. The region is dissected with narrow or broad valleys extending deep into the level landscape, and the drainage pattern is clearly dendritic. The major geographic units of Narayanganj are the high land or terrace, the low land or floodplain, depressions, and abandoned channels. The area is also characterized by extensive deltaic deposits, which have been formed over time as the river system has shifted its course. The dominant soil type is gray to dark gray alluvium, which is highly fertile and ideal for agriculture. The Narayanganj area is also rich in mineral resources such as limestone, clay, and sand, which are extensively used in the construction industry. The presence of these resources has contributed to the growth of industries such as cement, brick, and ceramics in the region. The region's

natural environment and the socioeconomic activities of the people living in the area are closely linked to the geology of the Narayanganj area.

2.6.2 Ground Water

In 2010, the groundwater level was found within 51 feet, which went under 142 ft in 2021. A total of 91 feet lowered in 10 years.

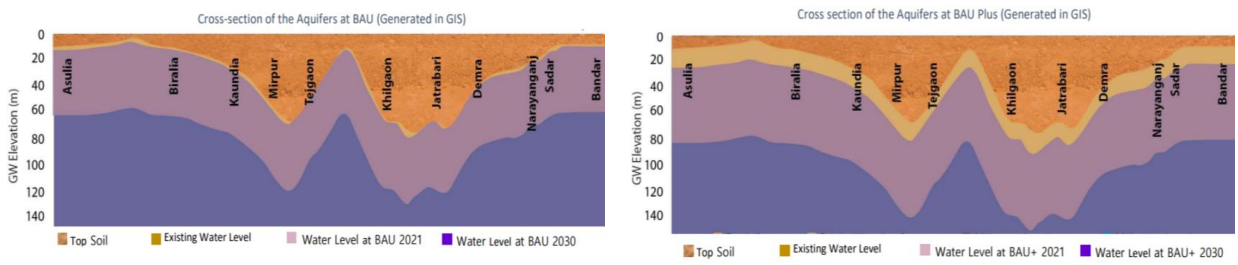


Figure 7 – Aquifer Cross-sections

2.6.3 Physiographic

Physiography of NCC area lies on the flats of Ganges-Brahmaputra-Meghna alluvial plain and is flanked by the Sitalakhya River on the east and the Buriganga River on the south and south-west. The dominant topographic elements are mid channel bars, ridges, inter-ridge depressions and basins, char land, active streambeds and abandoned channels. Drainage is provided by natural rivers and streams and a network of man-made canals (khal).

Figure 8– Physiographic Map ->

2.6.4 Earthquake Zone

Narayaganj falls under Zone2 Seismic zone, which is defined as moderately to intense.

Figure 9– Seismic Zone Map ->

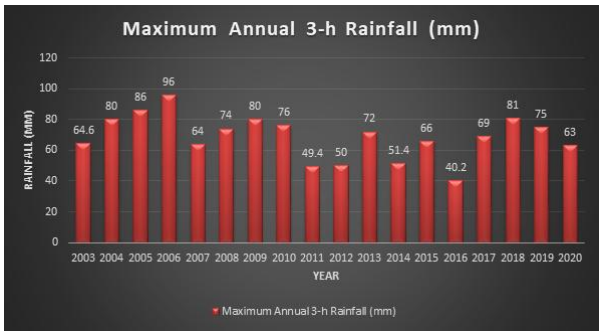
2.7 Climate

The impact of climate change is expected to have minimal effects on the annual average rainfall in Narayanganj, according to the Bangladesh Climate and Disaster Risk Atlas. The spatial distribution of rainfall is expected to remain relatively constant throughout the 4-decade period from 2011 to 2050. However, minor changes in precipitation are expected to occur in districts in the north-western and eastern parts of Bangladesh, while the rest of the country is unlikely to experience any significant change in annual average rainfall. The annual average rainfall in Narayanganj is expected to remain in the range of 3.01 - 5.21 mm/day for the next 30 years, which is the duration of the project. However, annual extreme rainfall is expected to exhibit a wide variation in rainfall with respect to the base year 2011, showing a decreasing trend in 2021, an increasing trend in 2031, and another decreasing trend in 2041-2050 for central and western Bangladesh. The annual extreme rainfall in Narayanganj is expected to remain rangebound between 11.02 and 16.20 mm/day for the next 30 years.

There is an anticipated increasing trend in rainfall from the north-western to the southern portions of Bangladesh. Similarly, there is a significant increase in annual extreme rainfall expected for the districts in northeast Bangladesh. These changes in rainfall patterns may affect the construction industry in Narayanganj, and necessary measures should be taken to ensure worker safety during adverse weather conditions.

2.7.1 Rainfall Data

(Bangladesh Meteorological Department, BMD has kept Daily Rainfall Data before 2003. Presently it keeps records of 3-hourly Rainfall data since 2003. As it has no Rainfall data station in Narayanganj, data of the nearest Rainfall data station, Dhaka will be analyzed to achieve Maximum Hourly Rainfall and used in the project area for design of drains/canals.



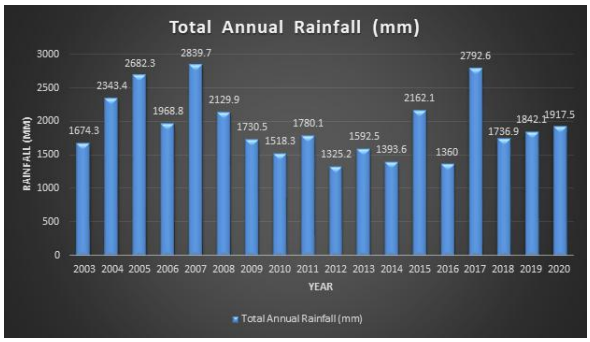


Figure 10 – Yearly Rainfall (Bar graph Representation)

2.7.2 Temperature

Narayanganj, a city located in central Bangladesh, falls under the NCC area and experiences a sub-tropical climate with warm temperatures throughout the year. The annual average temperature varies from a maximum of 36°C to a minimum of 12.7°C. The hottest months are from April to October, with temperatures ranging from 26°C to 35°C or higher. The monsoon season from June to September brings relief to the scorching heat with occasional showers and lower temperatures. However, the high humidity levels make the weather feel hotter than it actually is. The average annual rainfall in the NCC area is 2376 mm, with distinct dry and rainy seasons. Wind direction changes by the month, with northwest, south, and northeast winds being predominant. These meteorological components like humidity, temperature, sudden

rainfall, and wind speed can affect construction work in the area. High winds can cause quick spreading of dust generated from construction activities, and working during rain and high winds can increase the risk of injury. Moreover, working under high temperature and excess humidity can be challenging and may lead to dehydration problems. Therefore, it is essential for people in Narayanganj to take necessary precautions to protect themselves from adverse weather conditions.

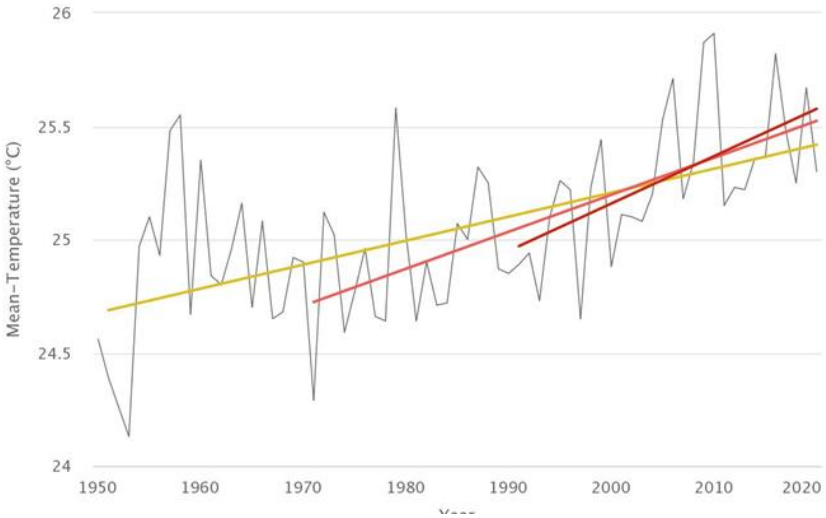


Figure 11 – Decadal Temperatue Change

2.7.3 Evaporation

Narayanganj, a densely populated city in Bangladesh, experiences a significant amount of evaporation due to it's geographical location and climate. The city is situated on the banks of the river Shitalakshya, and it's proximity to the Bay of Bengal also contributes to it's humid tropical climate. The average temperature in Narayanganj ranges from 26 to 34 degrees Celsius, and the relative humidity is often around 80-90% throughout the year. These conditions create ideal circumstances for evaporation to occur, particularly during the dry season, when precipitation is scarce. Statistical data suggests that Narayanganj experiences an average annual evaporation rate of around 1,500 to 1,800 millimeters, which is relatively high compared to other cities in Bangladesh. This high rate of evaporation has significant implications for water management in the area, as it reduces the available water resources and increases the risk of drought. Therefore, it is crucial for policymakers and water management authorities to take this factor into account while planning and implementing water management strategies in Narayanganj.

2.8 Soil

The soil of the Narayanganj area is predominantly gray to dark gray alluvium, which is highly fertile and ideal for agriculture. The soil's nutrient content is suitable for a range of crops, including rice, wheat, jute, and vegetables. According to the Bangladesh Bureau of Statistics, the Narayanganj district has a total area of 760.38 square kilometers, of which 62.28% is cultivable land. The district is known for its rice production, which is one of the major agricultural products in the region. The district produced 443,051 metric tons of rice in the 2019-2020 fiscal year, with an average yield of 3.82 metric tons per hectare. In addition to rice, the area also produces significant quantities of wheat, jute, and vegetables. The district produced 49,035 metric tons of wheat, 14,279 metric tons of jute, and 22,562 metric tons of vegetables in the same fiscal year. The soil type in the Narayanganj area is predominantly gray to dark gray alluvium,

which is derived from the Brahmaputra-Jamuna River system's sedimentary deposits. The soil is nutrient-rich and has a pH value of around 6 to 7.5, which is ideal for agriculture. The region is also characterized by Madhupur Clay soils, which are nutrient-poor and somewhat acidic, typically red or brown in color. These soils are not suitable for agriculture and are mostly used for afforestation purposes. In conclusion, the Narayanganj area's soil is highly suitable for agriculture, making it one of the major agricultural districts in Bangladesh. The region's fertile soil and favorable climatic conditions have contributed significantly to the growth of the agricultural sector and the overall development of the area.

2.9 Existing Landuse

The land use in the NCC area is dominated by residential and commercial activities, with around 54% of the city's land area used for settlements and 17% used for commercial purposes. The remaining land area is used for various purposes, including industrial activities, educational institutions, and public spaces.Land use within the city has been divided into fifteen broad categories as set out in Table below:

Land Use	Area In Acre							
	Block1 Wards	Block2 Wards	Block3 Wards	Block4 Wards	Block5 Wards	Block6 Wards	Grand Total	%
Administrative	56.83	54.88	90.88	161.80	67.71	93.48	525.59	4.51
Agricultural	11.79	4.37	367.27	68.37	95.33	111.77	658.90	5.66
Commercial	17.12	12.90	35.43	35.24	10.72	63.26	174.68	1.50
Community Facilities	6.45	4.69	15.81	8.62	6.55	13.05	55.18	0.47
Education/Research	7.83	18.68	11.79	14.18	6.70	15.39	74.58	0.64
Health Facilities	0.27	1.95	2.03	0.20	0.00	0.02	4.47	0.04
Industrial	42.50	32.94	187.90	166.40	80.93	75.76	586.43	5.04
Miscellaneous	2.37	16.2	63.85	18.48	15.10	15.15	131.16	1.13
Mixed Use	330.21	340.68	594.24	631.10	151.43	302.55	2350.21	20.19
Open Space	36.55	20.76	183.52	143.47	118.88	84.46	587.64	5.05
Recreational Facilities	4.50	8.08	11.29	3.63	2.99	17.97	45.47	0.39
Residential	271.36	196.50	1033.19	927.48	353.19	686.80	3568.51	30.68
Restricted	4.50	4.15	7.83	21.40	38.30	9.34	85.52	0.73
Transportation andCommunication	15.96	6.20	12.18	17.49	8.87	8.38	69.09	0.59
Water body	206.52	94.89	1017.23	539.75	303.90	562.31	2723.68	23.40
Total	1013.75	917.89	3634.46	2757.64	1260.68	2056.70	11641.11	100

Table 3–Existing Land use

2.10 Road Network

Narayanganj city is connected with other district of this division by few numbers of regional roads like Narayanganj Link Road, Panchabati-Munshiganj Road, Madanpur-Madanganj Road and Narayanganj-

Demra Road etc. NCC is served by Dhaka-Chittagong Highway (NH-01) at Siddirganj side. Dhaka-Chittagong Highway connects the city with the capital and other cities of the country. MuktiSarani (R-111) creates connection Narayanganj Core area with Dhaka-Chittagong Highway at Sign Board Intersection. Bandar-Madanpur Highway (R-113) creates connection with KadamRasul area and Dhaka-Chittagong Highway at Madanpur point. Demra-Narayanganj Road has connected Siddirganj area with Narayanganj city. Bangabandhu Road and Nawab Salimullah Road are the two major roads within the city area. Those two roads and SuktiSarani are traverse into Chashara Intersection which is most important intersection of the city.

According to the Action Area Plan published in 2016, NCC is served by a road network of 609.43 km. As per construction materials point these roads are divided in to katcha (34%), pucca (52%) and semi-pucca (14%) category.

According to the drainage toposurvey carried out by PSPS in 2021, Total length of Roads within Narayanganj City Corporation boundary is about 625km.

2.11 Water

Sources of the existing water supply are surface water and ground water. There are 2 surface water treatment plants at Godenail and Sonakanda which draws water from Shitalakshyariver, supplemented with 31 borewells, from where water is directly supplied in the distribution system. The treated water from treatment plants is stored in existing 9 nos Overhear Tanks/Tower (OHTs).

Godenail water treatment plant was commissioned the year 1990, with a production capacity of 45MLD. The footprint of the treatment system was accommodated within an area of 21000 sqm and located at the west bank of the river. Presently it is claimed to be in operation with half of its installed capacity.

Sonakanda water treatment plant is comparatively a new plan and was commissioned the year 2015. Its production capacity of 12MLD, but as per local operator (tertiary information) it is running at around than 50% of its capacity. It is a compact plant within an area of 700 sqm., apparently encroached substantial part of road width, thus restricted local conveyance system.

In addition to it, almost all houses, deprived of piped water supply, have facilities for private tubewells. The existing tube wells are to be phased out in accordance with Government of Bangladesh (GoB) environmental policies.

2.12 Natural Canals

The length of the natural canals within the City Corporation is given in Table below:

Type of water body	Length of water body (km)	Major constraints
River	35	i. Encroachments of natural canals
Lake	0.62	ii. Uncontrolled and indiscriminate disposal of solid wastes in khals and drains
Canal	55.5	
Borrow pit	8	iii. Absence of effective surface drains

Table 4–Water Body Coverage in NCC

2.13 Storm Water Quality

2.13.1 River Water Quality

BOD fluctuations over annual periods from 2016-2020 are shown in Table below: a maximum value of 49 mg/l has been recorded in March 2020..

MM YY	Jun	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	-	-	-	18.0	8.0	20.0	2.6	1.2	2.8	2.2	7.8	8.8
2017	20.4	36.5	36.6	12.2	12.2	-	2.8	0.5	-	2.8	8.2	12.3
2018	20.4	24.6	18.4	-	6.8	-	-	2.0	2.4	2.8	5.8	9.6
2019	-	30.0	-	12.0	10.0	10.0	3.0	9.6	4.8	2.4	-	11.0
2020	10.0	19.0	49.0	9.6	9.6	9.6	10.0	-	-	14.0	8.0	18.0

TSS fluctuations over annual period 2016-2020 are shown in Table below: A maximum value of 147 mg/l has been recorded in March 2017.

MM YY	Jun	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	-	-	-	42.0	22.0	14.0	41.0	89.0	40.0	34.0	18.0	28.0
2017	73.0	147.0	145.0	17.0	77.0	-	25.0	32.0	-	19.0	17.0	20.0
2018	73.0	44.0	86.0	-	24.0	-	-	86.0	25.0	19.0	19.0	19.0
2019	-	43.0	-	10.0	8.0	16.0	12.0	34.0	20.0	187.0	-	11.0
2020	38.0	45.0	24.0	14.0	14.0	20.0	24.0	-	-	21.0	15.0	15.0

Dissolved oxygen fluctuations over annual period 2016-2020 are shown in Table below: A minimum value of 0 mg/l has been recorded in Jan and Mar 2020.

MM YY	Jun	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	-	-	-	0.0	0.2	1.7	4.5	5.2	5.1	4.8	4.8	2.0
2017	0.0	0.0	0.0	2.8	0.4	-	4.7	7.0	-	5.0	3.8	0.0
2018	0.0	1.0	0.0	-	2.1	-	-	5.8	5.7	5.0	5.0	2.3
2019	-	0.6	-	1.0	1.4	1.0	3.0	4.2	4.6	4.5	-	1.0
2020	0.0	0.0	0.0	1.3	1.9	3.5	4.5	-	-	2.9	1.6	0.8

Table 5–River Water Quality

Manganese concentrations routinely exceed permitted levels.

2.13.2 Drain/Khal Water Quality

Samples of drain/khal water were taken at 6 points within the network and the results are tabulated in Table below:

Location/ Parameter	B.K. Road	Tribeni Canal	Godenail	School Ghat	Alomjinaghar	Ekrampur Khal	Adamjhee Road Drain	Haripur Khal	Shimrail	Allowable for Discharge in Inland Waters
pH	6.55	6.77	6.62	7.26	6.65	6.77	6.82	6.61	6.55	6-9
DO	3.94	3	3.4	3.87	3.52	3.51	2.24	4.3	3.6	4.5-8
BOD	136	3.5	144	8.8	3	272	30	4.5	200	50
COD	229	12	354	35	15	409	106	16	335	200
TSS	76	60	48	15	26	131	24	20	173	150
NO3-N	0.5	0.3	0.7	0.2	1.6	0.8	0.3	1	0.3	10
NH3-N	32.5	0.65	42	4.05	0.2	53	11.5	1.3	23.75	50
Phosphorous	13.6	0.37	17.2	2.65	0.37	23.3	5.2	1.25	11.25	
Chromium	-	-		-	-	-	-	-	-	0.5
Fecal Coliform	-	-		-	-	-	-	-	-	
Mercury	0.0022	-	0.006	-	-	-	-	-	-	0.01
Nickel	-	-	-	-	-	-	-	-	-	
NH4-N	34.4	0.69	44.5	4.3	0.21	-	12.2	1.4	25.1	

Table 6–Drain/Khal Water Quality

2.14 Sewage and Household Waste Disposal

From a visual inspection of selected properties, it would appear that a significant proportion of the approx. 30,000 household water connections are discharging their domestic wastewater directly to the stormwater drainage system, instead of to properly constructed septic tanks. Where septic tanks do exist, these are often old and require desludging with the result that they overflow directly to the drainage system during rainfall events. Furthermore, local people regularly dispose of their household water to the drainage channels causing frequent blockages. Some khals are not connected to primary canals or have inadequately sized drainage outlets and culverts. During site visits it was noticed that there has been encroachment of canals by unauthorized buildings land fill. Construction of innumerable culverts and bridges on primary and other drains and canals without any regulation in the size and number of vents further obstruct the flow. Examples of these are shown in Figure below.

Lack of coordinated and planned drainage maintenance programs to effectively maintain the drainage system is also important.

2.15 Solid Waste Management

Solid waste is dumped on the canals in an indiscriminate manner. It has a direct adverse effect on proper functioning of the drainage system. There is no proper system of solid waste management (SWM). A separate study on SWM is of utmost important.


2.16 Industry

2.16.1 Industrial Discharges

According to the Bangladesh Bureau of Statistics, the total number of industrial units is 2,408. However, the estimated number discharging untreated wastewater into the drainage system is estimated at 50 – this is borne out by the khal water quality test results which show little industrial pollutants in the drainwater.

Narayanganj City Corporation is an important administrative body in the central region of Bangladesh. The city of Narayanganj is known for its major industries such as jute, textile, and garment factories, which have significant impacts on the city's economy and the country's export earnings. These industries are mainly located near the banks of the Shitalakshya River and the Buriganga River, which have been used as water sources for various industrial purposes.

Some of the major industries located around Narayanganj City Corporation are:

i. Adamjee Jute Mills
ii. Eastern Jute Mills Ltd.
iii. Narayanganj Textile Mills
iv. The ACME Laboratories Ltd.
v. Aramit Cement Limited
vi. Bengal Windsor Thermoplastics Ltd.
vii. Beximco Pharmaceuticals Ltd.
viii. Confidence Cement Limited
ix. Deshbandhu Sugar Mills Ltd.
x. Dhaka Tobacco Industries
xi. Meghna Group of Industries
xii. Square Pharmaceuticals Ltd.
xiii. Tasnim Chemical Complex Ltd.
xiv. United Sugar Mills Ltd.
xv. Zaheen Spinning Ltd.

However, this industrial revolution has led to serious water pollution in the area, affecting the river's ecosystem and the health of the people who depend on it for their livelihoods. Moreover, the industrial effluents are also being released into the canals, which has increased the salinity levels of the water and caused significant damage to the local agricultural sector. Additionally, the industrialization process has also contributed to climate change through increased carbon emissions, deforestation, and the depletion of natural resources.

According to a report by the Asian Development Bank, Narayanganj City Corporation has been experiencing significant environmental degradation due to its industrial activities. The report states that the level of water pollution in the Shitalakshya River has increased by 72% over the last decade due to the discharge of untreated industrial effluents. Moreover, the salinity levels in the canals have also increased

by 50% in the same period, causing significant damage to the local agriculture sector. These impacts are further exacerbated by the city's climate, which is characterized by high temperatures and heavy rainfall.

In terms of economic impacts, Narayanganj City Corporation is a major contributor to Bangladesh's export earnings, with its jute, textile, and garment industries accounting for a significant share of the country's exports. However, the environmental degradation caused by these industries can have long-term economic consequences. For instance, the pollution of the Shitalakshya River has reduced the availability of water for agricultural purposes, which can affect the productivity of the local farmers and lead to food insecurity. Additionally, the damage caused to the ecosystem can also affect the fisheries and other natural resources, which are a major source of income for the local communities.

2.17 City Blocks

For administrative purposes, Narayanganj city has been divided into 6 blocks as shown in Figure

Figure 12 - City Blocks

3 CURRENT SITUATION IN NARAYANGANJ

3.1 Background

Narayanganj City is currently bounded by the Shitalakshya and Dhaleswari rivers and has four main zones as follows:

- Siddhirganj
- Narayaganj
- Khanpur
- Kadam Rasul

However, Khanpur is frequently included with Narayanganj area.

The city is low-lying with maximum elevation of 5m and is subject to frequent flooding during the rainy season (December to May). Some low lying peripheral areas which are connected to the river through canals or other water bodies become flooded due to the rise of water during rainy season. Although Narayanganj is heavily congested, those areas are free from any settlements and mostly serve as outfall of the existing drainage system or for agriculture during winter months.

The Kadam Rasul Zone is in better situation in term of topography- a gradual slope from land side to river bank. These areas are high land or have been raised above the annual flood level for habitation. But a substantial part of Kadam Rasul goes under water due to annual flooding, being low lying agricultural land. The areas are directly linked with the river system by khals or water bodies or low lying agricultural land. The areas also serve as outfall of present drainage network.

As most areas are of mixed use type, drainage water contains human waste (Soak well/septic tank connected with drain), kitchen waste, and chemical wastes from small/medium type of industries. The wastewater warrants different types of treatment processes in the treatment plant.

The city boundaries will be expanded during the design horizon of this project until 2046.

3.1.1 Description of Catchment Area

Siddhirganj - The Siddhirganj zone is severely affected in the wet season. The area within the embankments of a previous irrigation project has recently become more residential since the devastating flood of 1988, as more people bought land inside the bank protected area; this has exacerbated the situation. Unplanned housing and settlement s have had adverse impacts on the existing drainage system of NCC such that even minor rainfall can create severe waterlogging within DND areas. In some wards, invert levels of the canals lie below the river surface. Accordingly, pumps at Shimrail and Adamjee Nagar pumpings stations are deployed to dispose of the drainage water. Ward 9 is particularly affected in this regard.

Narayanganj - Although Narayanganj zone is heavily congested, most of the area is free from annual flooding. However, some low lying peripheral areas which are connected to the river through canals or other water bodies become flooded due to the rise of water during rainy season. Those areas are free from any settlements and mostly serve as outfall of the existing drainage system or for agriculture during winter months.
Khanpur lies to the north of Narayanganj and shares the same urban features, low-lying ground with high density population and subject to frequent flooding.

Kadam Rasul - The Kadam Rasul Zone is in a better situation in term of topography- a gradual slope from land side to the river bank. These areas are high land or have been raised above the annual flood level for habitation. But a substantial part of Kadam Rasul goes under water due to annual flooding, being low lying agricultural land. The areas are directly linked with the river system by khals or water bodies or low lying agricultural land. The areas also serve as outfall of present drainage network.

3.1.2 Catchment Boundaries

Using the topographical information obtained from the engineering surveys, individual surface water drainage catchments (zones) were identified. There are shown in Figure below:

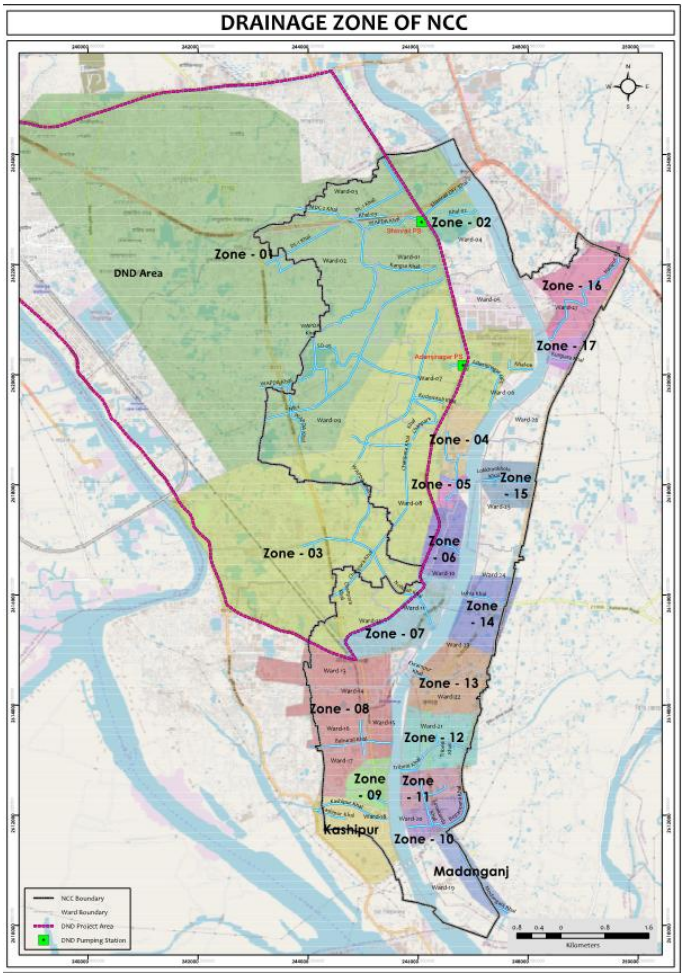


Figure 13 – Existing Drainage Zones of NCC

3.2 Canal System– Main Drainage Khals

The canal system cannot be functionally restricted within any administrative boundary. In order to study a canal system, the study area should not be limited to the project area only. The study should has been done holistically on a basin approach in the Master Plan. The canal (or khal[4]) system is the vertebrae of the

[4]Note – In this report 'Khal' and 'Canal' are of same meaning.

drainage system in NCC. Some of the canals are natural and some are man-made, being excavated under DND project[5] which falls under Sidderganj Zone. The length of canals with NCC attributed to the drainage of the basin that falls under NCC boundary and the length is about 61 km (including 7 km retention pond).Majority of the canals in general have existing slope from east to west, i.e. away from river, except a few small stretches from east to west.

3.2.1 Canals under Narayanganj Area

Sl. No.	Name of Khal	Location/ Flow	Ward No.
1	Baburail Khal	Located in on the South side of the Ward No. 16 and middle of the Ward No. 15. It was connected to the Shitalakhya in the east and tributary of Dhaleswari on the west. In recent years NCC administration blocked the outfalls at both ends and transform it into lake with overflow arrangement and used this as retention pond and recreation purposes. Intercepting drains were constructed below the embankment of the canal. It prevents the wasteflow to the retention pond and diverted to river (and other canals) through drain along embankment.	15 and 16
2	Kashipur canal (locally called river)	Located on the North East side of the Ward and flows into the Shitalakhya River	18
3	Shitalakhya Canal 2	Located on the West to East side of the Ward and flows to river	18
4	Khal 1	Located on the West to East side of the Ward and flows to river	18

Table 7–Canals in Narayanganj Area

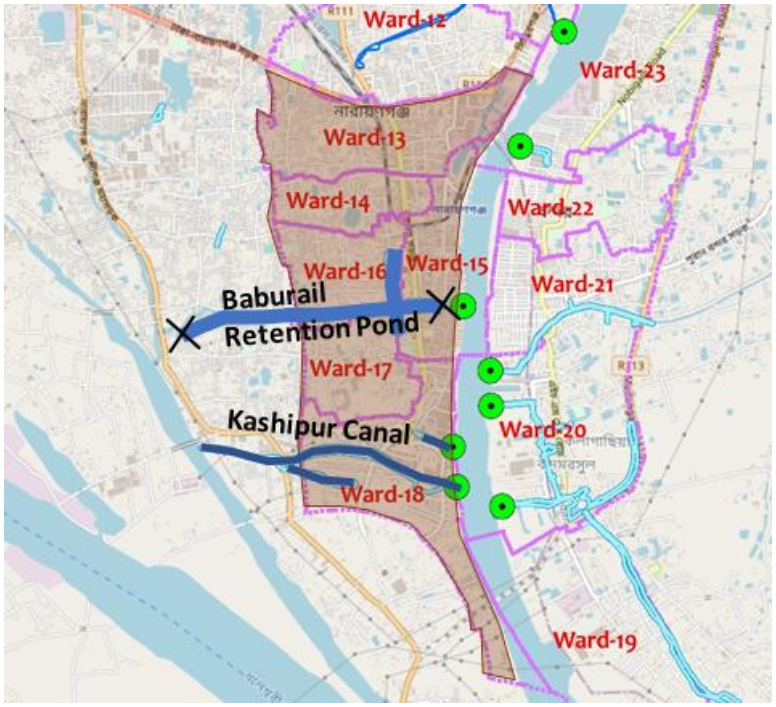


Figure 14 - Location Map of Canals Narayanganj administrative area

[5]DND- Dhaka-Narayanganj-Demra, administered by Department of Defence, Bangladesh

3.2.2 Canals under Siddhirganj Area

Sl. No.	Name of Khal	Location/ Flow	Ward No.
01	Konson Khal	The Konson Khal is connected to WAPDA khal and DND khal	01
02	WAPDA Khal	WAPDA khal is connected to the DND canal	01
03	Pagla Khal	Located on the North West side of Ward No. 02	02
04	WAPDA Khal	Located on the east side of Ward No. 02	02
05	Pagla Khal	Located on the west side of Ward No. 03	03
06	DND Khal	Flows through the Middle of the Ward to the north and falls in the Shitalakhya River	04
07	Khal	Located in the Middle of the ward	04
08	Khal	Located to the West and flows to the South	06
09	DND Khal	Located in the eastern side of Ward No. 01, 03 & 07	01, 03, 07
10	Khal	Located in the North West flows to the South	07
11	Chanpara Khal	Located in the North West side of Ward No. 08	08
12	Khal	Located in the North East flows to the South of Ward No. 08	08
13	WAPDA Khal	Located in the South side of W-08 and flows to the West side	08
14	Jalkuri Khal	Located in the South West side of Ward No. 09	09
15	DND Khal	Located in the north-west side of Ward No. 09	09
16	Khal	Located in the north-east side of Ward No. 09, flows to the west side of Ward No. 09, connected to the DND Khal at Ward No. 01	01 & 09

Table 8–Canals in Sidderganj Area

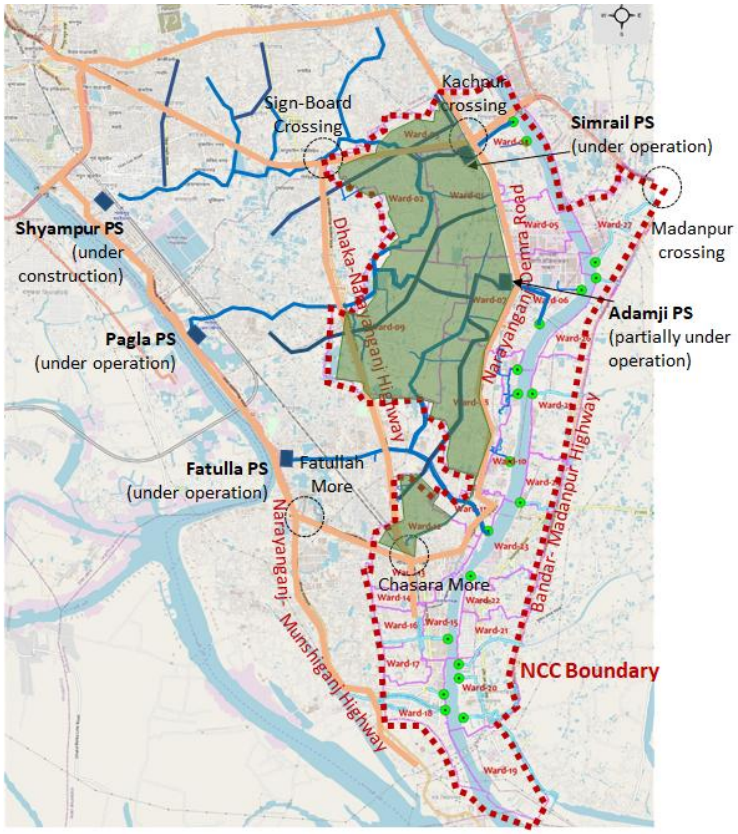


Figure 15 - Canals in Sidderganj Area (west side)

The canals under this area are under the purview of DND, who has taken up the project on rehabilitating the canals. Canals of Sidderganj are very much integrated, hence it is difficult to separate it out from functionality point of view.

Details of the canals specific to Sidderganj area (West side) are given below:

Canal Name	Ward	Canal Length(m)	Av. Depth (m)	Width (m)
Wapda Khal	Ward-01, Ward-02, Ward-09	6.62	3.084	23.10
MDC-2	Ward No. 01, Ward No. 03	0.78	2.593	19.34
NR-1	Ward No. 01 & 09	4.45	2.238	17.23
Chanpara khal	Ward-08	2.99	1.504	10.94
Jalkuri khal	Ward-07, Ward-08, Ward-09	3.39	1.174	15.61
DL-1	Ward No. 02, Ward No. 03	3.17	3.372	12.70
SD-5	Ward No. 07, Ward No. 09	2.39	1.838	18.56
Kadamtoli khal	Ward No. 07	6.46	1.190	8.98
Kangsa Khal	Ward-01	1.23	1.389	9.93
DND khal	Ward No. 01, 03 & 07	4.74	#DIV/0!	51.92
Shimrail OFC	Ward No. 04	0.89	1.425	43.24
NR2/R2	Ward No. 08, Ward No. 09	0.81	1.362	7.44
Adamjinagar OFC	Ward No. 06	1.68	2.750	17.59

Table 9–Canal Details in Sidderganj Area (West side)

Adamjee canal outfall and Simrail canal outfall(OFC) though falls under zone 3 but these were not considered under the proposal. These 2 (two) canals are being taken care by DND as a part of their project though it falls under Sidderganj.

Details of the canals specific to Sidderganj area (East side) are given below:

Canal Name	Canal Length (m)	Av. Depth (inclined)	Width (m)
Jelepara Khal	965	5.08	12-30
BJMC Khal	2526	3.31	12-18
Nolkhali Khal	730	4.53	12-18
Khal-06	333	3.60	18
Khal-01	620	4.26	16
Total	**5174**		

Table 10–Canal Details in Sidderganj Area (East side)

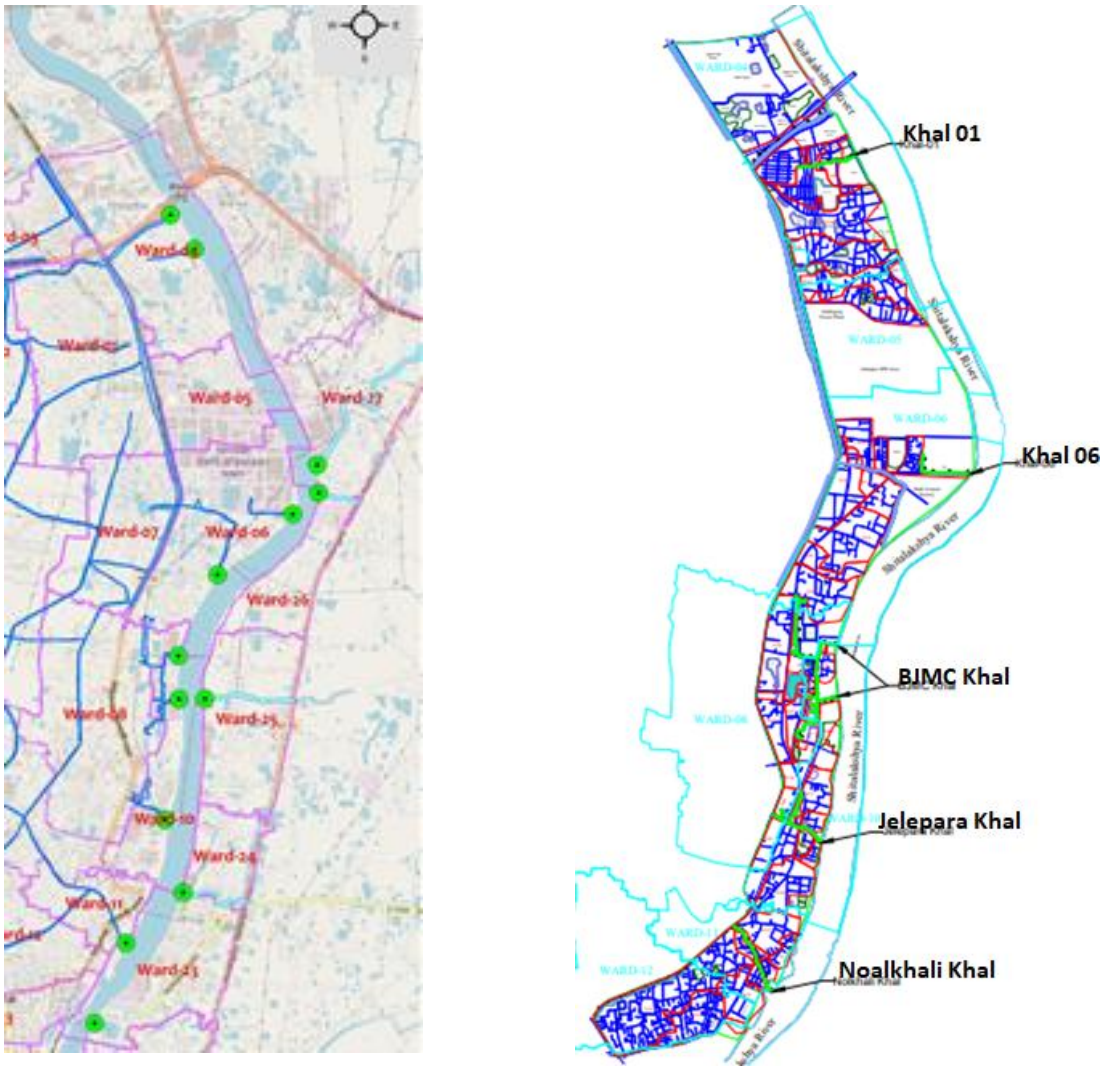


Figure 16 - Canals in Sidderganj Area (East side)

3.2.3 Canals under Kadam Rasul Area

The relevant canal locations of KadamRasul are given below.

Sl. No.	Name of Khal	Location/ Flow	Ward No.
1	Haripur Khal	Located in the Ward No. 20and flows to the Shitalakhya river. It starts outside NCC and carries discharge from outside NCC.	26
2	Kuripara Khal	Located on the South West side of the Ward No. 20 and flows to the Shitalakhya river	26
3	Lakkhon Khola Khal	Located in Ward no. 25 and flows to the Shitalakhya River. It starts outside NCC and carries discharge from outside NCC.	25
4	Nabiganj Khal	Located on the border line of Ward No. 23& 24 and flows to the Shitalakhya River	24, 23
5	Ispahani Khal	Located in Ward no. 23 and flows to the Shitalakhya River	23

Sl. No.	Name of Khal	Location/ Flow	Ward No.
6	Tipkani Khal	Located on the border line of Ward No. 20 & 21 and flows to the Shitalakhya River. It starts outside NCC and carries discharge from outside NCC.	20, 21
7	Tribeni Khal	Located on the South West side of Ward No. 23 and connected to the Tribeni khal	20
8	SonakandaKhal	Located on the south west side of Ward No. 20 and connected to the Shitalakhya River	20
9	MahmudnagarKhal	Located on the west side of Ward No. 20 and flows to the East side and connected to the Shitalakhya River	20
10	Madanganj Khal	Located to the North East side of the Ward and flows towards south to connect branch of Brahmaputra river.	19

Table 11–Canal in KadamRasul Area

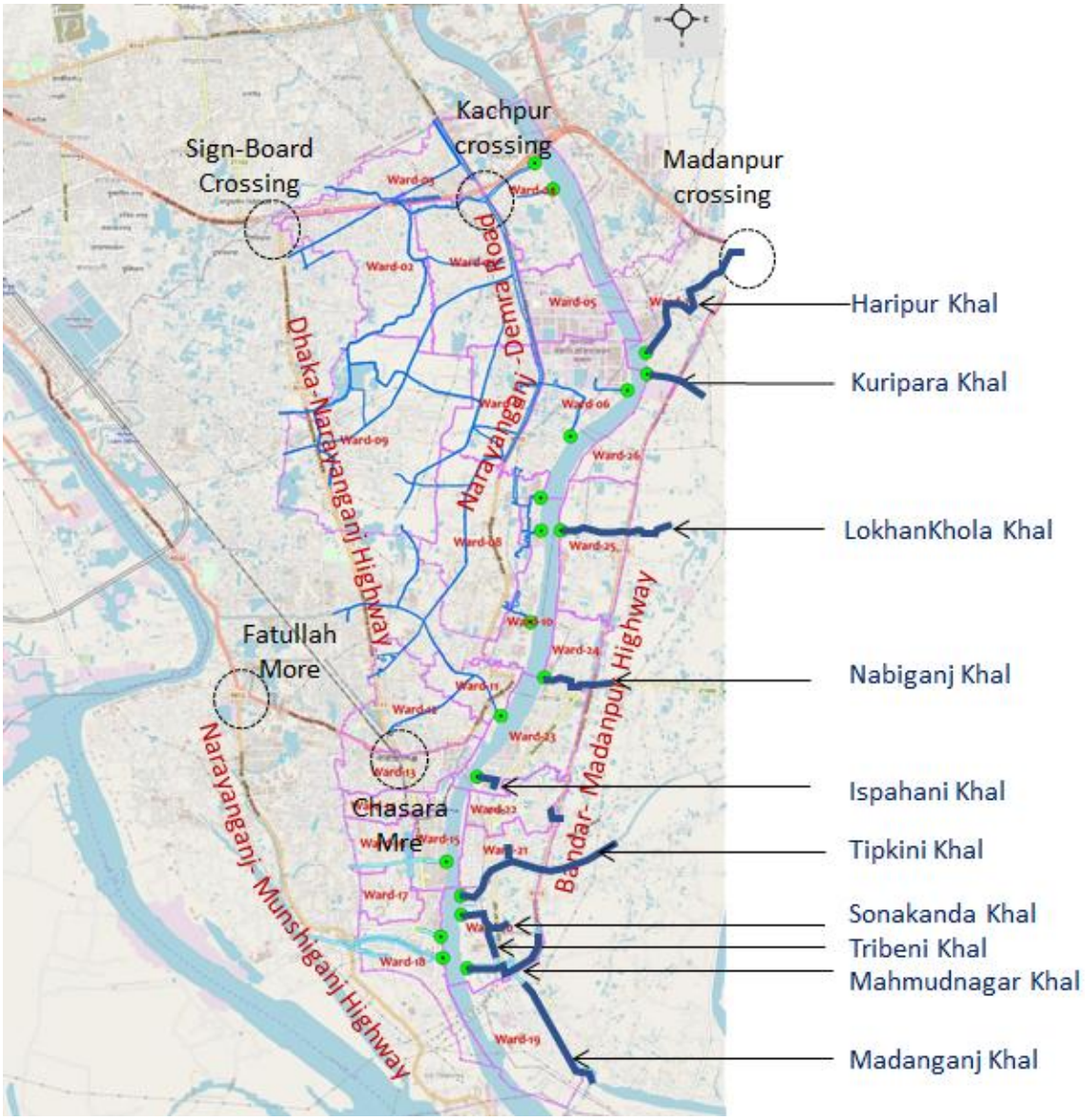


Figure 17 - Canals in KadamRasul Area

Details of the canals specific to KadamRasul area are given below:

Sl. No	Canal Name	Canal Length (within NCC) (m)	Av. Existing Depth (m)	Width (m)
1	Haripur Khal	2655	2.634	21-30
2	Kuripara Khal	452	3.277	12
3	Lakkhon Khola Khal	1004	3.196	24-30
4	Nabiganj Khal	889	3.427	21-30
5	Ispahani Khal	339	5.787	16
6	Tipkani Khal	1188	4.905	24
7	Tribeni Khal	1562	4.365	12-18
8	SonakandaKhal	961	1.772	8-18
9	MahmudnagarKhal	1618	6.738	12
10	Madanganj Khal	1736	7.183	12-18
	Total	**12404**		

Table 12–Canal Details in KadamRasul Area

3.3 Canals under DND (Dhaka-Narayanganj-Demra)

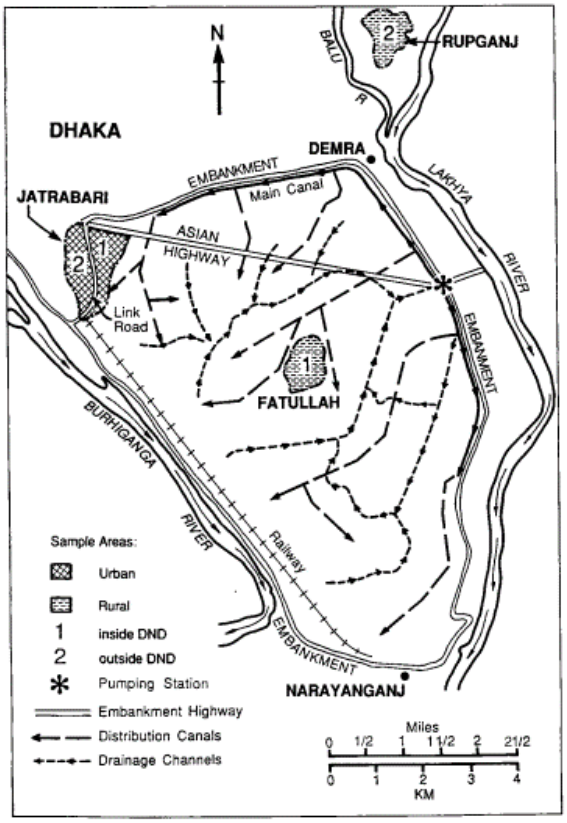


Figure 18 – DND Embankment

3.3.1 About DND

In the year 1960 Dhaka-Narayanganj-Demra (DND) dam project was taken up. It is a triangular-shaped fresh-water polder that was constructed by reinforcing existing highways and roads and building additional embankments along the Burhiganga (tributary of Daleswari) and the Sitalakshya rivers. It covers an area of approx. 6000 ha.

This polder was designed as a demonstration project to enhance agricultural productivity by regulating flood levels inside the enclosed embankments. A pumping station on the eastern embankment serves the main function of regulating water levels by pumping out excess rain water from the polder during the monsoon season and then reversing the flow during thewinter/dry season, when irrigation water is extracted from the Sitalakshaya River and is distributed inside the polder through a network of canals and drainage channels.[6]

[6] Source – Journal- Impact Assessment (ISSN: 0734-9165 (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tiap19)

Being situated in the urban fringe of Dhaka, it has experienced phenomenal growth in population since the independence of Bangladesh in 1972, unplanned urban and industrial sprawl has altered the fundamental nature of settlements inside the western section of the polder.The objectives, to a large extent, got nullified by the indiscriminate urbanisation of the project area and fish farming by damming the canals. The canal network is the lifeline of the people living inside the DND area.

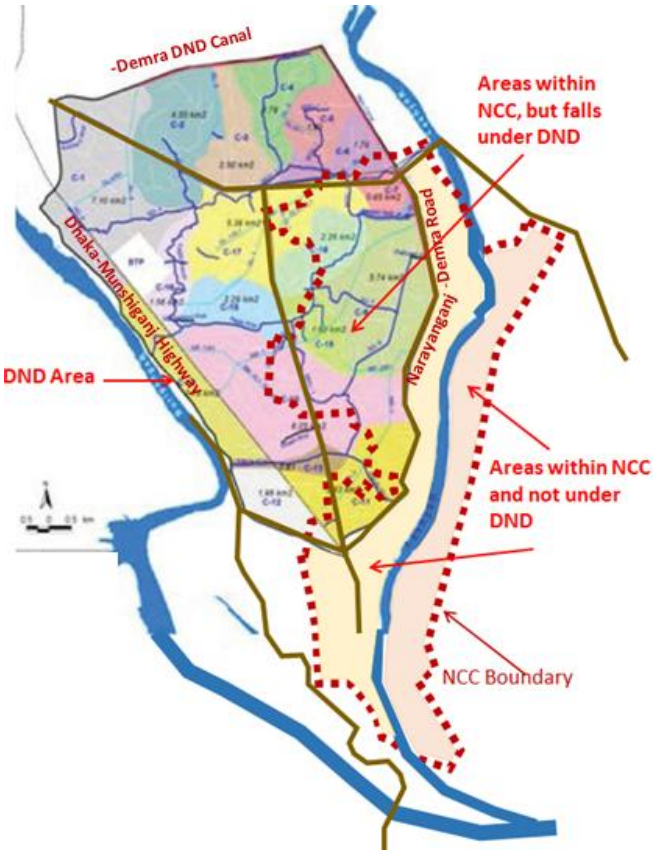


Figure19 - Jurisdiction of DND Area

3.3.2 DND Jurisdiction

Presently jurisdiction of DND is same as was perceived in 1960. The only change is that due to the pressure for further urbanization, which was increased since the completion of the Dhaka-Chittagong Road (earlier called Asian Highway) in 1988, the polder was bifurcated into two triangular tracts of unequal size. Most of this unplanned urban sprawl lacks such basic municipal facilities as water supply and sewage. Some of the post-construction environmental problems inside the urbanized section of the DND embankment have been exacerbated by this lack of municipal facilities.

Triangular shape of DND area is bounded by: (i) Buriganga river in the east (Dhaka-Munsiganj Road being the embankment Road), (ii) Demra-Narayanganj Road in the east, (iii) Demra DND canal in the north. Total area under DND is 58 sqkm.

The department is re-constructing the canals to its designed shape and size, cleaning the canals, making embankment roads, canal crossover (bridges/culverts), lining to proper shape, constructing storm water

pumping stations, rehabilitating its outfall channels to rivers (2 numbers- for Adamjee PS, and Simlrail PS to Sitalakshya river + 3 nos. to Buriganga river).

3.3.3 NCC Wards under DND

The NCC wards covered under DND area are Wards- 1, 2, 3, 7, 8(part), 9, 11(part), 12(part). It contributed to about 1/3rd of NCC area.

W-1	2.905	W-7	1.634	W-11 (35%)	0.273
W-2	2.428	W-8(73%)	2.211	W-12 (62%)	1.133
W-3	1.503	W-9	5.635	**Total**	**17.2 sqkm**

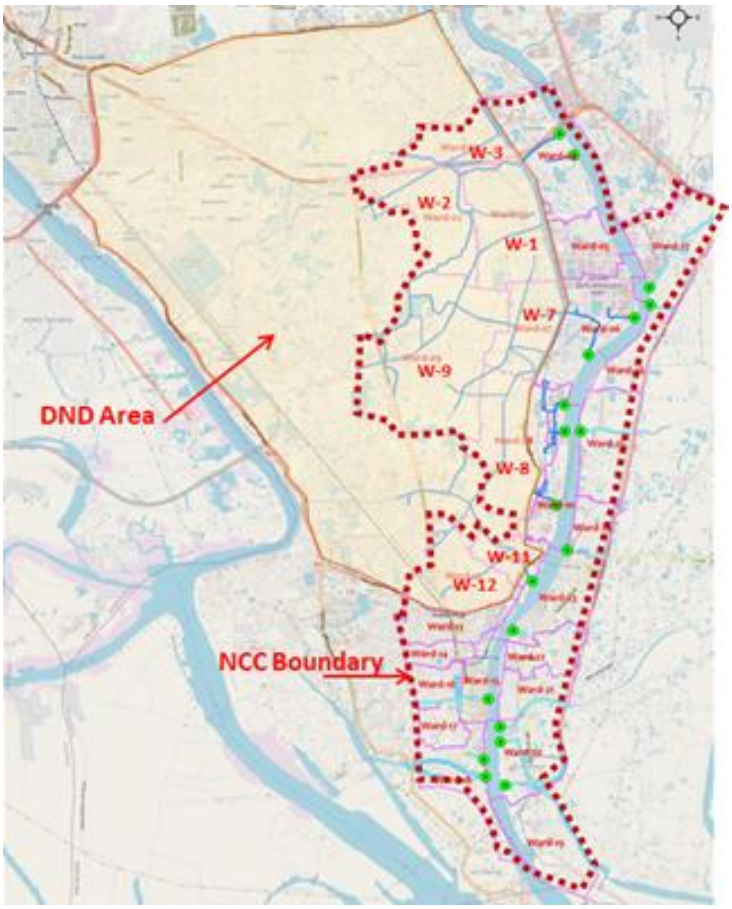


Figure 20 - NCC Wards under DND

3.3.4 Canal System Rehabilitation

DND is currently involved in canal system rehabilitation. The activities undertaken are:

- cleaning of canals, resectioning of the canals to designed section in proper slope and sizes;
- establishing defined canal edge, construction of bridges and culverts, embankment roads;
- construction of drainage pumping stations, pumping station discharge outfall arrangements, securing proper bypass arrangement.

Re-sectioning of canal

Cleaning of canal

By-pass Arrangement

Culvert construction

Salient details of canal rehabilitation –

- Canal length – 94 km , width 20m to 30m
- Canal Pumping stations - 5 nos.
- RCC bridge – New 22 nos, (16-20m) + 52 nos repair
- Culverts – 69 nos. (Culvert vent – 4m x 3m)
- Walkway – 44km
- Dust bin – 100 nos.
- Plantation – 50000 trees

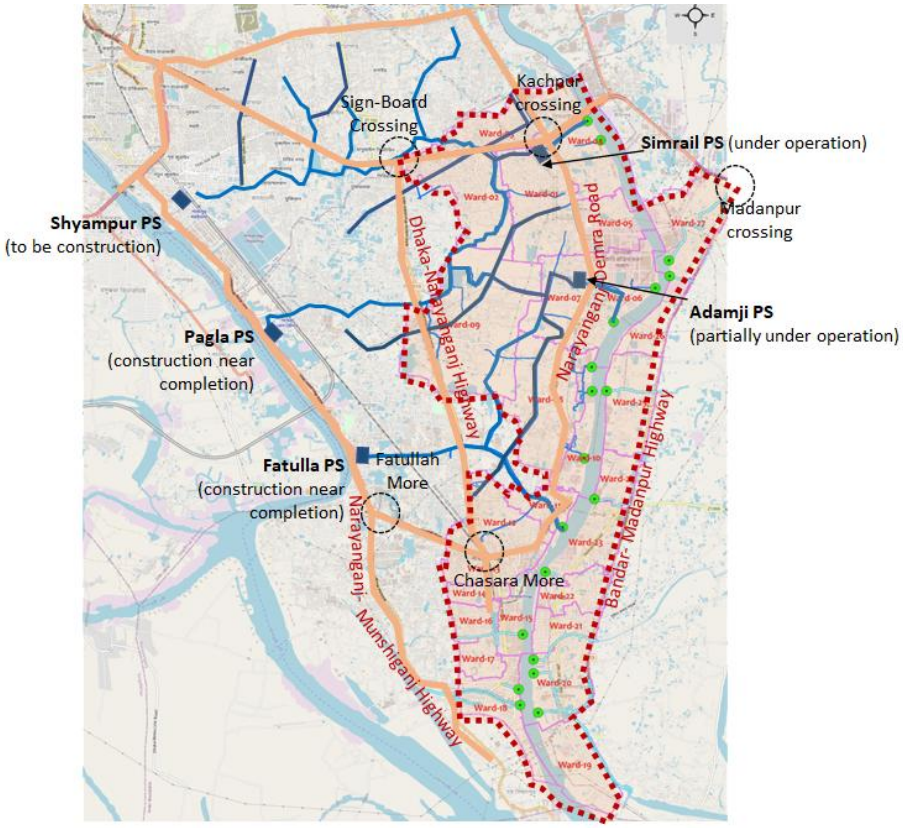


Figure 21 - Existing Canal System maintained under DND

3.3.5 Canal Pumping Station

Sl. No.	Drainage Pumping Stations	Pump Capacity	Discharging to river	Present Status	Remarks/ Pending works
1	Simrail PS	38.5 m3/sec	Sitalakhya	Under operation	
2	Adamjee PS	33.0 m3/sec	Sitalakhya	Under operation	
3	Fatullah PS	3.36 m3/sec	BuriGanga	Under operation	Near completion
4	Pagla PS	2.80 m3/sec	BuriGanga	Under operation	Near completion
5	Shyampur PS??	0.28 m3/see	BuriGanga	Under construction	Initial work started
	TOTAL	**77.9 m3/sec**			

Table 13–Pumping Station Details under DND

3.4 Canal (Khal) Outfalls

A map[7] showing canal outfalls with NCC, prepared during Action Area Plan, has been studied. Location is validated by site reconnaissance, as also shown in the figure below.

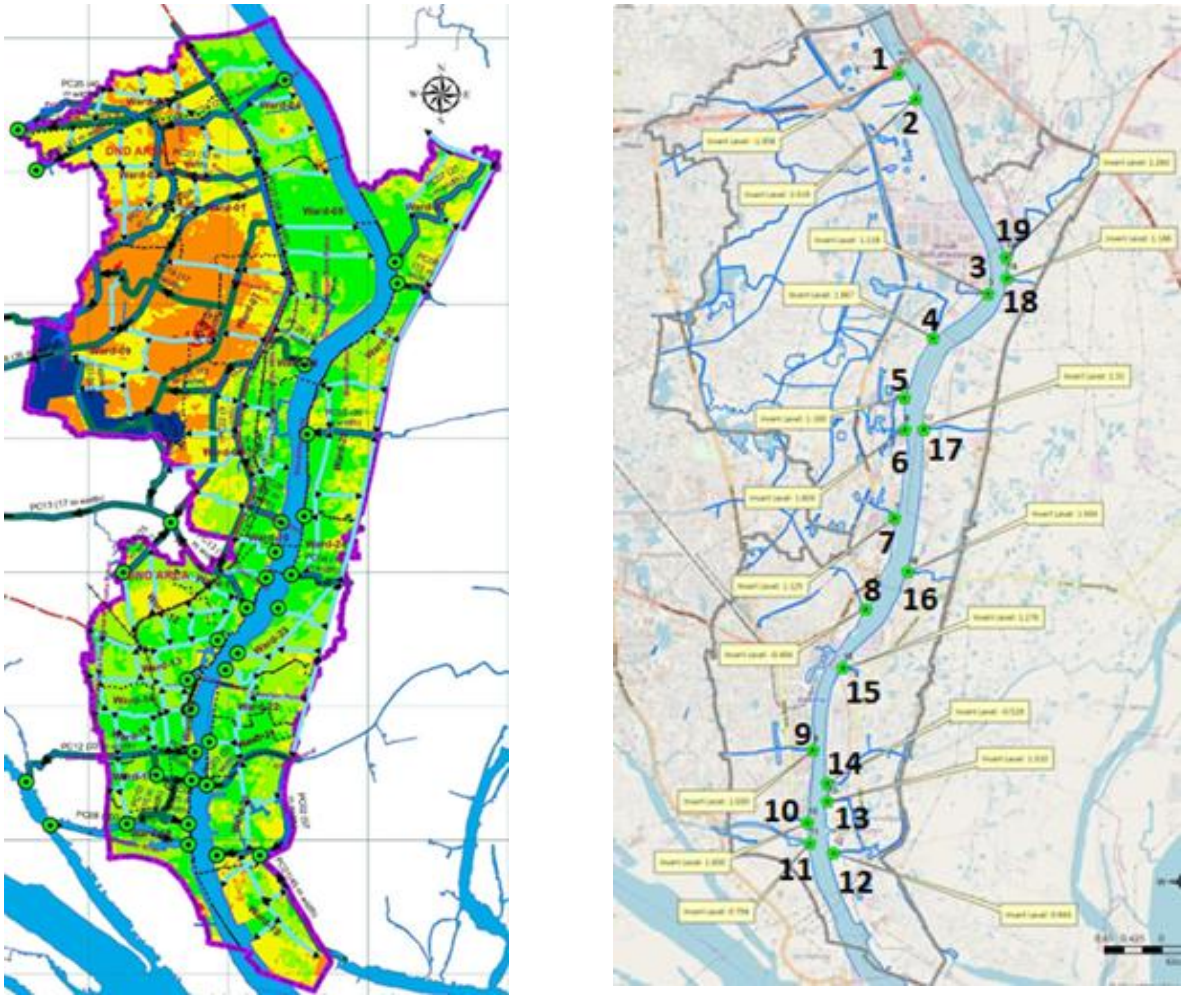


Figure 22 – Existing Canal Outfall

[7] Source – Report on 'DRAINAGE PROBLEMS IN NARAYANGANJ CITY CORPORATION AREA AND URBAN DEVELOPMENT' prepared by Urban Planner PSPS

Details of existing canal outfalls are given below –

Sl. No.	Outfall	Canal name	Existing Invert level[8]	Administrative Zone	Remarks
1	Outfall 1	Simrail Outfall Channel	(-) 1.958	Siddergani	Pumping outfall from DND area
2	Outfall 2	Khal 2	(+) 2.019	Siddergani	
3	Outfall 3	Khal 6	(+) 1.118	Siddergani	
4	Outfall 4	Adamjee outfall channel	(+) 1.867	Siddergani	Pumping outfall from DNA area
5	Outfall 5	BJMC (1)	(+) 1.160	Siddergani	
6	Outfall 6	BJMC (2)	(+) 1.603	Siddergani	
7	Outfall 7	Jelepara	(+) 1.125	Siddergani	
8	Outfall 8	Noilkhal	(-) 0.456	Naraynaganj +	Siddergani
9	Outfall 9	Baburail	n/a	Naraynaganj	Acting as reservoir/lake
10	Outfall 10	Khal 1	(+) 1.695	Naraynaganj	
11	Outfall 11	Kashipur	(+) 0.756	Naraynaganj	
12	Outfall 12	Mahmudnagar Khal	(+) 0.943	KadamRasul	
13	Outfall 13	Tipkini khal	(+) 1.310	KadamRasul	
14	Outfall 14	Tribeni khal	(-) 0.57	KadamRasul	
15	Outfall 15	Isphania khal	(+) 1.276	KadamRasul	
16	Outfall 16	Luhia	(+) 1.507	KadamRasul	
17	Outfall 17	LakshanKhola Khal	(+) 2.31	KadamRasul	NabiganjKhal
18	Outfall 18	Kuripara khal	(+) 1.186	KadamRasul	
19	Outfall 19	Haripur khal	(+) 1.283	KadamRasul	

Table 14–Details of Existing Canal Outfalls

3.5 Surface Runoff

Referring to the topographical features as discussed above, a runoff pattern has been collected from Action Area Plan. A map of surface runoff[9] is shown in figure below. It indicated that the natural surface runoff of the areas west of Demra-Narayanganj road (embankment road) flows in the west direction towards the low lying pockets, which is potential to cause flooding and water stagnation. However, the runoff in the east of the embankment road flows directly to the river either directly by drains or indirectly via canals.

[8]Invert level is based on MSL (mean sea level) obtained from old survey data.

[9] Source – Report on 'DRAINAGE PROBLEMS IN NARAYANGANJ CITY CORPORATION AREA AND URBAN DEVELOPMENT' prepared by Urban Planner PSPS

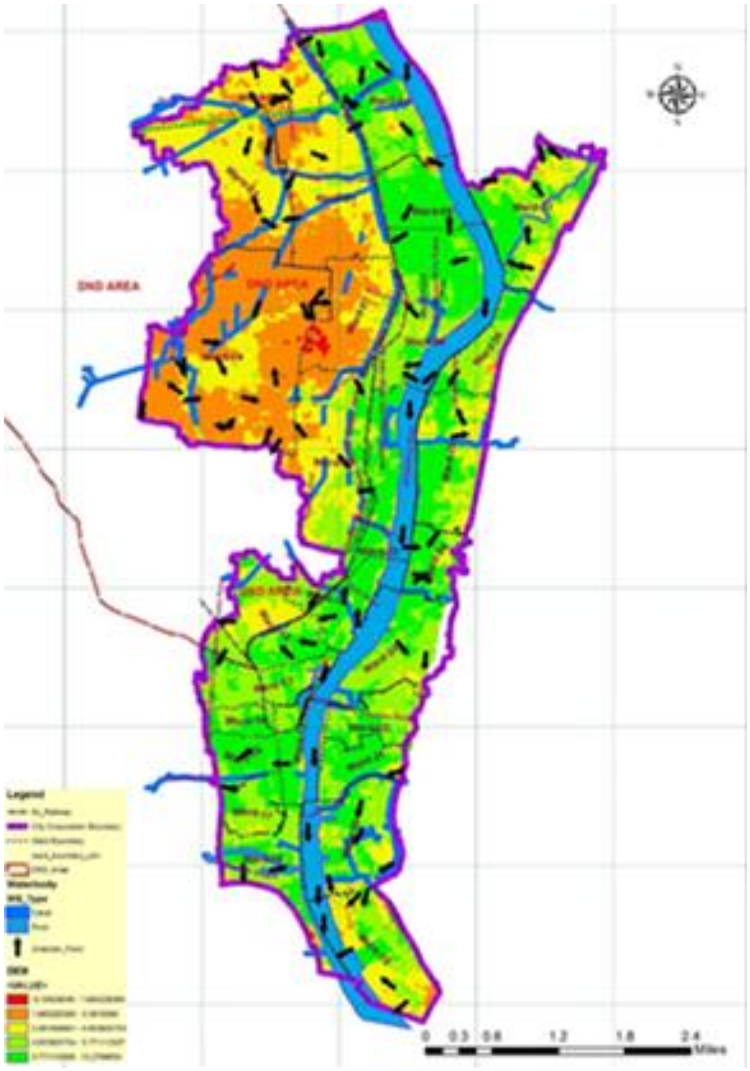


Figure 23 – Surface Runoff Pattern

3.6 Water Logged Pockets

The areas prone to water logging is shown below indicatively in a map. The causes for water logging are:

(i) directly affected by high water level in river, thus not allow gravity flow at outfalls;
(ii) presence of low lying areas which was naturally formed;
(iii) entrapped areas due to infrastructure development (railway and roads);
(iv) mismanagement of drainage system by adjacent unions, and
(v) local depression. Some water logging areas, as indicated in the above map, are listed below based on Field Group Discussion (FGD)[10].

Based on the group discussion and studies priority areas of existing drains required are identified which needs to be rehabilitated or need up gradation.

[10] Conducted by PSPS

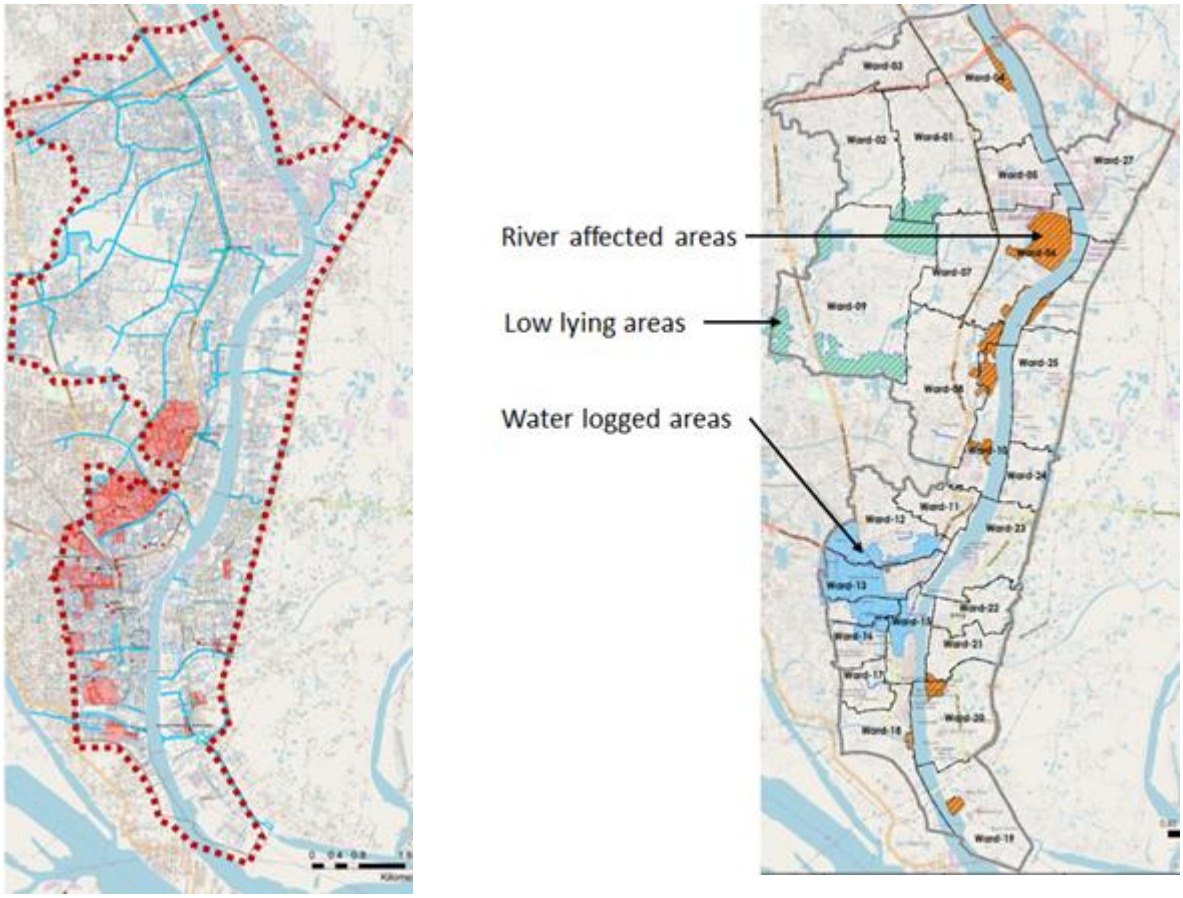


Figure 24 - Water logging areas within NCC

Name of some notable water logging areas are listed below based on field group discussion. –

Sl. No	Name of Area	Administrative Zone	Road Name	Ward No.	Inundation Depth (m)	Inundation Hours
1	Bangabandhu Sharak Area	Narayanganj	Bangabandhu Sharak	Ward-13	0.0-0.5	1 to 1.5
2	Jelepara	Siddhirganj	Enayat Nagar Road Jelepara	Ward-08	0.5-1.0	6 to 9
3	Hajiganj	Narayanganj	Goopta Road & Chairman Bari Road	Ward-11	0.5-1.0	6 to 9
4	Tolla	Narayanganj	Tolla Road	Ward-11	0.5-1.0	6 to 12
5	Chanmari	Narayanganj	Hossain Sardar Road	Ward-12	0.5-1.0	3 to 6
6	Khanpur	Narayanganj	Khanpur Main Road	Ward-12	0.5-0.75	3 to 6
7	Sugandha Bekery area	Narayanganj	AKM Samsujoha Road	Ward-12	0.5-1.0	6 to 9
8	Isdair	Narayanganj	Isdair Bazar Link Road	Ward-12	0.5-1.0	3 to 6

Sl. No	Name of Area	Administrative Zone	Road Name	Ward No.	Inundation Depth (m)	Inundation Hours
9	Tolaram College area	Narayanganj	College Road	Ward-13	0.5-0.75	3 to 6
10	Jamtola	Narayanganj	Haji Hayder Ali Road, Masjid Road	Ward-13	0.5-0.75	3 to 6
11	Begum Rokeya School	Narayanganj	Sohid Sabbir Alam Khandakar Rd	Ward-13	0.5-0.75	3 to 6
12	T & T Colony	Narayanganj	West Allama Iqbal Road	Ward-13	0.5-1.0	6 to 9
13	Golachipa	Narayanganj	College Road Golachipa	Ward-13	0.5-1.0	3 to 6
14	Masdair	Narayanganj	West Masdair Road	Ward-13	0.5-1.0	3 to 6
15	Nandipara	Narayanganj	Nandipara Road	Ward-14	0.5-0.75	3 to 6
16	Palpara	Narayanganj	Ali Ahmed Chunka Road	Ward-14	0.5-0.75	3 to 6
17	Deobhog	Narayanganj	Sayed Khaza Nazmul Hassan Rd	Ward-16	0.5-0.75	3 to 6
18	Paikpara	Narayanganj	Sha Shuja Road, Saheed Bappi Sharani Road	Ward-17	0.5-1.0	6 to 9
19	Mahamud Nagar	Kadamrasul	H M Sen Road	Ward-20	0.5-0.75	3 to 6
20	Bandar Girls School & College area	Kadamrasul	Babupara Road, H M Sen Road	Ward-21	0.5-0.75	3 to 6
21	Baitul Mamur Masjid area	Kadamrasul	Ali Bari Sharak, H M Sen Road	Ward-22	0.5-0.75	3 to 6

Table 15–Water logging Area Names

3.6.1 Inundation Areas

Inundation areas by ward are given in Table below.

Ward No.	Ward Area (sqkm)	Inundation in NCC (5-YR)		
		Flood Extent (sq.km)	Flooded HHs (%)	Flood Free HHs (%)
Ward-01	2.93	2.79	97.5%	2.5%
Ward-02	2.43	2.41	99.6%	0.4%
Ward-03	1.50	1.39	99.3%	0.7%

Ward No.	Ward Area (sqkm)	Inundation in NCC (5-YR)		
		Flood Extent (sq.km)	Flooded HHs (%)	Flood Free HHs (%)
Ward-04	3.06	0.65	18.4%	81.6%
Ward-05	1.25	0.02	1.5%	98.5%
Ward-06	2.82	0.56	29.1%	70.9%
Ward-07	1.63	1.61	99.9%	0.1%
Ward-08	3.04	2.22	75.2%	24.8%
Ward-09	5.63	5.61	99.9%	0.1%
Ward-10	1.61	0.03	5.7%	94.3%
Ward-11	0.78	0.14	19.6%	80.4%
Ward-12	1.84	0.94	56.0%	44.0%
Ward-13	1.10	0.20	14.4%	85.6%
Ward-14	0.46	0.04	4.6%	95.4%
Ward-15	1.00	0.00	9.8%	90.2%
Ward-16	0.63	0.06	1.7%	98.3%
Ward-17	0.61	0.17	11.7%	88.3%
Ward-18	1.42	0.50	23.2%	76.8%
Ward-19	1.91	0.92	27.1%	72.9%
Ward-20	2.06	0.39	17.9%	82.1%
Ward-21	0.82	0.10	5.3%	94.7%
Ward-22	0.90	0.25	14.0%	86.0%
Ward-23	1.93	0.35	16.7%	83.3%
Ward-24	0.72	0.19	3.4%	96.6%
Ward-25	1.84	0.84	8.2%	91.8%
Ward-26	0.90	0.40	39.5%	60.5%
Ward-27	2.38	0.99	24.8%	75.2%
Grand Total	47.18	23.75	50.3%	49.7%

*Green = Pump Stations are Installed recently

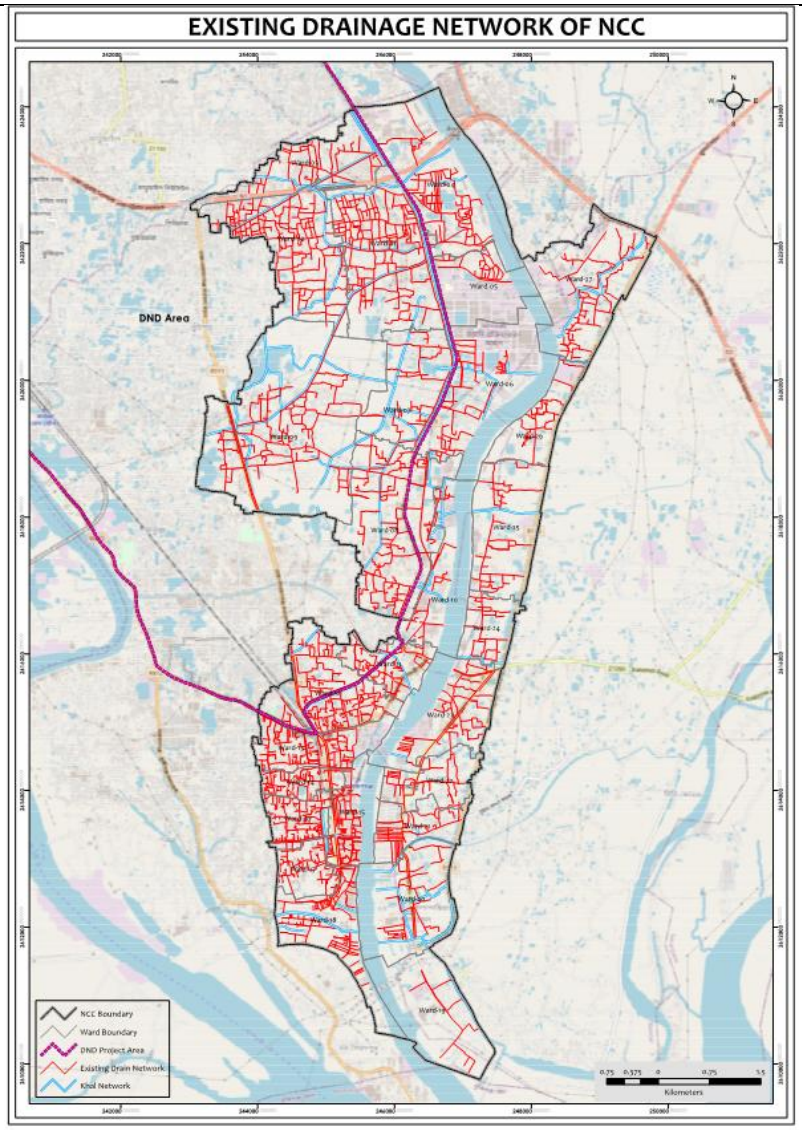
Table 16–Ward-wise Inundation

Ward wise flood prone areas is given in **Annexure V**.

3.7 Existing Drains

A topographic survey of existing drains within NCC area was carried out and identified a total of 562 km of existing main drains. The total length of roads within NCC extends to approx. 662km. giving a drainage coverage of 85%. It is assumed that the remaining roads are minor (less than 5m in width), do not contribute significantly to runoff and need not be provided with roadside drains in accordance with experience of other countries in the region.

The existing drainage network in Narayanganj of existing primary drains and 17 no. khals (principal drains) of length 63km. There are 19 low lying areas which are generally waterlogged. Most drains and khals ultimately discharge to the Shitalalakshya river. The existing drainage network is shown in Figure below.



Note - Drainage channels are shown in red while the main khals are shown in blue

Figure 25 – Existing Drainage Network

All wards were visited by the Consultant's drainage engineers. A review was made of the extent of the existing surface water drainage systems in each ward and discussion were held with local ward councillors, NCC in charge officials and with the public to develop a better understanding and inadequacies in the system. In order to define the scope of the proposed works to be included in the Drainage masterplan, comprehensive field surveys were made in all the wards to determine the existing conditions and locate suitable alignments for new drains.

Existing condition of drains and its analysis are discussed in detail in the following chapter/s. As an overview it can apparently be concluded that the overall drainage system situation in the zones is not in proper shape. Most of the drain are not functioning though being adequate in size, The main reason may be attributed to lack of awareness in people within NCC who dispose solid waste in drains. One of the main reason is the lack of intention (or motivation) of adjoining council/administration in west of NCC boundary to clean the drains/canals which carries the flow from NCC.Detail analysis has been done in the following chapter/s.

Drain Length	Under NCC	Under Narayanganj Admin. Area	Under Siddhirganj		Under Kadamrasul Admin. Area
			West of Adamjee Rd.	East of Adamjee Rd.	
Total length of road	**662 km**[11]	98 km	297 km +	99[12] km	125 km
Total length of existing drains[13]	**596 km**	94 km	244 km +	85 km	120 km
% coverage	**90 %**	96 %	84 %		96 %

Table 17–Drain Coverage in NCC

Existing condition of drains and it'sanalysis are discussed in detail in the following chapter/s. As an overview it can apparently be concluded that the overall drainage system situation is not in proper shape. Some of the drainare functioningbelow its capacity though being adequate in size. The main reason may be attributed to lack of awareness in people within NCC who dispose solid waste in drains.

3.7.1 Existing Drain Flow Pattern

The existing drainage pattern of the zones is shown below.In Naryanganj area the drain flow is directed to both east and west side. In the east side it gets discharged in the Sitalakshya river. In the west side the drains enter into the adjoining unions and finally lead to tributary of Dhaleswari river.

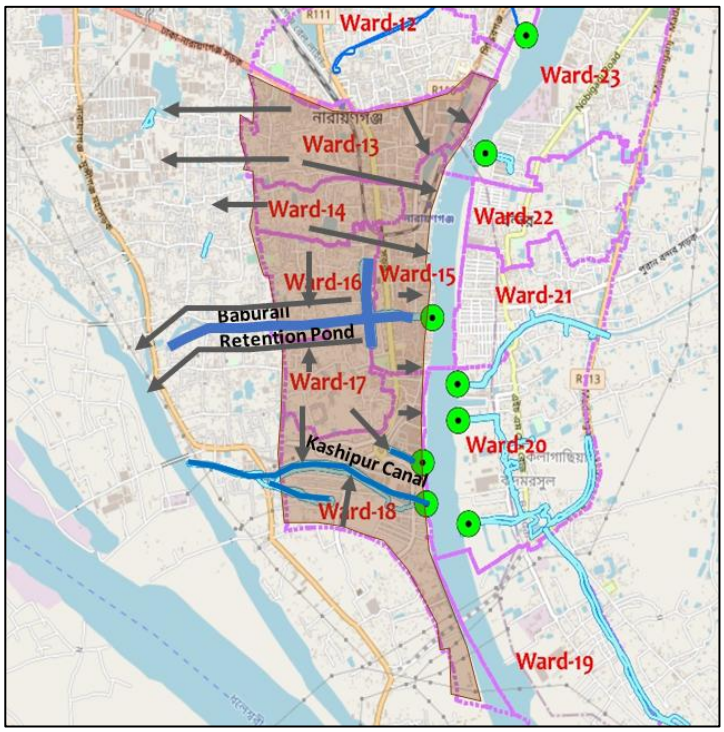
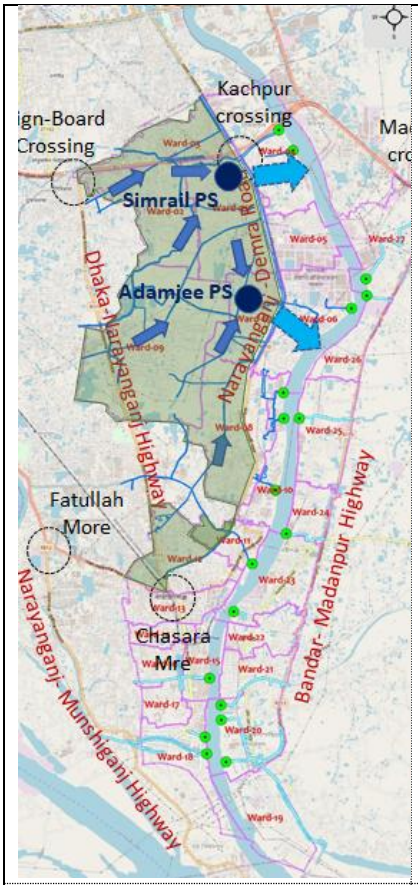


Figure 26 - Existing Drain flow pattern in Narayanganj Area

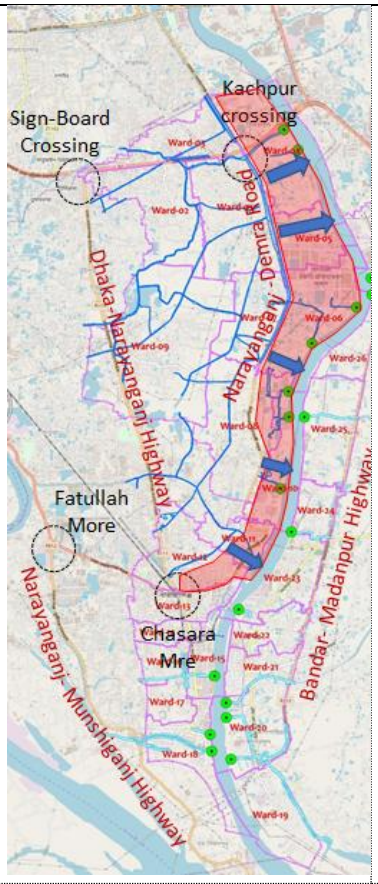
[11] Includes private roads as captured in survey

[12] Total road length (110.85, as per survey) – Narayanganj-Demra Road (embankmemt road 12) = 98.85km

[13] Source- Drain and Topographical surveys conducted by PSPS



(West of Adamjee Raod)



(East of Adamjee Raod)

Figure 27 - Existing Drain flow pattern in Sidderganj area

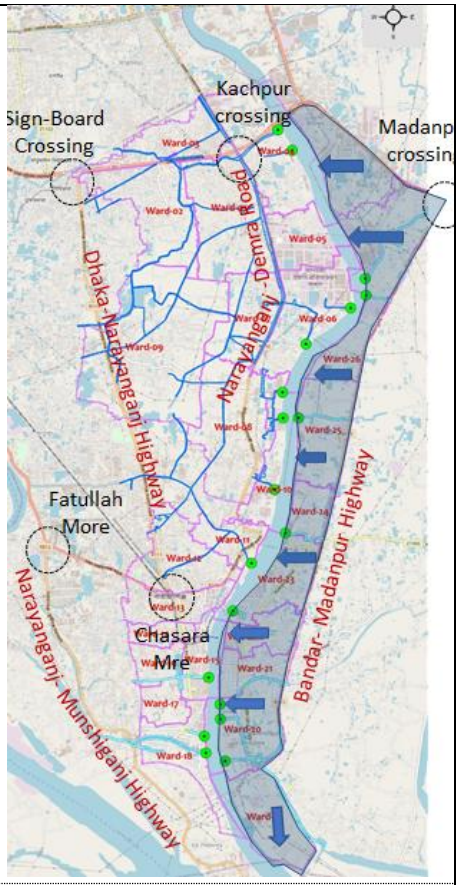


Figure 28 - Existing Drain flow pattern in Kadam Rasul Area

In Siddirganj area Narayanganj-Demra Road (also, known as Adamjee Road) is acting as an embankment. It acts as a barrier for normal flow from this zone-2 to river. This road is also the line of defense from the high water flooding from the river. The existing drainage pattern in Zone-2 is towards the drainage pumping stations within this zone. The canal network within this zone carries storm water flow towards Adamjee PS and Simrail PS. The pumping stations pumped out the stormwater to its outlet channels which leads to the river by gravity.

As stated earlier, Narayanganj-Demra Road is acting as a barrier or embankment as a second line of defense from the high water flooding from the river. The existing drainage pattern in Zone-3 is from this embankment road towards the river, i.e. from west to east. This is how the concept of Zone-3 boundary has been framed up for proposal. In addition to numerous small canals within this strip, which ranging from 0.65km to 1.35km width and 11.5km length, two major canals carrying outfall discharges from Adamjee PS and Simrail PS are presently aligned through this strip (Zone-3). These two canals are being renovated under DND project, hence not considered in this report. However, the drains discharging runoff to these two canals bave been considered in this proposal.

The remaining canals within this zone discharges to the river. Some of the drains in this zone directly discharge storm water to the river. Some drains carry the runoff to the canals, which ultimately discharge to the river.

Bandar-Madanpur Road is an embankment road on the eastern side of the NCC boundary (also for Zone-4). As such the zone, being on the western side of the embankment road and on the bank of Sitalakshya river, is supposed to be vulnerable to flooding. There is no second line of defense from the high water flooding from the river. Presently BIWTA has undertaken a project on bank protection and road along the bank of the river. This embankment would likely to act as first line of defense.

The existing drainage pattern in Zone-4 is from this embankment road towards the river, i.e. from east to west. The canals within this zone discharges storm runoff into the river. Some of the drains in this zone directly discharge storm water to the river, some via canals.

3.7.2 Capacity Assessment of Existing drains of NCC

The adequacy of the total existing drainage system of NCC has been assessed, by using the software (SEWER GEMS). The summary of the hydraulic report on existing drainage system assessment is given below (Refer **Annexure II**).

No. of stretches (model)	40314 nos.
Total length of drain	556 km
Material	RCC
Coefficient of roughness	0.014-0.015
Runoff coefficient	0.085
Average slope	1 in 1290
Average width	1.05 m
Maximum depth	3.7 m(near railway station)
Minimum elevation	1.873m PWD (in Siddergani area)
Maximum elevation	8.7m PWD (in Zone 4 embankment road)
Max. rational flow	40 m3/sec
Inadequate stretch	40.062 km

3.8 Wastewater flow in Drains

Presently the wastewater (grey water + black water) generated at the individual household level is directly discharged to the drains, which in turns flow to river through the canal drainage system. NCC should take feasible measures in near future to intercept wastewater discharge (directly or indirectly) to the river and handle it through an appropriate design and management tool.

Study for proposal on black water is beyond the scope of thisreport. However, till wastewater management system comes under operation, the wastewater will be conveyed through drains. Thus drains will act as combined system. Wastewater load is assessed to be negligible (aboutless than 2%) with respect to the drainage system capacity proposed and as such not considered in calculation.

3.8.1 Wastewater handling

In the wastewater blackwater is beyond the scope of the ToR and Grey water will be considered for the master plan.

3.9 Drainage Water Quality

Water quality in drains is discussed vividly in the chapter on Investigation.

3.10 Operation and Maintenance

Proper functioning of the existing drainage system is constrained by the following:

- disposal of solid waste directly into drainage channels, reducing their hydraulic capacity;
- poor enforcement of laws to prevent unregulated modifications and illegal connections, including sanitary waste connections made directly from toilets;
- encroachment onto drainage channels by unauthorized fill and construction; - lack of coordinated & planned maintenance programs for the drainage system;
- poor community awareness of the need to maintain an effective drainage system; &
- disposal of toxic industrial and medical wastes to the drainage channels which causes severe environmental effect.

There are no authorised Solid Waste (SW) landfill sites and if such waste is disposed on urban roads, it subsequently makes its way into the drainage channels and obstructs normal drainage. Furthermore, the predominant sanitary sewerage system consists of open drains and unsafe hanging latrines. Sanitary wastes are also discharged directly into drains, streams and rivers or dumped into vacant grounds. Accordingly, the effluent quality of internal drains, canals and even rivers cannot support any significant aquatic life owing to high BOD and resultant lack of dissolved oxygen. Raising of public awareness is therefore required regarding the related taboos and justifiably, benefits of improving urban environmental quality becomes an imperative. The importance of O&M of drainage system to ensure the overall environmental safety of the locality cannot be overstated.

3.11 Evaluation of Current Drainage Problems

3.11.1 Causes of Ineffectiveness of Drainage System

A review of the existing situation revealed a number of important common factors that reduce the effectiveness of the drainage of surface runoff. These include:

- relatively flat topography within the surrounding areas
- poorly defined secondary and tertiary drainage channels connected or not connected to primary drainage channels, coupled within adequately sized drainage outlets and culverts
- absence of an intermediate network of secondary drainage channels to adequately convey the surface runoff to primary drains
- absence of an integrated network of road side drains to convey the discharges to discharge to the secondary drains
- undersize of drainage channels in the design or by prolonged siltation with wastes thereby making them unable to accommodate required discharge
- sharp angular bends in the drains thereby reducing their hydraulic efficiency
- disposal of solid wastes directly into drainage channels, which further reduces their hydraulic capacity
- little or no enforcement of laws to prevent unregulated modification and illegal connections, including sanitary waste connections made directly from bathrooms
- encroachment of channels by unauthorised fill and construction of buildings with insufficient enforcement of regulations to prevent encroachment by land-grabbers

- lack of coordinated and planned drainage maintenance programs to effectively maintain the drainage system
- inadequate minimum longitudinal slope for attaining the non-silting velocity in the drains for the relatively flat topography
- poor communal awareness of the need to maintain an effective drainage system, restricting the disposal of solid and other wastes and the need to prohibit the building encroachments on the drains
- construction of innumerable culverts and bridges on primary and other drains and canals without any regulation in the size and number of vents obstructing

3.11.2 Drainage Problems/Issues in General

A review of the existing situation revealed a number of important common factors that reduce effectiveness of the drainage of surface runoff. These are broadly:

- Inadequate Drainage Infrastructures
- Improper Drainage Infrastructures
- Hindrance of Natural Drainage
- Indiscriminate Land Development
- Undesired Land Development at water retention areas and flood flow zone

Detailed discussions are given below:

<u>General:</u>

- Relatively flat topography (to be specific – bowl shaped) within the surrounding areas (from secondary documents), Low lying areas are waterlogged.
- Less numbers of access road leading to Sitalakhya river to have adequate windows for storm discharge points. Majority length of the river bank is occupied by industries. This posed difficulty to make a comprehensive drainage plan for getting easy access to the river.

<u>For Canals:</u>

- Poorly defined boundary/edge of primary canals, secondary and tertiary canals
- Some canals are not connected to primary canals.
- Inadequately sized drainage outlets and culverts.
- Absence (or blockage) of an intermediate network of secondary drainage canal connectivity to allow adequately convey the surface runoff to primary drains.
- Disposal of solid wastes directly into drainage canals. It is common phenomenon observed.
- Encroachment of canals by land fill and construction of buildings.
- Relatively flat topography.
- Construction activities of culverts and bridges on canals.
- Road development (example- expansion of road width of Dhaka-Narayanganj Link Road) project constricted its capacity in localised area is likely to influence upstream drainage.
- Some drainage outfalls (not khal) have been constructed below the jetty/walkway or other public infrastructure, or vice versa, which hinders easy maintenance.
- In some canals the bridge abutments are of colonial era, which intruded into khal pathway.
- Absence of intermittent screens at regular intervals.
- Lack of coordinated and planned maintenance programs to effectively maintain the drainage system.

Road-side Drains:

- Lack of adequate roadside drains throughout NCC.
- Inadequacy of an integrated network of roadside drains to convey discharges to the secondary drains.
- Undersize drain and prolonged siltation by wastes.
- Disposal of solid wastes directly into drainage drains, which further reduces their hydraulic capacity.
- Inadequate longitudinal slope for attaining the non-silting velocity in the drains

Household and Connection:

- Little or no enforcement of laws to prevent unregulated discharge of sanitary waste connections.
- Construction of building encroaching the canal embankments
- Lack of community awareness of the need to maintain an effective drainage system.
- Existing septic tanks overflow and domestic wastewater to drainage system
- Households without septic tanks are connected to the nearest drain
- Household rubbish (sometimes industrial waste) is disposed to drains or khals

3.11.3 Lack of Effective Support

- Financial Constraint
- Drainage and Floodplain Encroachment
- Poor Public Awareness
- Improper Solid Waste and Conduit Management
- Lack of Training and Equipment
- Monitoring of Developers and Contractor's Activity
- Improper Wastewater Management
- Desludging of Septic Tanks

3.11.4 Snaps of Existing Canal System

Apparent Encroachment of Canals

Canal Width restriction by colonial bridge

Undefined canal edges

Narrow passage for drainage inlet to PS

Canal erosion- causing damage to wall

Canal Rehabilitation works (under progress)

3.11.5 Summary of Drainage Issues and Solution

Sl. No.	Issues	Solution	Intervention from Authority
1	Uncontrolled conversion of low lying areas to urban land through landfill	Policy and regulation enforcement	NCC Administration
2	Encroachments of natural canals	Policy and regulation enforcement	NCC Administration
3	Absence of effective surface drain system	Sectoral Master plan and implementation	Proper design
4	Uncontrolled and indiscriminate disposal of solid waste into khals and drains	Meetings and Awareness program	NGO and agencies with support from NCC
5	Lack of proper operation and maintenance of drainage system	Dedicated fund allocation	NCC
6	Lack of awareness of people about the need and function of drainage system	Meetings and Awareness program	NCC Administration
7	Lack of Operation and Maintenance	Rule and Regulations	NCC
8	Lack of Cooperation among agencies	Meetings and Awareness program	City Committee
9	Integrated Urban Development Plan	Discussions	Razuk/LGED, NCC
10	Integration of Fragmented Jurisdiction	Meetings and Awareness program	Govt. of Bangladesh
11	Proper Planning and Implementation	Master plan	NCC Administration
12	Reduction of Lack of Act, Legislation and Enforcement	Meetings	Govt. of Bangladesh
13	Implementation of Building Codes and Landuse Restrictions	Master plan	NCC Administration

The interventions from the authority shall be in line with the Strategy plans as prescribed under DAP, DMDP, 2010 by Rajdhani Unnayan Kartripakkha (RAJUK) in 2010

3.12 Analysis of Specific Problem/Issues

The reasons for water logging have been identified as discussed below. Drainage blocking or deposition of debris in the drain is one of the major reasons of water logging. It is recommended to avoid drainage blockage. The other reasons are:

- Inadequate section of the existing drains, mainly attributed to slope,
- Obstruction in the drains, inadequate cleaning and maintenance of the drains,
- Disposal of solid waste in the drains.
- Poor maintenance of canals.
- Hindrance of natural flow due to railway line and highway
- Obstruction in the downstream stretches of the affected zone.

3.12.1 Consequence of Inadequate Drainage in Narayanganj

Drainage in Narayanganj has assumed considerable significance of late due to the enormous population growth and the rapid but haphazard urbanization evident in most wards. Failure to provide adequate drainage is directly linked to the resurgence of malaria, the spread of diarrhea diseases, damage to housing and property, disrupted communications, lost income and environmental degradation. An effective drainage network as well as proper management of that system is critical to the future development of Narayanganj and the wellbeing of its residents.

3.12.2 Inadequate Drain size and slope

The adequacy of the existing drainage system in has been assessed, by using the excel spreadsheet by using the software (SEWER GEMS). It is discussed in the relevant chapter of this document.

No. of stretches (model)	40314 nos.
Total length of drain	596 km
Material	RCC
Coefficient of roughness	0.014-0.015
Runoff coefficient	0.85
Average slope	1 in 1290
Average width	1.05 m
Maximum depth	3.7 m (in Zone 1 near railway station)
Minimum elevation	1.873m PWD (in Zone 2)
Maximum elevation	8.7m PWD (in Zone 4 embankment road)
Max. rational flow	40 m3/sec
Inadequate stretch	40.062 km

3.13 Current Institutional Arrangement

Drainage is an important municipal service. However, the service provided by NCC is considered as sub-optimal. There exists substantial scope for improvement in the services provided by NCC. The key constraints are:

- Drainage networks and the drainage infrastructure in the NCC area are not maintained properly, creating “hot spots” of water logging and over spills
- Lack of O&M machinery, equipment and tools
- Inadequate staff and lack of attention to skill development
- Encroachments of natural canals
- Indiscriminate disposal of solid waste into khals (minor drainage canals) and drains
- Absence of effective surface drainage system

- Inadequate sewerage network and only one Sewerage Treatment Plant for the whole of NCC area. This creates contamination of drainage flow with untreated sewage

NCC requires a functioning well-resourced drainage section to ensure that any new investment in drainage infrastructure in Narayanganj is properly maintained.

4 METHODOLOGY

4.1 Preliminary Field Investigations

The Project Team conducted field investigations to verify existing storm drainage system, typical cross-sections of storm water khals, roadside drains & culverts and flow directions of khals. The information about the flood prone areas were collected and details of the flood frequency, history of past floods in these areas were collected from the residents/ users of the area.

4.2 Collection of Primary Data

Following are the survey and investigations conducted to formulate a comprehensive design report on storm water drainage of NCC. The survey data have been used in preparation of the detailed designs.

4.2.1 Topographical Survey

The drainage topographical survey that was conducted in all 27 wards of Narayanganj. The survey work started on December 2021 and completed to March 2022. The primary objective of the topo survey is to provide a comprehensive analysis of the drainage system in Narayanganj and identify the necessary improvements needed to ensure that the drainage system is functioning properly and effectively.
The topographical survey was carried out which gave a clear picture of the terrain and contour pattern. The survey activity captured:

- Road alignment along with the above the ground surface features, road levels;
- Existing drain details – size and invert levels, slab cover, material of construction;
- Canal details, with bridges and culverts, cross section, bed level, outfall details.

The survey for the drain was expected to be completed within six months from the start of the project. Total length of road, as derived from map details, was 662 km, out of which roads having drains was calculated to be in a tune of 485 km. Canals length within NCC boundary was approximate 54 km, excluding 7 km of canal shaped retention pond.

The survey began in December 2021 and site activities were completed in March 2022, within the stipulated timeframe. The agency took an additional months to complete the reporting, drawing, and data analysis for the project, handing over the completed work to the authorities in August 2022. To rectify some

discrepencies, the agency was remobilized and completed the remaining work in October 2022. The data gap was restricted, and the total length of drain came to 562 km.

The standard Permanent Bench Mark (BM) data was collected from the Survey of Bangladesh (SoB) and the NCC area was located with 18 nos. Temporary Bench Mark (TBM) by RTK GPS in 27 wards of NCC. The survey work of 27 wards was completed in stages through the total Station, Level Machine & RTK GPS. The levels for establishing TBMs were carried from Government's permanent bench mark PBM. The details of some PBMs are shown below.

Pic	Lat. (degree N)	Long. (degree E)	Elevation PWD lvl.	Location
1	23.649150	90.507938	6.10	Boubazar, Siddhirganj, Narayanganj
2	23.658524	90.508110	6.00	Siddhirganj, Narayanganj
3	23.696435	90.506197	5.00	Mijmiji, Siddirganj, Narayanganj

Pic. 1

Pic. 2

Pic.3

Based on the survey results, PSPS designed effective implementation of drainage solutions for the city, which will include improving the existing drainage system and building new drainage structures where needed. The design had taken into consideration the expected flow rate, the gradient of the channels, and the types of materials that will be used for the drainage structures.

Based on the topo-survey the base map is prepared which shows the existing network. The same base map has been used for proposed drainage network. Source of the details are referred in **Annexure I**.

4.2.2 Survey on Water logging Identification

A Focal Group Discussion (FGD) survey was conducted by the consultant, ARRA Research and Consultancy. It was done ward-wise.A report was submitted by the agency on 14 Nov 2022. Output summary of the discussion, relevant to this report in specific, has been included elsewhere in this report. This survey helped in identification the actual water logging areas. It helped to analyse the actual site specific problem.

The category of the participants for FGD participants were of different professional groups. With the Ward Councilors, there were Local Businessmen, Day labor, Local Elites, Businessmen, Landowner, Female participants, and general people of the area who were aware of the present drainage situation/condition of their local area as well as the waterlogged drainage areas and inadequate drains were present, and help to make a full drainage network system of NCC. This survey captured the following information through discussion with the ward people:

- Inadequate drain (from local discussions)
- Need canal connection,
- Need a deeper drain,
- Need a new drain,
- Need to clean the drain,
- Need to cover drain, and
- Need to repair drain, Water logged drain



Focal group discussions in Zone-1

In this Socio-economic & Inventory of Loss Survey for Drainage Network, 27 FGDs have been carried out and the findings and recommendations those were received from the sessions have been considered for analysng the existing situation and validation of the design output..


Focal Group Discussions in Zone-2 and Zone 4

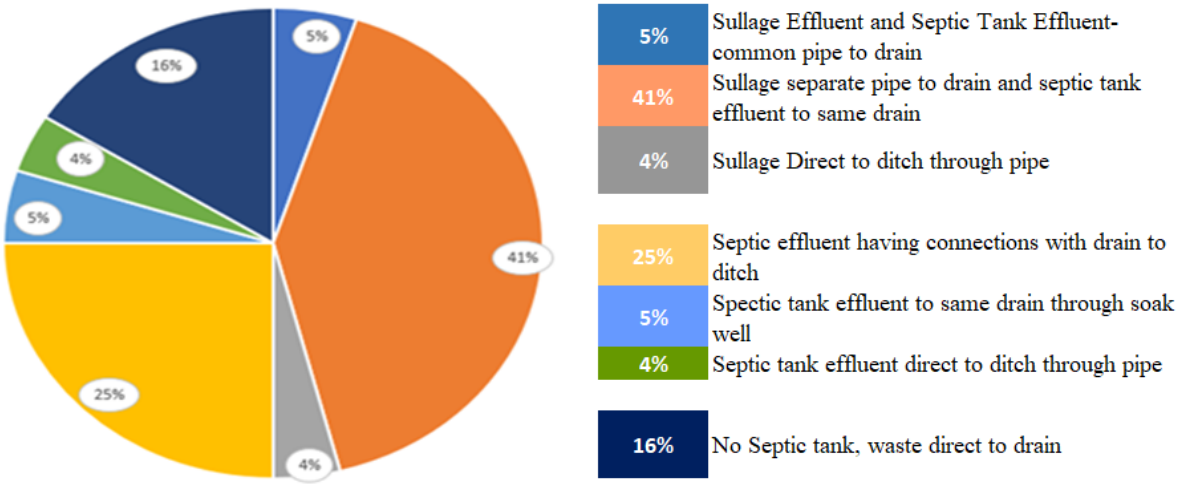
4.2.3 Household survey - Discharge of Wastewater/Sewage to Drains

It was known that wastewater from the household is being discharged to the canals through drains. There is no separate system to manage wastewater. Wastewater being pollutant in general, it is not advisable to mix with the storm drain water which ultimately flows to the river. There is another different school of thought which claims that septic tank effluent does not come into drains and hence impact of pollutant is limited. In this dubious situation the expert endeavored to get a survey of the households on sample basis to know the nature of internal household plumbing. This will help to know the actual facts, i.e. discharging scenario of septic tank effluent. Accordingly, a survey was conducted and analysed. From the result is

evident that 95% septic tank effluent waste is getting discharged to drains, ditches, canals, etc. and the rest 5% is being discharged to soak well.

The details collected are:

- Common pipe to drain through septic tank
- Separate pipe to drain
- Septic tank to same drain through Sockwell
- Connection with drain Yes/No
- Direct to ditch through pipe



Discussion with household members

4.2.4 Waste water survey

The primary motto of this wastewater survey was to observe the water quality of Shitalakshya river, also to detect whether industrial effluents are being carried to the river by urban drains. Therefore outfalls were selected taking into account that they are having high probability of carrying out industrial waste alongside residential waste. 9 drain outfalls were selected in total; 5 outfalls on the west side of Shitalakshya river (Narayanganj & Siddhirganj area) and rest 4 being on the east portion (Kadamrasul zone).

The 15 parameters tested were: pH, DO, BOD5, COD, TSS, TDS, TS, NO3-N, NH3-N/NH4-N, TP, Cr (Total), Fecal Coliform, Mercury(Hg), Nickel(Ni) and Temperature. While Temperature test was carried out on site, other tests were done in the specialized laboratory of BUET/BRTC.
For each location, a 1L plastic water bottle and a 500mL plastic water bottle full of wastewater were collected. The latter bottle sample was separately collected for fecal coliform test. As soon as the sample

being collected in container, a thermometer was used instantly to determine the temperature. It was ensured during collection that no void prevailing in each sample-filled container. Proper labelling was placed incorporating sample collection location, date and time. Sampleswere preserved in icebox filled with ice until reaching laboratory. The whole sample were sent to the laboratory within the next 4 hours after collection for testing.

The overall testing was carried out on 11th September, 2022 maintaining the guidance of BRTC/BUET. Test result took about one month to publish.

	Parameter	**Unit**	**Discharge on**			**Point**								
Sl. No.			**Inland Water**	**Public Sewer**	**Irrigated land**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	pH		6-9	6-9	6-9	6.55	6.77	6.62	7.26	6.65	6.77	6.82	6.61	6.55
2	Dissolved Oxygen (DO)	mg/l	4.5-8	4.5-8	4.5-8	3.94	3	3.4	3.87	3.52	3.51	2.24	4.3	3.6
3	Biochemical Oxygen Demand (BOD5)	mg/l	50	250	100	136	3.5	144	8.8	3	272	30	4.5	200
4	Chemical Oxygen Demand (COD)	mg/l	200	400	400	229	12	354	35	15	409	106	16	335
5	Total Solids (TS)	mg/l	–	–	–	545	629	1113	221	621	863	478	176	681
6	Total Suspended Solids (TSS)	mg/l	150	500	200	76	60	48	15	26	131	24	20	173
7	Total Dissolved Solids (TDS)	mg/l	2100	2100	2100	469	569	1065	206	595	732	454	156	508
8	Nitrate - Nitrogen (N03 - N)	mg/l	10	–	10	0.5	0.3	0.7	0.2	1.6	0.8	0.3	1	0.3
9	Ammonia-Nitrogen (NH3 - N)	mg/l	50	75	75	32.5	0.65	42	4.05	0.2	53	11.5	1.3	23.8

Sl. No.	Parameter	Unit	Discharge on			Point								
			Inland Water	Public Sewer	Irrigated land	1	2	3	4	5	6	7	8	9
10	Total Phosphorous (TP)	mg/l	–	–	–	13.6	0.37	17.2	2.65	0.37	23.3	5.2	1.25	11.3
11	Chromium (Cr)	mg/l	0.5	1	1	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
12	Fecal Coliform (FC)	CFU / 100 ml	–	–	–	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC
13	Mercury (Hg)	mg/l	0.01	0.01	0.01	<MDL	<MDL	0.006	<MDL	<MDL	<MDL	0.015	<MDL	<MDL
14	Nickel (Ni)	mg/l	1	2	1	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
15	Ammonium-Nitrogen (NH4-N)	mg/l	–	–	–	34.4	0.69	44.5	4.3	0.21	56.1	12.2	1.4	25.1

MDL – Minimum detection Level
TNTC – Too Numerous To Count

Table 18–Drain water Quality as Surveyed

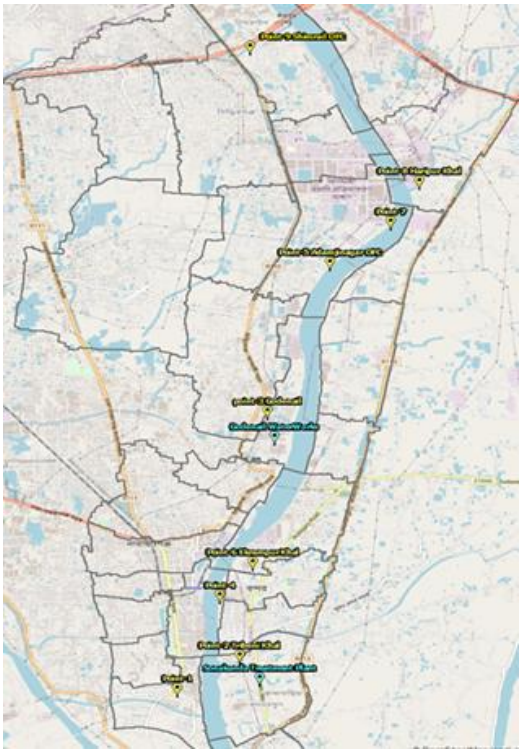


Figure 29 – Waste water sampling locations

Water sample collection at Tribeni Khal

4.2.5 Secondary Data

The following data and documents were collected from different authorities as secondary data. The data were consulted to frame up the master plan.

Sl. No.	Data/ Documents Collected	Contribution to Master Plan
1	River water Level and Discharge Data	This data was consulted to assess requirement of gated structure and embankment level and pumping stations.
2	Meteorological Data	In preparation of rainfall analysis and generation of IFD curve.
3	Mouza/Cadastral Map	To have an overall idea on the area, its topographical nature.
4	Structure Plan – Action Area Plan	Consulting the future plan of NCC, so that this master plan can be aligned with AAP if not grossly conflicting.
5	Existing Landuse Data	In getting an overall idea on the existing land use pattern and assessing the storm surface runoff coefficient
6	Strategic Zone	The administrative strategic zones needs to be has been studied to recommend the scope of development
7	Existing BM/TBM	It is required to conduct the topographical survey of the study area.
8	Hydrological Survey	Mainly the survey of the receiving water body (herein canal) will provide limiting parameter drainage design.
9	Previous Studies	Relevant points considered in framing up the report

4.3 Mapping and Zoning

The existing drainage network of the city was overlaid on top of the existing base maps of the city. Basins (catchments) of Khals were identified based on topography and elevation contours. These basins were then divided into several sub catchments for drainage master planning. The area of each zone was calculated, along with present land use classes and their areas

4.4 Hydrological Analysis

Precipitation data for Narayanganj for the period 2003 to 2020 was collected from BMD Dhaka station for 3h continuous interval. This was then analyzed by Least square method to develop Rainfall IDF curves. A hydrologic model was developed to predict the volume of flow generated at any point in a drainage basin based on rainfall data. For this purpose, each drainage basin in the study area will be divided into sub-catchments at a certain number of nodes. A node represents a location where runoff rates will be calculated. Nodes will be located at critical drainage facilities and points in the study area. All nodes will be designated based on the drainage sub-catchments contributing to them.

4.5 Analysis of Rainfall Data

As indicated, the best possible estimation of peak run off rate is possible where the gauge records of rainfall are available from automatic rain gauge recorder. As such the nearest rain gauge station with short duration rainfall data is Dhaka. As such rainfall data of Dhaka (25 Km from Narayanganj) for year 2003 to 2020, as available, were used for rainfall data analysis (see Table 18 below).. Precipitation data for Narayanganj for the period 2003 to 2020 is collected from BMD Dhaka station for 3h continuous interval (see Figure 25 below). Total annual rainfall is shown in Figure 26 below. The given rainfall data is analyzed by Least square method to develop Rainfall IDF curves. Developed IDF curve for various return period shown in Design Criteria. Analysis is given in **Annexure III**.

4.6 Assessment of Coefficient of Runoff

The coefficient of runoff (C), is a function of the nature of surface and assumed to be the same for all storms of all recurrence probabilities. Recommended values of C on various surface types of catchment are given in Table below.

Type of Area	Description	Run Off Coefficient
1	Impervious/Paved Surfaces/Roads	0.85
2	Industrial/Commercial area	0.8
3	Residential- High density	0.65
4	Residential- Low density	0.5
5	Open grounds with bushes, steep slopes	0.35
6	Open grounds, gardens, lawns, low to moderate slopes	0.15

Table 19–Standard Values of Runoff Coefficient

Landuse pattern has been studied from Area Action Plan 2016. A composite runoff co-efficient value has been calculated. It is pertinent that landuse pattern will change in next 30 years, where agricultural, open space and water bodies will decrease and other landuses like commercial, residential, etc. will increase. A logical assumption has been done to project the runoff coefficient value for Yr. 2046.

		Yr.2016				Projected in Yr. 2046		
Sl. No.	**Landuse**	**% landuse**	**C-value (assumed)**	**Weighted C-value**		**% landuse**	**C-value**	**Weighted C-value**
1	Administrative	4.51	95	428.45		6.765	95	642.675
2	Agricultural	5.66	10	56.6		0	10	0
3	Commercial	1.5	95	142.5		2.25	95	213.75
4	Community Facilities	0.47	80	37.6		0.705	80	56.4
5	Education and Research	0.64	95	60.8		0.96	95	91.2
6	Health Facilities	0.04	95	3.8		0.06	95	5.7
7	Industrial	5.04	100	504		7.56	100	756
8	Miscellaneous	1.13	80	90.4		1.695	80	135.6
9	Mixed Use	20.19	65	1312.35		20.19	65	1312.35
10	Open Space	5.05	50	252.5		3.367	50	168. 3
11	Recreational Facilities	0.39	65	25.35		0.585	65	38.025
12	Residential	30.65	85	2605.25		45.975	85	3907.875
13	Restricted	0.73	65	47.45		1.095	65	71.175
14	Transportation Facilities	0.59	100	59		0.885	100	88.5
15	Water body	23.41	0	0		7.803333	0	0
		100		5626.05		99.895		7487.583
				56.260				74.954

Table 20–Runoff Coefficient Projected Values

The composite weighted runoff coefficient value has been projected to 75%, i.e. 0.75. A conservative approach has been considered to assume it as 0.85 for year 2046.

4.7 Formulation of Design Criteria

4.7.1 General

A basic design criteria on drainage system design[14] is given below for better understanding and guidance. As part of planning, design and project formulation process, the basic design parameters have to be predetermined so as to analyses the carrying capacity of existing drains and also for the design of new drains. These parameters are as follows:

1. Return period
2. Intensity Duration Frequency Curve
3. Time of Concentration (Tc)
4. Runoff coefficient for the project area
5. Method of computing discharge in drains

The design criteria discussed below are indicative and shall be reviewed during detailed design. For details **Annexure IV** shall be referred.

[14]Source – Draft Master Plan Report on Drainage, prepared by PSPS Consultant, Sept 2022.

Computation of Design Flow

The peak runoff at any given point is calculated using the following rational formula.

$$Q_P = \frac{CIA}{360}$$

Where,Q = Runoff in m3/sec.
C = Coefficient of Runoff
I = Rainfall intensity in mm/hr.
A = Drainage area in hectares

Return Period

Sl.no.	Urban Catchment	Return Period	
		Mega cities (Pop.> 1 lakh)	Other cities (Pop.< 1 lakh)
1	Central Business and commercial	Once in 5 years	Once in 2 years
2	Industrial	Once in 5 years	Once in 2 years
3	Urban Residential Core Area	Once in 5 years	Once in 2 years
4	Airports and other critical infrastructure	Once in 100 years	Once in 50 years

Table 21–Return Period

In the present project, NCC is predominantly an urban residential area, so 5 years return period may be considered for design of drainage system

Coefficient of Runoff (Imperviousness factor)

Type of Area	Description	Run Off Coefficient
1	Impervious/Paved Surfaces/Roads	0.95
2	Industrial/Commercial area	0.8
3	Residential- High density	0.65
4	Residential- Low density	0.5
5	Open grounds with bushes, steep slopes	0.35
6	Open grounds, gardens, lawns, low to moderate slopes	0.15

Table 22–Imperviousness Factor

Rainfall Data Analysis

Precipitation data for Narayanganj for the period 2003 to 2020 is collected from BMD Dhaka station for 3h continuous interval. The given rainfall data is analyzed by Least square method to develop Rainfall IDF curves.

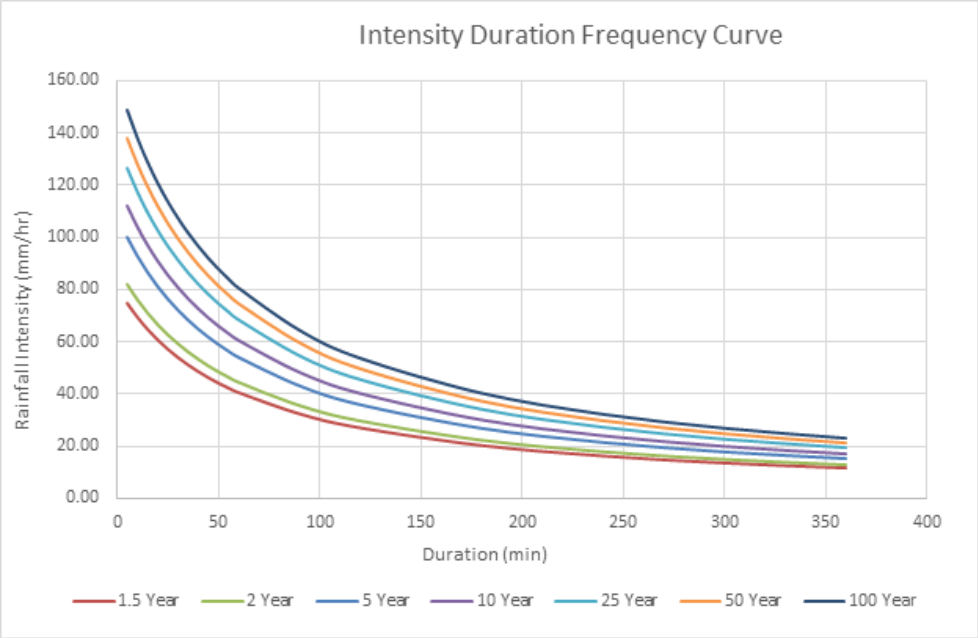


Figure 30 – IDF Curve

Time of Concentration

The simplistic formula is:

$Tc = [3.26 \times (1.1 - c) L^{1/2}] / S^{1/3}$

Where,Tc is Travel time in minutes; C is the Coefficient of Runoff,
L is the hydraulic length in m, and S is the slope in m/m.
Time of Inlet of 10 minutes may be kept at design stage level

Design considerations for outfall

Design condition	Design tail water level
Minor storm (< 1 in 5 years)	In the range of Mean HFL
Major storm (> 1 in 5 years)	In the range of Mean HFL
Effect of climate change	Additional 0.3 m

Hydraulic Calculation

The hydraulic capacity of the drains is computed by using Manning's Formula having the Following expression:

$V = (1/n) R^{2/3} S^{½}$

Where,V = Velocity in m/sec., minimum velocity in the drains shall generally be as 0.60 m/sec
R = Hydraulic radius in m,
S = Invert slope,
n = Manning's Coefficient of Roughness

Coefficient of roughness:

Drain Type	Description	Manning's "n"
1	Natural drain, meandering-with vegetation	0.035
2	Natural drain, largely straight-without vegetation	0.03
3	BB/Stone masonry walls natural bed	0.025
4	BB/Stone masonry walls with pointing and stone paving bed	0.02
5	BB/Stone masonry walls-concrete bed or concrete walls with stone paving bed	0.018
6	PCC/RCC walls, concrete bed	0.015
7	RCC pipe drain	0.013

Table 23–Manning's Coefficient

Freeboard of drain

Drain Size	Free Board
upto 300 mm bed width	10 cm
Beyond 300 mm & up to 900 mm bed width	15 cm
Beyond 900 mm & up to 1500 mm bed width	30 cm

Table 24–Minimum Freeboard

For larger drains, the free board shall be higher up to 90 cm depending upon the discharge.

4.7.2 Design Considerations Adopted

Sl. No.	Design Parameters	Values	Remarks
1	Wards covered	All wards 1 to 27	Peripherals fringe areas along rivers, canals and lakes have not been considered.
2	Storm event Return period	Once in 5 years[15]	The critical rainfall event will occur once in 5 years. The proposed assets for drainage (i.e. drains/PS/outfalls) will be underutilized
3	Effect of climate change	Additional 0.1 m on river water level rise	Reduced effect has been considered because the return period has already been considered on the higher side.
4	Minimum time of concentration	10 min	
5	Rainfall intensity	Refer ***Annexure***	.
6	Design life	30 years	
7	Ground water infiltration	Nil	

[15]Return period was considered in line with the design criteria considered for canal rehabilitation by DND, which is presently under implementation stage.

Sl. No.	Design Parameters	Values	Remarks
8	Coefficient of runoff	0.85	The landuse is a mixed area of residential and industrial. Details explained below.
9	Minimum size of drain	750mm depth (where ground situation permits)[16] x 600mm width	For existing drains, which are proposed to be retained, the existing size has been kept.
10	Minimum velocity (for proposed)	0.6 m/sec	
11	Free board	150 mm	
12	Rational flow/Capacity	1.0	In some cases it can be considered as 1.5. It will make the system financially viable for a return period of 1 in 5yrs.
13	Flooding (or inundation) in flood prone areas	60 min	It will make the system financially viable.

4.8 Proposed Approach for Drainage System Design

The design approach are proposed to be taken up in the following steps during detail designs.

- Study of existing drainage system
- Study of canals and outfalls
- Identification of water logging and assessment of problems /issues
- Adequacy check of the existing drainage system
- Demarcation of existing catchments based on existing network
- Identification of land-locked areas/catchments
- Proposal for proposed catchments delineation
- Sub-catchment calculation within each catchment
- Proposal and alignment of Trunk drain
- Proposed secondary/tertiary drainage network (on the basis of trunk)
- Designing the system (based on excel spread sheet and simulation in SEWER Gems software)
- Classifying or categorization of the design stretches as – Existing drains to be retained, Existing drains to be renovated/ replaced, and New proposed drains
- Site verification and identification of site constraints

4.8.1 Model by SewerGEMS

SewerGEMS is a widely used hydraulic modeling software developed by Bentley Systems, which is used for designing and analyzing sewer networks. For this project SewerGEMS software is used to simulate and analyze the condition of existing drainage networks, identifying the inadequate drains and eventually re-section the inadequate drains to remove the water logging due to storm water runoff. The SewerGems hydrodynamic model has been calibrated and validated to ensure its accuracy and reliability in simulating storm water drainage system

[16] Where ground situation does not permit, minimum depth is kept as 600mm

4.8.2 Model Calibration

To calibrate and validate the SewerGEMS model, the following steps were followed:

i. Data Collection & Analysis: For Narayanganj City Corporation (NCC), 3 hourly rainfall data of Dhaka Raingage station (Index: 11111) have been collected from Bangladesh Meteorological Department (BMD). 3 hourly rainfall data from 2003 to 2020 was available for this station. These data have been analyzed and used for developing IDF curves. Extreme Value Type I (Gumbel) Distribution has been used for developing the curves for different return periods. IDF Curves of 5 years Return is incorporated as rainfall input in the model. Hydrographic data such as river level data, Canal cross sections, RLs of backline, Pump Station details are collected from Bangladesh Water Development Board (BWDB).

ii. Model Setup: The second step is to set up the model by creating a network of pipes, nodes, and other system components. The model input data for existing network such as pipe dimensions, slopes, and material properties are extracted from survey output report. Rational method is used for calculation the volume of storm runoff.

iii. Calibration Setting: The calibration process involves adjusting the model's parameters to match the measured data. The runoff coefficient value 0.08 is used in the model. Manning coefficient is 0.015 and .025 is used for RCC and earthen drains respectively. 10 minutes is inputted as the minimum time of concentration.

iv. Model Validation: After calibration, the model is validated by comparing the model's output to the measured data. The capacity of Shimrail pump station and Adamjee Pump station are 38.5 cumec and 33.0 cumec respectively. The model system rational flow is 39.32Cumec and 37.59 cumec of the 2 nodes which shows 2.13% & 13.90% deviation.

4.8.3 Design in Excel Spreadsheet

NCC area had been proposed to be divided into 4 (four) storm runoff zones (herein, it was called as Drainage Zones). For the design of a zone, the zone was initially divided into catchments. The UP node to DOWN nodes were noted down according to the existing invert level into an excel sheet. The stretch length were measured from node to node. The catchment area of individual catchment were measured. The catchment area of an individual stretch were calculated based on proportion. It was done by calculating nodal length divided by total length multiplied by the total area.

After that, the Inlet time was assumed as 10min, which measured the time of flow rate. Finally, time of concentration was calculated by adding inlet flow and time of flow. For the calculation of Rainfall intensity, the formula followed as:

Rainfall Intensity = 54.188*[2/{(Time of Concentration/60)+1}]

The rainfall intensity per stretch was measured. Its unit was converted in (m). The Storm runoff was calculated.

Then storm runoff = CIA wss calculated, where

C = Co-efficient which is 0.85,

I = Runoff Intensity, which was already calculated

A = Area (Cumulative area per stretch).

Its unit in cumec (m3/sec) was denoted by "q". After the storm runoff, the Hydraulic Radius was calculated which was denoted by "R" and its unit was in "m". For this calculation, the desired parameters was calculated by the formula R = (B*d)/(B+2*d), where B= width of the drain d= water depth (assumed).

For the measurements of velocity of a flow through two nodes, slope and a co-efficient runoff "n" was assumed initially. The slope was calculated from differing the invert levels divided by length. The "n" value ranging from 0.011 to 0.013 was assumed.

For the velocity, they used Manning's Formula, Velocity (v) = 1/n* R^(2/3)*S^(1/2)

where n= Co-efficient (0.011 to 0.013)
R= Hydraulic Radius (already discussed)
S= Slope (already discussed)

Now, after getting the velocity of a node of a drain, they needed to measure the discharge which was denoted by Q and unit was cusec. For the calculation of discharge, they used a formula. Here it is

Q = Av Here, A= Area (Width*Water depth) V= Velocity

At last, the ratio of storm runoff and discharge of a stretch of the drain was calculated. If the ratio was less than 1, the stretch was considered as ok. If the ratio was more than 1, the node was supposed to be decided as not ok. So, the design of the stretch needed to be redesigned for renovation of existing drain. From the practical and economic considerations on retention of existing stretch a value of 1.5 has been assumed as the critical limit.

4.9 Proposed Approach for Canal Design

-
- Study of total storm catchment basin (in general it will go beyond the city);
- Zoning for Drainage proposal;
- Identification of feasible storm outfall location, tentative pumping station location;
- Dividing of total catchment to smaller catchment area;
- Evaluation of existing carrying capacity of canals and assessment of its rehabilitation possibility;
- Proposal for canal system and its network;
- Proposal for drain network;
- Preliminary Design of canal system and drainage network;
- Block costing;
- Phasing and prioritization;

5 DRAINAGE MASTER PLAN

5.1 Study of Watershed

5.1.1 Theoretical Study

Narayanganj and its extended/adjoining areas are bounded by 4 rivers – (i) Dhaleswari-Briganga on the west, (ii) Meghna in the far east, (iii) Brahamaputra in the east, and (iv) Sitalakshya intersecting NCC. The rivers are running almost in near-parallel alignment and converge at the south of NCC.

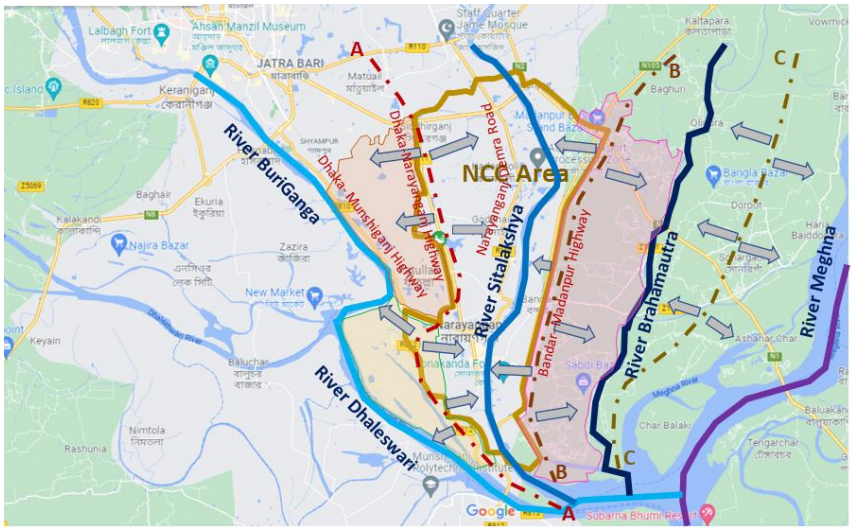


Figure 31 – Theoritical Watershed Boundary

Theoretically the watershed line can be drawn near-parallel with a converging tendency at south. It is observed that the watershed boundary of NCC area can be theoretically drawn along Dhaka-Narayanganj Highway and Narayanganj-Munsiganj Highway in the east, and Bandar-Madanpur Highway in the east, as shown.

5.1.2 Validation from Ground Truthing

Validation through ground truthing has been done, keeping the theoretical study as ready reference. Reconnaissance was done along the canal flow and its alignment. It has been seen that the watershed line is no way matching to the theoretical study. The railway line Kamalapur (Dhaka)-Narayanganj, running parallelly east to the Dhaka-Munshiganj Road, is more or less acting as the watershed boundary.

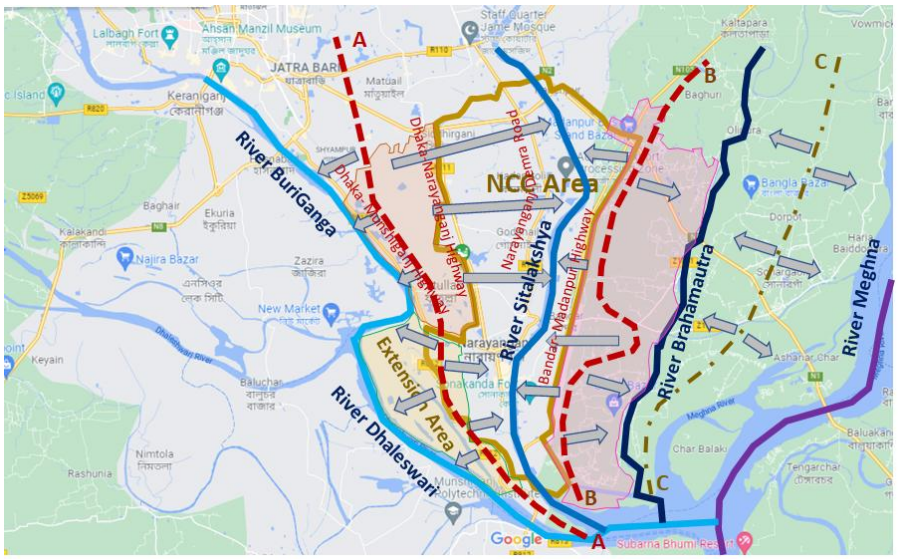


Figure 32 – Watershed Boundary after Ground verification

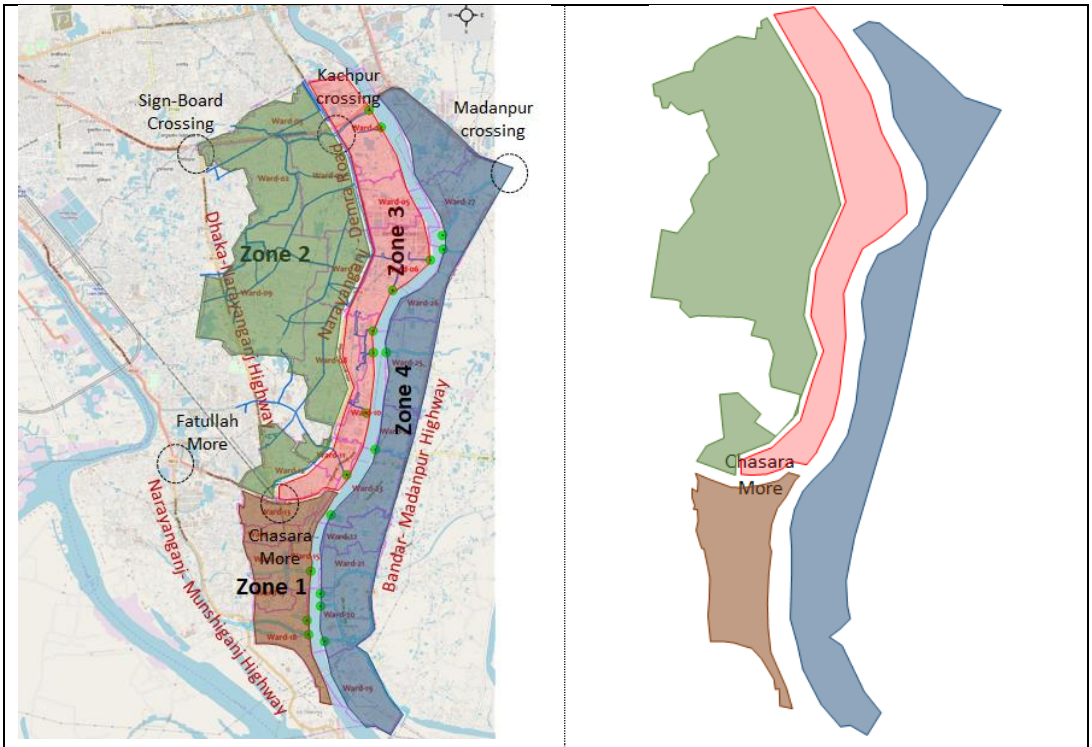
NCC catchment area falls under this watershed. Details of NCC catchment boundary is discussed below.

5.2 Drainage Zones

NCC area is approximately defined at three sides- (i) Dhaka_Narayanganj Highway and Dhaka-Munshiganj Highway in the west, (ii) Bandar-Mdanpur Highway in the east, and (iii) Dhaka-Chitagong Highway in the north. Drainage zoning have been done based on the canal system, highways, river course. The proposed approach towards framing up a comprehensive proposal for the drainage system is discussed below.

The catchment is proposed to be divided in 4 zones. Based on the concept, the storm drainage runoff area of NCC has been divided into 4 zones. The basis of division of zones are:

- Highway connecting Fatullah, Chasara, Adamjee, Kachpur (Narayanganj-Demra Road)
- River Sitakshaya
- DND project by other authority.
- Compartmentalisation of DND[17]



Drainage Zone Map | Skeleton Representation of Zones

Figure 33 – Proposed Drainage Zone

Zone 1	Wards - 13, 14, 15, 16, 17, 18
Zone 2	Wards - 1, 2, 3, 17, 8(73%), 9, 11(35%), 12(62%)
Zone 3	Wards - 4, 5, 6, 8(27%), 10, 11(65%), 12(38%)
Zone 4	Wards - 19, 20, 21, 22, 23, 24, 25, 26, 27

[17] This matched with proposal under DAP 2010.

Ward	Land Area[18] in Sqkm					% Contribution			
	Zone 1	Zone 2	Zone 3	Zone 4	Total	Zone 1	Zone 2	Zone 3	Zone 4
1	0.00	2.90	0.00	0.00	2.905	0	100	0	0
2	0.00	2.43	0.00	0.00	2.428	0	100	0	0
3	0.00	1.50	0.00	0.00	1.503	0	100	0	0
4	0.00	0.00	2.20	0.00	2.201	0	0	100	0
5	0.00	0.00	1.13	0.00	1.131	0	0	100	0
6	0.00	0.00	2.14	0.00	2.140	0	0	100	0
7	0.00	1.63	0.00	0.00	1.634	0	100	0	0
8	0.00	2.21	0.83	0.00	3.038	0	73	27	0
9	0.00	5.64	0.00	0.00	5.635	0	100	0	0
10	0.00	0.00	1.61	0.00	1.607	0	0	100	0
11	0.00	0.27	0.51	0.00	0.780	0	35	65	0
12	0.00	1.13	0.70	0.00	1.835	0	62	38	0
13	1.11	0.00	0.00	0.00	1.106	100	0	0	0
14	0.46	0.00	0.00	0.00	0.458	100	0	0	0
15	0.71	0.00	0.00	0.00	0.707	100	0	0	0
16	0.63	0.00	0.00	0.00	0.631	100	0	0	0
17	0.60	0.00	0.00	0.00	0.605	100	0	0	0
18	1.43	0.00	0.00	0.00	1.427	100	0	0	0
19	0.00	0.00	0.00	1.60	1.603	0	0	0	100
20	0.00	0.00	0.00	1.70	1.700	0	0	0	100
21	0.00	0.00	0.00	0.82	0.819	0	0	0	100
22	0.00	0.00	0.00	0.90	0.897	0	0	0	100
23	0.00	0.00	0.00	1.35	1.347	0	0	0	100
24	0.00	0.00	0.00	0.72	0.725	0	0	0	100
25	0.00	0.00	0.00	1.84	1.843	0	0	0	100
26	0.00	0.00	0.00	0.91	0.905	0	0	0	100
27	0.00	0.00	0.00	2.38	2.381	0	0	0	100
TOTAL	**4.933**	**17.722**	**9.114**	**12.219**	**43.987**				

Table 25–Ward-wise Contribution to Drainage Zones

5.3 Proposal for Zone 1

Catchment of zone 1 has been initially delineated based on the existing network and its outfalls. There were 38 nos. major outfalls and hence same numbers of catchments were conceptualized. At later stage, with further iteration based on the proposed network, subsequent changes in the catchment boundaries have been done to modify it in line with the proposal. Some of the initial catchments were merged to establish final catchment boundaries. Final delineation of catchment boundaries are shown in the Drawing section.

[18] Land area is taken from survey map, excluding river and canals areas on plan.

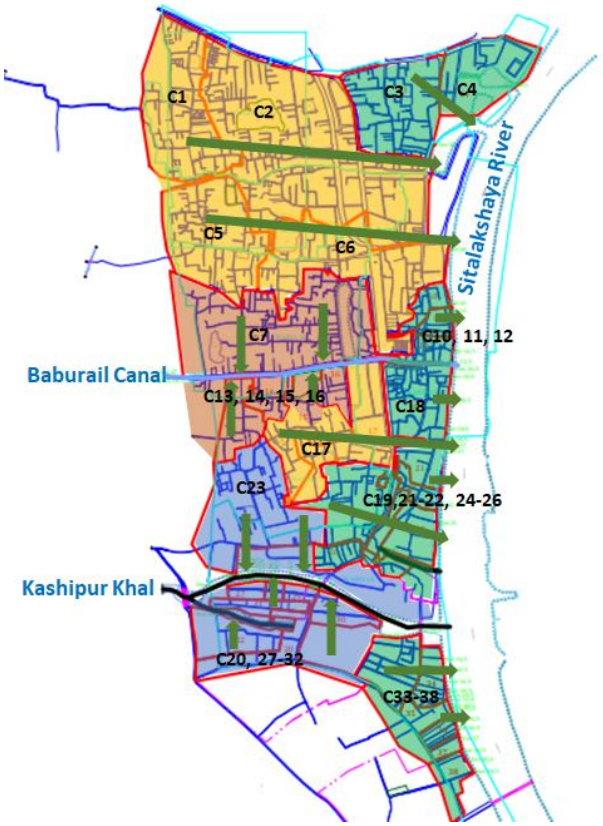


Figure 34 - Catchments with Outfall points (Proposed) in Zone 1

Catchments proposed to outfall in Sitalakshaya river through Trunk main/drain
Catchments proposed to outfall in Sitalakshaya river
Catchments proposed to outfall in Baburail canal embankment trunk drains
Catchments proposed to outfall in Kashipur khal

Salient detail of catchment is given below.

Catchment No.	Area (sqkm)	Road (km)	Catchment No.	Area (sqkm)	Road (km)	Catchment No.	Area (sqkm)	Road (km)
1,2,5,6	1.76	38.3	16	0.038	1.261	28	0.009	0.197
3	0.217	5.824	17	0.262	6.223	29	0.015	0.403
4	0.153	1.651	18	0.129	4.058	30	0.041	0.555
7	0.443	8.75	19	0.023	0.649	31	0.030	0.691
8	0.059	1.006	20	0.092	1.527	32	0.082	0.927
9	-	-	21	0.044	1.387	33	0.088	2.24
10	0.033	1.091	22	0.026	0.835	34	0.043	1.185
11	0.024	0.91	23	0.267	5.09	35	0.072	1.322
12	0.031	1.558	24	0.163	4.097	36	0.019	0.831
13	0.070	1.205	25	0.066	0.924	37	0.012	0.17
14	0.041	0.854	26	0.031	1.239	38	0.042	0.983
15	0.036	0.549	27	0.016	0.38	**Total**	**4.55**	**98.18**

Table 26–Catchment Details in Drainage Zone 1

*Catchment 8 has later been added and designed to catchment 6.

** Catchment 9 does not exist.

Contributory area of each stretch is sub-catchment of that respective stretch. Sub-catchment has been calculated based on:

(i) Theism polygon – This is applied to bigger catchments, mainly the catchment having landlocked all round, and

(ii) Proportion to stretch length – Itis applied to smaller catchments, mostly on the bank to canals and rivers. In this case the sub-catchment area is calculated by dividing the catchment area in proportion to the length of stretch within the catchment.

Trunk main is conceptualized for the land-locked catchment. In this case it is Catchment 1256 and 17. Length of trunk is more than 1.5 km. Other catchments are smaller mostly located near the river/canals. These have short route (about 0.5km) to reach the discharging points at the receiving water body.

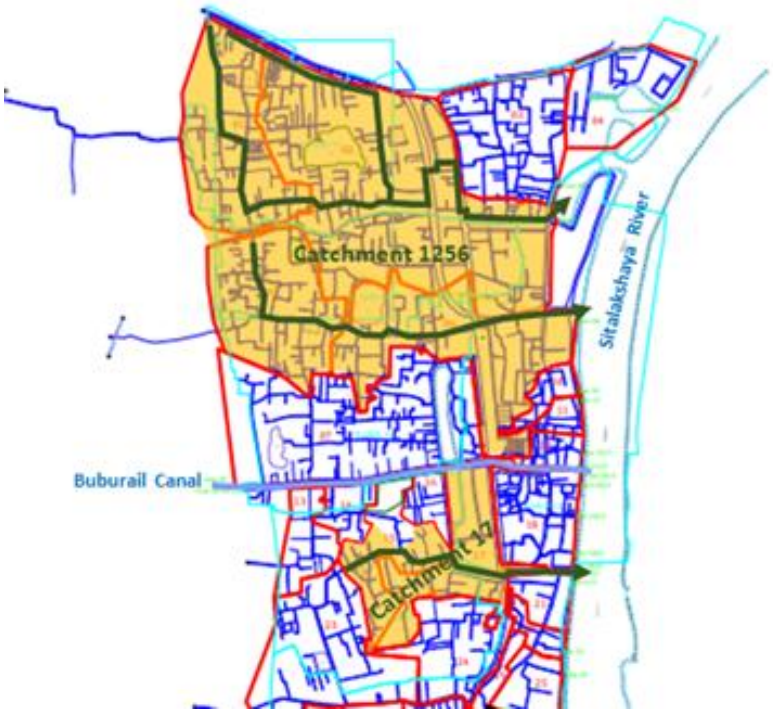


Figure 35 - Trunk Main/Drain Concept in Catchment

Provision of Looping and flow Diversion (LoD) in a drainage network is an effective tool in an urban drainage. It plays a major role in case there develops an inadequacy at any stretch with the system due to poor maintenance. This arrangement comes into play in diverting flow, thus not allow to overtop at ground level. It also provide enough flexibility in the system. It is proposed to provide LoD at 7 identified locations.

Sl. No.	Looping and Diversion nos.	Between Catchments	Location
1	LoD-1	Within 1256	Shown below
2	LoD-2	Within 1256	
3	LoD-3	Within 1256	
4	LoD-4	Within 1256	
5	LoD-5	Between 5 and 7	
6	LoD-6	Between 17 and 23	
7	LoD-7	Between 17 and 24	

Table 27–Looping and Diversion Location in Drainage Zone 1

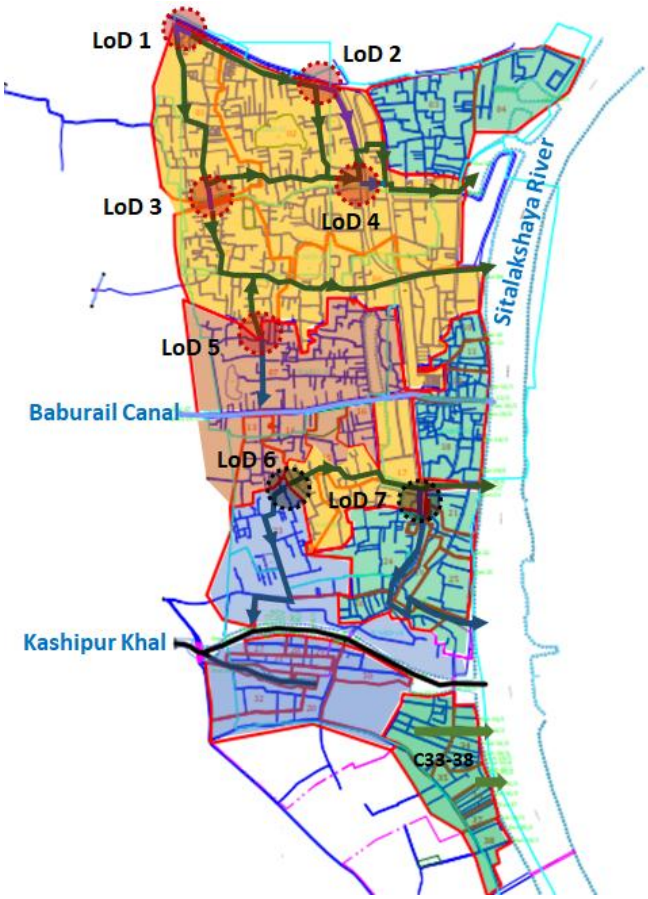


Figure 36 - Looping and Diversion (LoD) Concept

The network system was designed in excel spread sheet and simulated in SEWER Gems software. For the trunk main catchments, SEWER Gems was used and for other catchments excel spreadsheet was used. Salient details are:

- Length of the system 98999 m
- Average depth 1.206 m
- Average Width 806 m
- System capacity 107339 m3

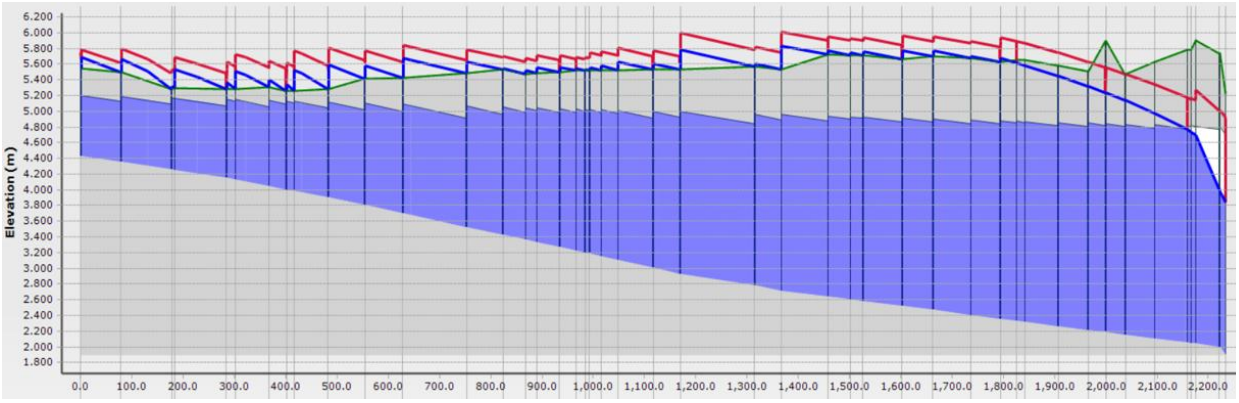


Figure 37 - Hydraulic profile of Trunk Main (Chasara) in Zone 1considering HWL in river

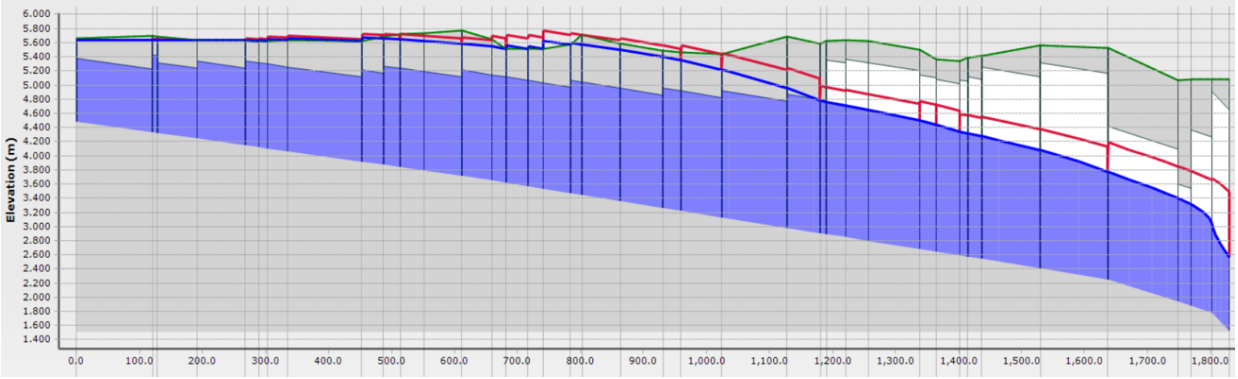


Figure 38 - Hydraulic profile of Trunk Main (Paikpara) in Zone 1 considering free flow in river

5.4 Proposal for Zone 2

Catchment of Zone 2 has been initially delineated based on the existing network and its final outfalls. In this zone the canals are all connected to the major pumping stations, some are towards Adamjee and Shimrail PS and the others are towards Fatullah, Pagla and Shyampur PS. In this case the basis of catchment delineation is based on the storm water pumping station where the storm water gets terminated presently.

It can be delineated to 3 sub-catchments. The major catchments is flowing towards east to Shimrail and Adamjee PS. The other two catchments are flowing towards west.

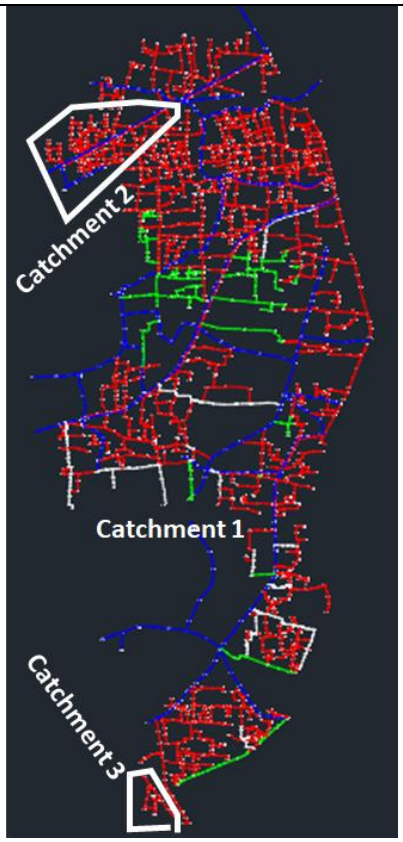
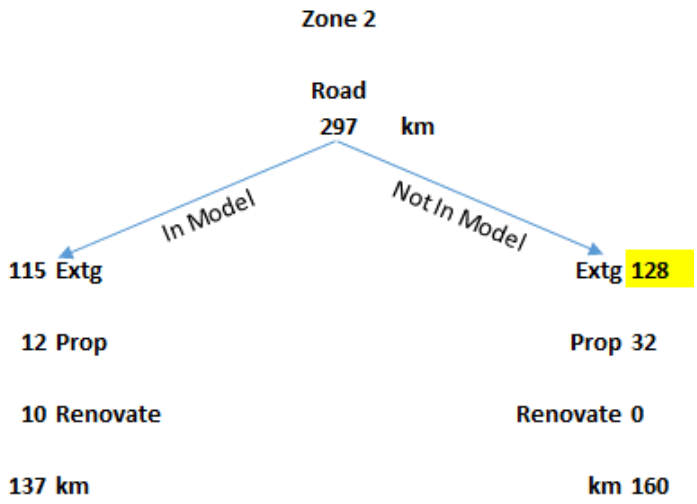


Figure 39 – Zone 2 Catchments

Salient detail of catchment is given below.

Catchment No.	Area (sqkm)	Stretch (km)
1	0.20	3.6
2	0.71	18.3
3	16.7	274.6
Total	**17.7**	**296.6**

Contributory area of each stretch is sub-catchment of that respective stretch. Sub-catchment has been calculated based on Theism polygon. The smaller stretches are ignored in calculating the catchment area of each sub-catchment. Only the bigger catchment areas are given input, which includes the smaller stretches (or in other words, smaller catchments).



The network system has been designed in SEWER Gems software. Salient details are:

- Length of the system 296620 m
- Average depth 1.219 m
- Average Width 925 m
- Average slope 1 in 1104
- System capacity 266332 m3
- Adequacy 59.2%

5.5 Proposed Design in Zone 3

Catchment of Zone 3 has been initially delineated based on the existing network and its outfalls. There were 48 nos. major outfalls and hence same numbers of catchments were conceptualized. At later stage, with further iteration based on the proposed network, subsequent changes in the catchment boundaries have been done to modify it in line with the proposal. Some of the initial catchments were merged to establish final catchment boundaries. Final delineation of catchment boundaries are shown in the Drawing section.

Salient detail of catchment is given below.

Catchment No.	Area (sqkm)	Stretch (km)	Catchment No.	Area (sqkm)	Stretch (km)	Catchment No.	Area (sqkm)	Stretch (km)
1	0.863	7.500	16	0.037	0.138	31	0.103	1.500
2	0.115	3.400	17	0.074	1.364	32	0.032	0.457
3	0.034	0.819	18	0.156	2.215	33	0.169	4.722
4	0.024	0.638	19	0.252	4.250	34	0.032	0.500
5	0.007	0.220	20	0.091	1.127	35	0.026	0.600
6	0.038	0.650	21	0.216	2.952	36	0.186	2.753
7	0.141	2.450	22	0.203	2.950	37	0.142	2.000
8	0.329	5.500	23	0.047	0.964	38	0.042	0.938

Catchment No.	Area (sqkm)	Stretch (km)	Catchment No.	Area (sqkm)	Stretch (km)	Catchment No.	Area (sqkm)	Stretch (km)
9	0.235	4.500	24	0.039	0.766	39	0.010	0.157
10	0.210	4.673	25	0.024	0.617	40	0.022	0.713
11	0.149	3.350	26	0.018	0.471	41	0.025	0.550
12	0.100	2.200	27	0.062	1.139	42	0.136	2.145
13	0.112	4.779	28	0.009	0.100	43	0.599	12.328
14	0.014	0.259	29	0.097	0.450	44	0.179	4.273
15	0.013	0.284	30	0.054	0.837	48	0.042	0.521
						Total	**5.55**[19]	**95.71**[20]

Table 28–Catchment Details in Drainage Zone 3

Contributory area of each stretch is sub-catchment of that respective stretch. Sub-catchment has been calculated based on proportion to stretch length. Itis applied to all sub-catchments being smaller in area. In this case the sub-catchment area is calculated by dividing the catchment area in proportion to the length of stretch within the catchment.

As the catchments are smaller in size and length of flow is less, the trunk main concept is not adopted in true sense. The critical stretch of the network in any catchment is identified based on the time of flow, which has been further analysed. This can be assumed as trunk alignment, instead of trunk drain, for argument sake.

The network system has been designed in excel spread sheet. Salient details are:

- Length of the system 94242 m
- Average depth 1.12 m
- Average Width 945 m
- Average slope 1 in 1030
- System capacity 114714 m3
- Adequacy 87.2%

5.6 Proposed design in Zone 4

Catchments of Zone 4have been initially delineated based on the existing network and its outfalls. After examining the existing network 42 nos. major outfalls have been initially conceptualized based on the theory one catchment with one outfall. At later stage, with further iteration based on the proposed network, subsequent changes in the catchment boundaries have been done to modifyit in line with the proposal, there by 121 major and minor outfalls were proposed under 42 catchments. Some of the initial catchments were merged to establish final catchment boundaries. Final delineation of catchment boundaries are shown in the Drawing section.Salient detail of catchment is given below.

[19] Area at the periphery of river and canals, embankment roads, big lake/ponds, areas under industries whose outfalls falls in the rivers and canals are not considered in catchment area calculation.

[20] Length of road Narayanganj-Demra highway, length of roads within industries are not included in design calculation.

Catchment No.	Area (sqkm)	Stretch (km)	Catchment No.	Area (sqkm)	Stretch (km)	Catchment No.	Area (sqkm)	Stretch (km)
1	0.127	1.908	15	0.166	3.061	29	0.273	4.761
2	0.350	4.510	16	0.242	4.522	30	0.172	2.110
3	0.027	0.640	17	0.199	3.254	31	0.072	0.592
4	0.193	2.174	18	0.034	0.675	32	0.308	4.861
5	0.026	0.256	19	0.134	2.112	33	0.041	0.763
6	0.068	1.124	20	0.158	3.272	34	0.016	0.392
7	0.062	0.809	21	0.130	3.050	35	0.182	3.655
8	0.170	2.930	22	0.325	5.115	36	0.028	0.778
9	0.168	2.461	23	0.234	2.800	37	0.136	2.180
10	0.015	0.475	24	0.109	2.086	38	0.067	0.926
11	0.052	0.706	25	0.662	10.798	39	0.180	3.625
12	0.135	2.535	26	0.078	1.794	40	0.131	2.739
13	0.205	3.965	27	0.471	11.935	41	0.169	2.170
14	0.176	3.455	28	0.354	8.650	42	0.264	5.406
						Total	**7.105**[21]	**124.63**

Table 29–Catchment Details in Drainage Zone 4

There are many big water bodies in the eastern fringes of the zone. These water bodies are not considered in the catchment area calculation. In futures if these water bodies get transformed to residential or commercial areas, its surface runoff shall be considered to be concentrated at the canals at the point of crossing Bandar-Madanpur Highway. It shall be included in the FinalMaster Plan.

Contributory area of each stretch is sub-catchment of that respective stretch. Sub-catchment has been calculated based on proportion to stretch length. Itis applied to all sub-catchments being smaller in area. In this case the sub-catchment area is calculated by dividing the catchment area in proportion to the length of stretch within the catchment.

As the catchments are smaller in size and length of flow is less, the trunk main concept is not adopted in true sense. The critical stretch of the network in any catchment is identified based on the time of flow, which has been further analysed. This can be assumed as trunk alignment, instead of trunk drain, for argument sake.

The network system has been designed in excel spread sheet. Salient details are:

- Length of the system 134941 m
- Average depth 1.289 m
- Average Width 935 m
- Average slope 1 in 1290
- System capacity 159828 m3
- Adequacy 87%

[21] Area at the periphery of river and canals, embankment roads, big lake/ponds, areas under industries whose outfalls falls directly in the rivers and canals are not considered in catchment area calculation.

5.7 Summary of Drain Proposals

Sl. No.	Drain categories	Length		Remarks	
1	Existing drains to be cleaned and retained	518009	m	82.9	%
2	Proposed new drains	68637	m	11.0	%
3	Existing drains to be renovated	38156	m	6.1	%
	TOTAL	624802	**m**		

Table 33–Drain Summary Proposal

Design output is given in **Annexure VI**. Names of some roads/lanes/areas, where drains are proposed to be newly laid or renovated/rehabilitated, are given in **Annexure XI**

5.8 Categorisation of Drains

5.8.1 Based on Importance (Design Approach)

From importance point of view the drains are categorised as

- Trunk drain, W>1.8m
- Main drain, W>1.2m and <=1.8m
- Secondary drain, W >0.75m and <= 1.2m
- Tertiary drain, W = 0.6m to 0.75m

From design perspective tertiary drain shall be design first followed by secondary, main and trunk drains. But from construction perspective trunk drain shall be targeted first followed by main, secondary and tertiary drains.

5.8.2 Based on Nature of Works (Construction Approach)

The design output has been categorised in 3 types of drains –

1. Existing drains to be retained
2. Existing drains to be renovated (or replaced)
3. Proposed new drains

The proposed drains are mainly on the roads where they are no drains. These are basically new roads, smaller in size, terminal ones (i.e. starting stretches). These drains lead to the existing system. Hence, though a minimum size of 750mm depth was tried to be kept but due to limitation of depth in the existing downstream system minimum drain size has been kept to 600mm depth.

In the existing system it has been observed that some existing drains are directed to unknown destination got vanished in course and some terminated to borrow pit or ponds/lakes or ditches. In such situations new drains have been proposed to tap these existing drains and diverted to an organized alignment towards the river/canals.

Some of the existing drains are proposed to be renovated. The main reason attributed for modifications of these existing drains are its slope and invert depth. In few cases it is also observed that even the existing

drains are adequate in size, it could not support the neighboring areas due to its higher invert levels. The habitants surrounding it is at a lower level. In all these scenarios the existing drains are proposed to be renovated as per the designed section and slope.

Zone	Drain categories	Length		Remarks	
Zone 1	Existing drains to be cleaned and retained	84679	m	85.5	%
	Proposed new drains	2896	m	2.9	%
	Existing drains to be renovated	11424	m	11.5	%
	TOTAL	**98999**	**m**		
Zone 2	Existing drains to be cleaned and retained	243359	m	82.0	%
	Proposed new drains	44672	m	15.1	%
	Existing drains to be renovated	8589	m	2.9	%
	TOTAL	**296620**	**m**		
Zone 3	Existing drains to be cleaned and retained	76517	m	81.2	%
	Proposed new drains	7799	m	8.3	%
	Existing drains to be renovated	9926	m	10.5	%
	TOTAL	**94242**	**m**		
Zone 4	Existing drains to be cleaned and retained	113454	m	84.1	%
	Proposed new drains	13270	m	9.8	%
	Existing drains to be renovated	8217	m	6.1	%
	TOTAL	**134941**	**m**		

Table 30– Zone wise Proposed Drainage Output Summary

5.9 Outfalls of Proposed Drainage System

Sl. No.	Zone	Nos. of Outfall	Invert level range below 3.15m PWD	Status	Remarks
1	Zone 1	62	9	Renovate/New	14%
2	Zone 2	127	-	Renovate/New	Taken care by DND pump stn.
3	Zone 3	66	10	Renovate/New	15%
4	Zone 4	119	27	Renovate/New	27%

Table 31–Zone wise Proposed Outfall Summary

Details of outfalls are given in **Annexure XII**.

5.10 Provision of Screen

It has been envisaged that provision of screens at strategic locations, mainly at the outfall locations of drains to canals/river, will be advantageous to the authority from maintenance point of view. It will prevent unwanted bigger size materials to get carried with the flow in canals and river to flow with it. Size of screens shall calculated based on clear spacing of 80mm between bars 0r 1.5 times width of drain which eber is maximum. It shall be of stainless steel quality. In case of non-availability of stainless steel MS rod epoxy painted can be used as an alternative. Maintenance frequency for MS rod will be less than SS rod.

Bamboo Screen (Present practice)

Modified SS Screen (proposed)

5.11 Provision of Siltation Tanks at Drain Outlet to Khals

In order to ensure that the drainage system does not become clogged with solid waste or silt being conveyed within the system, and to prevent these discharging to the Shitalakshya river; a series of desiltation tanks fitted with bar screens should be installed along the major drains and integrated at the end of the outfalls as shown in Figure below:

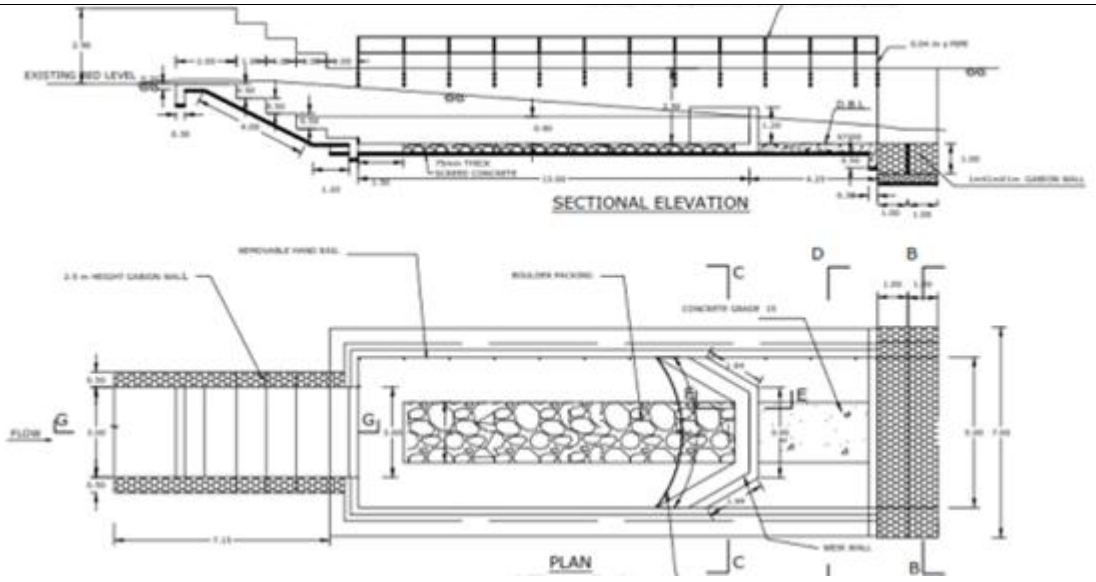


Figure 40 – Typical Outfall Arrangement with Silt Chamber

Such elements should also be installed in other outfalls from the community/street drains to the different khals. A silt collection pit shall be provided at one end of the siltation tank to facilitate silt removal by excavator. The bar screens should be fitted with manual scrapers to remove any captured solid waste elements.

5.12 Solid Waste and Silt Removal from Drains

Solid waste disposal in the drains shall be discouraged and enforce by law. However if there is any requirement for removal of solid waste it shall be cleaned through maintenance schedule of NCC.

5.12.1 Supply of Equipment

It is proposed to include high pressure jetting equipment, trucks, etc to ensure that NCC would have sufficient resources to clean an maintain the drainage system.

5.13 Study on requirement of Gates at Outfall

In order to ensure that any river surge levels are not transmitted back into the khals system, a series of floodgates will be constructed at each drain outlet upstream of the BIWTA embankment where applicable. The structures will comprise a number of rectangular non-return flap valves according to the drain width. If there is limitation of budget, installation of flap gates can be deferred to the next phase.

Requirement of gated structure at the outlet of drain to canal/river, i.e. at outfall location, will depend on the water level rise in the river. In case the river water level raises above the drain level, there is possibility of river water to get into the system. In that case provision of outfall gates may be considered.

A set of river data was obtained from the monitoring station in Narayanganj (23.66degreeN, 90.52degreeE) Bangladesh Water Development Board (BWDB), as given below[22].

Year	Maximum WL (m PWD)	Minimum WL (m PWD)	Year	Maximum WL (Pm WD)	Minimum WL (m PWD)
1996	5.27	2.13	2009	5.04	0.69
1997	5.11	0.88	2010	4.8	0.67
1998	6.45	0.81	2011	4.9	0.67
1999	5.51	0.51	2012	5.1	0.59
2000	5.44	0.54	2013	4.84	0.97
2001	4.93	0.57	2014	5.42	1.02
2002	5.33	0.70	2015	5.12	0.89
2003	5.94	0.72	2016	5.34	1.02
2004	6.27	0.56	2017	5.26	1.07
2005	5.23	0.79	2018	4.42	1.23
2006	4.2	0.50	2019	4.85	0.82
2007	5.57	0.22	2020	5.39	0.98
2008	5.51	0.63			

Table 32–River water Level data

Maximum water level in river is the decisive criteria for provision of gate for preventing river water to flow inside the drainage system. Considering the median of the last 2 decades maximum water level comes to 5.13m PWD. In some pockets of the zones the average ground level is below the maximum water level So during the critical time of that day when river will have maximum water level some drains within the drainage system will not have free flow condition.

If average of maximum and minimum water levels are considered, the median value for last 2 decades comes to 3.15 m PWD, considering 0.1m rise due to climate change till year 2046. Some of the outfalls

[22] BWDB data – 0.48 = PWD data

will be below this level. Hence, requirement of gated structure at these outfalls may be considered. Flap gates may be proposed at theseoutfalls. Flap gate do not require any manpower to operate. Even if gates are not provided water level in the river will act as virtual gate. The storm water will be stored inside the system.

In a critical climatic condition with HWL in the river and designed rainfall event occurs successively in consecutive 2 (two) days, then there will be requirement to drain out accumulated water from the system. During the period when gate will be closed due to high water level at the downstream side of the system i.e. in Sitalakshaya river, the combined flow can be diverted to a pumping station. It shall be proposed under the Master Plan.The proposed drainage system needs to be integrated with the long term master plan.

From the above discussion it has been revealed that few times in a year, mainly in monsoon period, the invert levels of outfalls will be below the high water level of Sitalakshaya river. So it needs to be drained out from the system through pumping, only when it is required, or wait for river to attain its low water level. Installation of pumping facilities shall be taken up in the next phase as per Master Plan, preferably with the comprehensive wastewater plan.

Presently the proposed drainage system will act combined system (DWF+SWF), discharge the flow to the canals and river. Further to it, the design life considered for the proposed drainage system is 30 years. Hence, utilization of the assets (drains) will be of utmost importance throughout its design life.

The comprehensive wastewater master plan shall consider interception and diversion of DWF from this combined system. It shall be transmitted to treatment facilities along the BIWTA embankment roads through intermediate pumping facilities. Hence, pumping stations are envisaged to be a must in the wastewater system. It can be transformed to a combined PS to cater both for SWF and DWF.

5.13.1 Flooding due to River Surge Levels

Although the incidence of flooding of low lying areas on the west side of the Shitalakshya river (Narayanganj, Khanpur) from river surge levels has been rare over the recent years, climate change will lead to increasing river levels. In this regard, BIWTA has commenced the construction of an earthen embankment along the western bank of the river.

As the ground level along the east bank of the Shitalakshya river is some 5 metres higher than the west bank, flooding of the Kadam Rasul area from river surge levels is rare.

From the data it has been observed that highest invert level of the canals is (+) 2.13m. Hence, requirement of gated structure at the outfalls are evident. However, detailed assessment could be done after hydraulic model. Flap gates are proposed at the outfalls where river water HFL exceeds bed level of canal by 0.45m. Size of the gates shall be determined after hydraulic canal modeling.

Tentative gates:

Zone 1 – 9 nos

Zone 2 –

Zone 3 – 10 nos

Zone 4 – 27 nos

Total flap gates– 46 nos locations

Typical Flap Gate

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5.13.2 Impact of System Volume

As per existing BWDB practice, 2 day consecutive rainfall with 5 year return period is usually considered as design rainfall event. Therefore, 2-day consecutive rainfall event with 5 year return period have been estimated as 234 mm. Enumerated design event is also very close to the estimate as provided in different study report 239 mm and 245 mm (JICA, 1992 and JICA, 1987 respectively). The difference found is due to the use of only one station by JICA for their study, while the mean of two stations is used in this study. Considering the coverage of a drainage area, the value structure, regulator and pump station is important factors. To be in the safer side, the study has considered the design rainfall amounting to 245 mm. So, rainfall data of BMD has been used in all analyses[23]. The above statements are quoted from the source referred.

A worst situation is analysed considering rainfall event with 2 day consecutive rainfall having 5 year return period and assuming the situation will be worsen with maximum water level in the river. The analysis is given below.

Capacity of Drainage system:		
Zone 1-	107,349	m2
Zone 2-	266,332	m3
Zone 1-	109,935	m3
Zone 1-	159,828	m3
	……	
Total capacity	643,444	m3
say	6.5	lakh m3
Area of NCC	43.987	sqkm
	43987000	sqm
Area of canal and water bodies	10	%
Net area of runoff	39,588,300	sqm
Runoff coefficient	0.85	

[23]Source: International Journal of Scientific & Engineering Research, Volume 4, Issue 10, October-2013

Rainfall of 2 day consecutive with		
5 year return period	234	mm in 2 days
Average Intensity of rainfall	4.875	mm/hr in 2 days
Rainfall duration, assume	4	hrs in a day
Total rainfall	19.5	mm
	0.0195	m
Runoff in a day	CiA	
	656,176.07	m3
say	6.50	lakh m3

Hence under this most critical condition the system can absorb 4 hours rainfall with an event of 5-years return period intensity.

5.14 Proposal of a Typical Drain Section

Sl. No	Drain Nomenclature	Drain Width	Invert Depth (d in mm)
1	T-1	600mm	Up to 900mm
2	T-2	Up to 1200mm	Up to 1200mm
3	T-3	Up to 1500mm	Up to 1500mm
4	T-4	Up to 1800mm	Up to 1800mm
5	T-5	Up to 1800mm	> 1800mm

Table 34–Drain Nomenclature

Primary Drain	>1500mm	T4, T5
Secondary Drain	>900mm upto 1500 mm	T2, T3
Tertiary Drain	600mm upto 900mm	T1

Clear Cover of reinforcement

Base-50mm
Vertical-50mm
Top slab-40mm
Rebar - 420Mpa

Clear gap between drain outer face and earthwork line

X = 150mm for d upto 900mm
x =300mm for d > 900mm

Sketches of typical drain Sections are shown below. Bar bending schedule of each standard drain section is shown in drawing section.

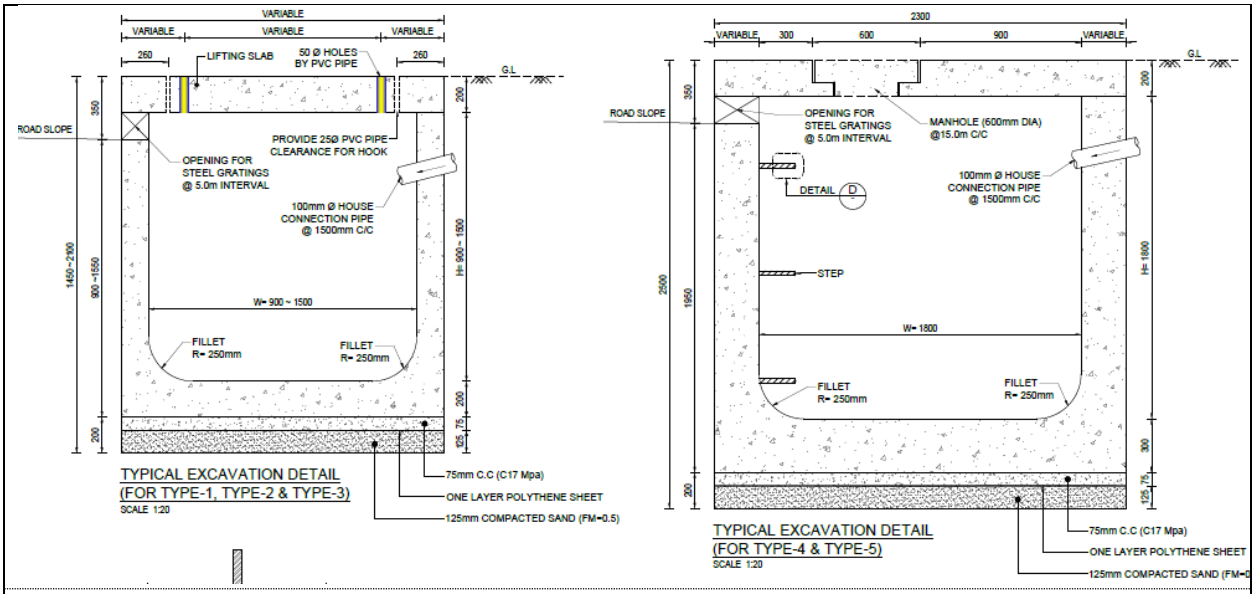


Figure 41 – Typical Drain Crss Section

6 REHABILITATION OF CANAL & WATER BODIES

6.1 Canal Rehabilitation under Zone 1

In Zone 1 there is one main canal apart from a few small canals. This connects the tributary channel of Dhaleswari river and Shitalakshya river. It is too big to be called as a canal, hence locally its is known as Kashipur river. It is designated as 'canal' in this report for easy understanding.

It is proposed to provide all-through embankment roads and make well defined canal edge. Provision of flow regulation by gated structure at the canal outlets are not envisaged at this stage. Canal slope pitching or lining is required to render a defined shape and size.

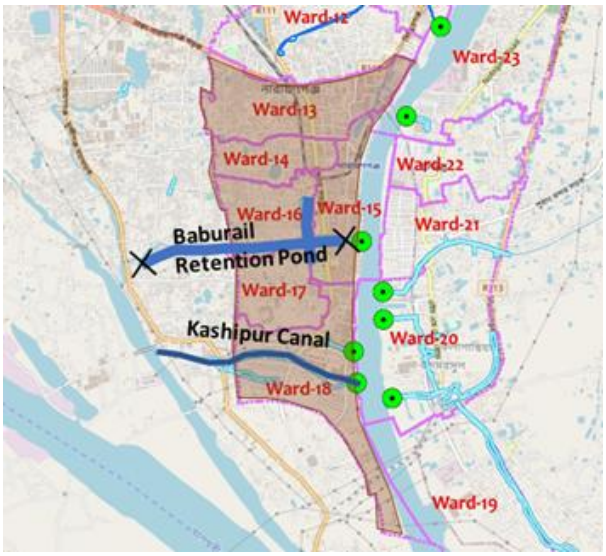


Figure 42 – Rehabilitation Canals in Zone 1

There is another big canal, named as Baburail khal. It is basically a retention pond, neither connected to Dhaleswari river nor to Sitalakhya river. The excess water in monsoon overflows to the river. NCC has constructed it to a proper shape, lined at both slopes (mostly concrete block, and some stretches earthen slope with vegetation), modified its banks to walkways, intercepted all wastewater flow from household to the pond by constructing drains parallel to both sides of the Baburail khal.

Baburail Canal (Retention Poad)

Kashipur Canal

Proposed canals for Rehabilitation	Khal 1 – 0.33 km Kashipur – 1.5 km	Total length – 1.83 km

The proposed canal sections are:

Sl. No.	Name of Khal	Length (m)	Proposed Invert level (m) of/at					Av. Prop. depth of canal (m)	Width
			Outfall to river	Extg. av. of canal	Prop. lvl of canal (U/S)	Prop. lvl of canal (D/S)	Drain O/F to canal		
1	Kashipur Khal	1926	0.576	1.049	0.216	0.024	3.127	4.26	existing
2	Khal -1	333	2.188	1.695	1.257	1.223	3.127	3.3	

Table 35–Proposed canal Rehabilitation in Zone 1

6.2 Canal Rehabilitation under Zone 2

In Zone 2 there is a network of canals which are under DND's scope. Theses canal serves not only NCC but also the adjoining union areas. For detail information on DND the relevant chapter shall be referred. Total length of canals within NCC is about 37km approx. All canals are connected to 5 nos. of storm pumping stations. The major canals are:

Sl/No.	Canal Name	Location /Flow	Ward No.	Length(km) within NCC	Av Depth (m)	Av. Width (m)
1	Wapda Khal	WAPDA khal is connected to Shimrail PS	Ward-01, Ward-02, Ward-09	6.62	3.084	23.10
2	MDC-2	Located on the west side of Ward No. 03 and connected to WAPDA khal	Ward No. 01, Ward No. 03	0.78	2.593	19.34
3	NR-1	Located in the north-east side of Ward No. 09 and flows to the west side of Ward No. 09 and connected to the SD-05	Ward No. 01 & 09	4.45	2.238	17.23
4	Chanpara khal	Located at the North West side of Ward No. 08	Ward-08	2.99	1.504	10.94
5	Jalkuri khal	Located in the South East side of Ward-09 and West side of Ward-07	Ward-07, Ward-08 Ward-09	3.39	1.174	15.61

Sl/No.	Canal Name	Location /Flow	Ward No.	Length(km) within NCC	Av Depth (m)	Av. Width (m)
6	DL-1	Located on the Ward No. 02 Ward No. 03 and connected to MDC-2 khal	Ward No. 02 Ward No. 03	3.17	3.372	12.70
7	SD-5	Connected Jalkuri khal and WAPDA khal	Ward No. 07 Ward No. 09	2.39	1.838	18.56
8	Kadamtoli khal	Located in the middle of the ward No. 07	Ward No. 07	6.46	1.190	8.98
9	Kangsa Khal	The Konson Khal is connected to WAPDA khal	Ward-01	1.23	1.389	9.93
10	DND khal	Located in the eastern side of Ward No. 01, 03 & 07	Ward No. 01, 03 & 07	4.74	#DIV/0!	51.92
11	Shimrail OFC	Outfall canal of Shimrail Pump Station connected to the Shitalakhya river	Ward No. 04	0.89	1.425	43.24
12	NR2/R2	Located in the Ward No.08 & Ward No.09 and connected to the Jalkuri khal	Ward No. 08 Ward No. 09	0.81	1.362	7.44
13	Adamjinagar OFC	Outfall canal of Adamjinagar Pump Station connected to the Shitalakhya river	Ward No. 06	1.68	2.750	17.59

Table 36–Canal Rehabilitation in Zone 2 by DND

Figure 43 – Canals under Zone 2 with Pumpig Stations

Noilkahil khal comes under this zone is beyond DND's scope. Hence this khal has been considered under rehabilitation. The khal will be connect to the DND canal network, which ultimately leads to Adamjee pumping station. Apart from a part of Noilkhali Khal, DND is rehabilitating all canals under Zone 2.

Sl. No.	Name of Khal	Length (m)	Proposed Invert level (m) of/at					Av. Prop. depth of canal (m)	Width
			Outfall to river	Extg. av. of canal	Prop. lvl of canal (U/S)	Prop. lvl of canal (D/S)	Drain O/F to canal		
1	Nolkhali Khal (West)	625	2.209	1.973	1.704	1.642	3.127	2.671	existing

Table 37–Proposed Canal Rehabilitation in Zone 2

6.3 Canal Rehabilitation under Zone 3

In Zone 3 there are 5 (five) major canals apart from Adamjeee outfall canal and Simrail Outfall canal. All the canals start from the embankment road (Narayanganj-Demra Road) flow towards west and terminates to Sitalakshya river. Location details are given below. Total length of canal system under consideration is 5.17 km. Canal slope pitching or lining is required to render a defined shape and size.

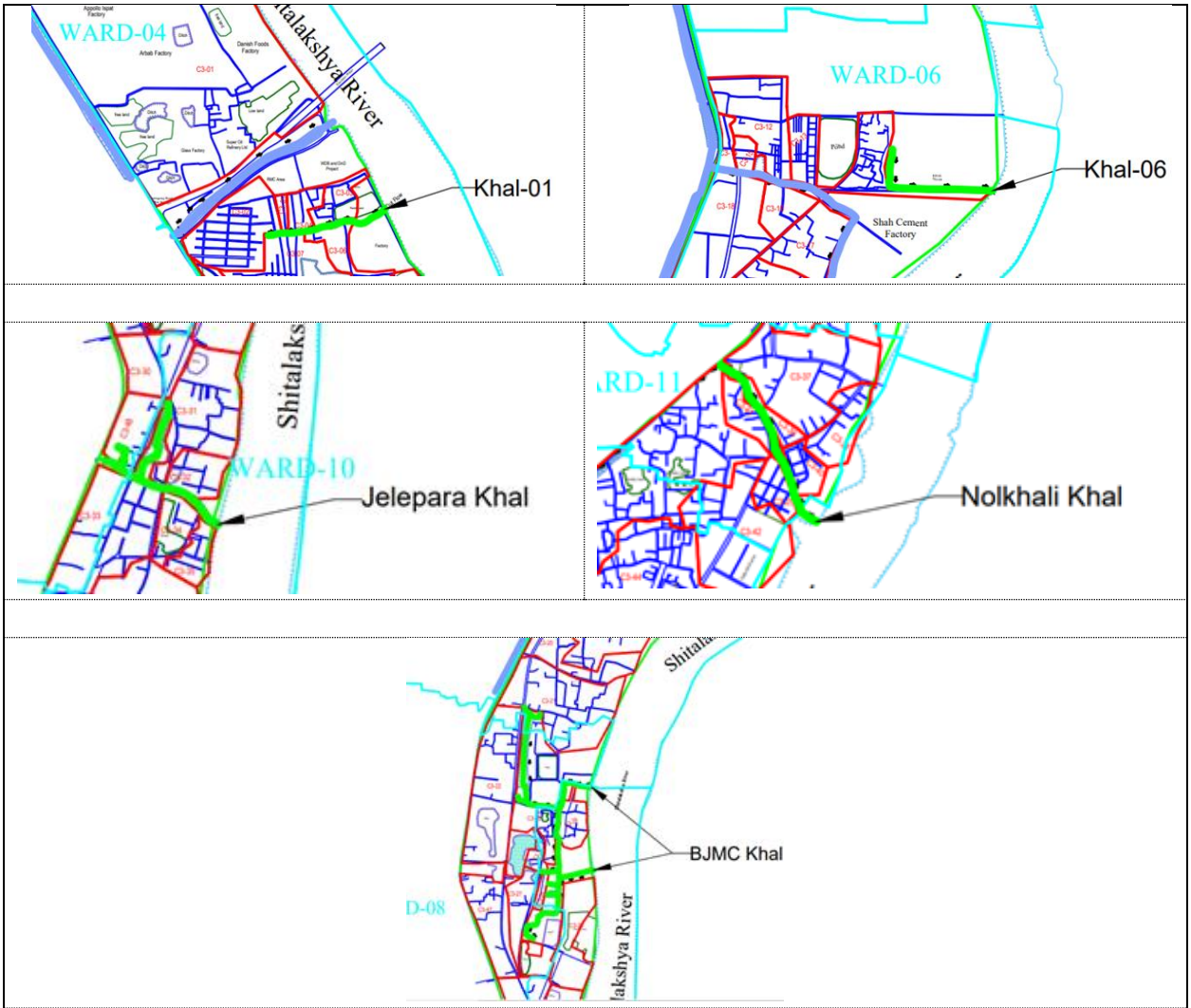


Figure 44 – Canal Rehabilitation under Zone 3

The proposed canal sections are:

Sl. No.	Name of Khal	Length (m)	Proposed Invert level (m) of/at					Av. Prop. depth of canal (m)	Width
			Outfall to river	Extg. av. of canal	Prop. lvl of canal (U/S)	Prop. lvl of canal (D/S)	Drain O/F to canal		
1	Jelepara Khal	965	1.021	1.033	0.618	0.522	3.7	3.851	As per existing canal width
2	BJMC Khal	2526	1.16	1.929	0.836	0.584	3.126	3.426	
3	Nolkhali Khal (East)	730	-0.241	0.651	-0.514	-0.587	2.4	4.224	
4	Khal-06	333	1.866	1.542	1.107	1.073	2.531	2.853	
5	Khal-02	620	0.843	1.695	0.421	0.359	3.5	4.147	

Table 38–Proposed Canal Rehabilitation in Zone 3

6.4 Canal Rehabilitation under Zone 4

In Zone 4 there are10 (ten) canals. All the canals flows towards west and terminates to Sitalakshya river.Location details are given below. Total length of canal system under consideration is 12.4 km.Canal side slope has been proposed to be 2(H):1(V). Pitching or lining is required to render a defined shape and size.

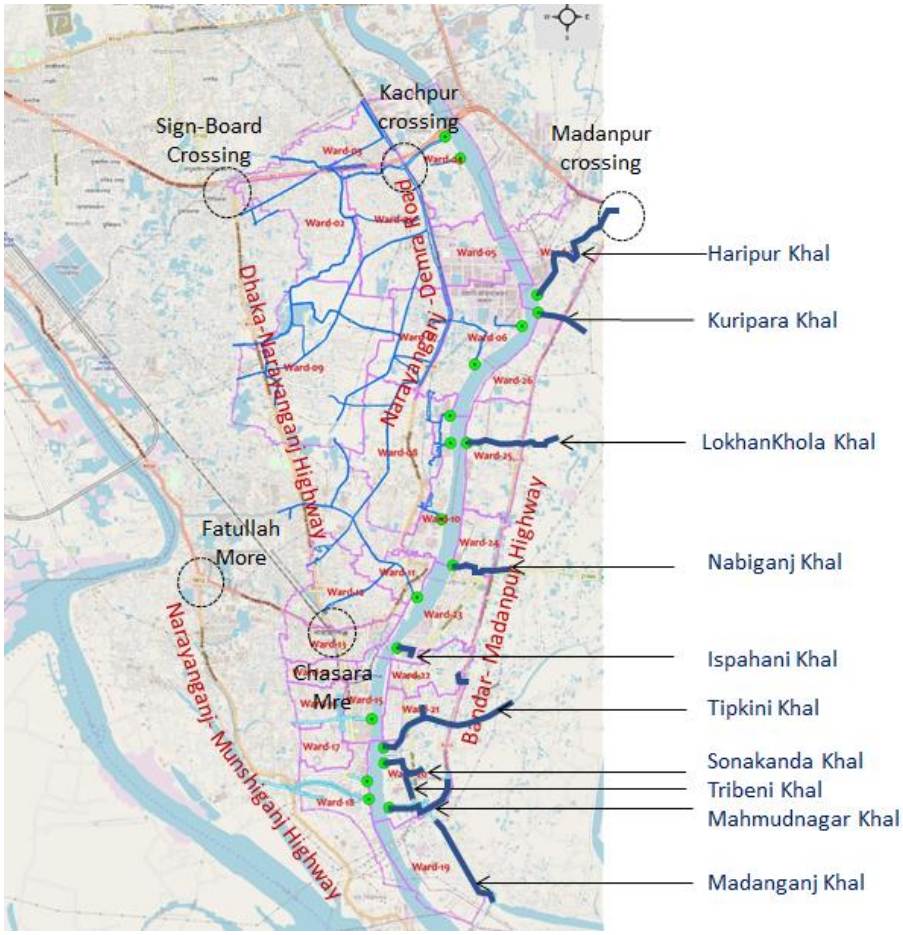


Figure 45 – Canal Rehabilitation under Zone 4

The proposed canals are:

Sl. No.	Name of Khal	Length (m)	Proposed Invert level (m) of/at					Av. Prop. depth of canal (m)	Width
			Outfall to river	Extg. av. of canal	Prop. lvl of canal (U/S)	Prop. lvl of canal (D/S)	Drain O/F to canal		
1	Haripur Khal	2655	1.283	1.562	1.067	1.333	2.445	2.996	As per existing canal width
2	Kuripara Khal	452	1.186	1.843	1.477	1.523	-	3.620	
3	Lakkhon Khola Khal	1004	2.31	2.814	2.450	2.550	4.219	2.445	
4	Nabiganj Khal	889	1.507	2.278	1.556	1.644	3.376	2.963	
5	Ispahani Khal	339	1.276	1.622	1.283	1.317	3.06	4.179	
6	Tipkini Khal	1188	0.57	0.606	0.241	0.359	3.467	3.574	
7	Tribeni Khal	1562	1.31	2.435	1.422	1.578	2.031	3.845	
8	Sonakanda Khal	961		3.237	2.552	2.648	3.788	1.818	
9	Mahmudnagar Khal	1618	0.943	1.526	1.119	1.281	3.404	4.818	
10	Madanganj Khal	1736		0.046	-0.387	-0.213	3.159	5.137	

Table 39–Proposed Canal Rehabilitation in Zone 4

It has been observed that the Roads and Highways Department (RHD) has undertaken a project in executing widening works of Bandar-Madanpur Road. The department is constructing new culverts for canal crossings. The invert level of the culvert is one of the guiding parameter to set the invert level of the canal.

Culvert on LakhonKhola Khal

Culvert on Kuripara Khal

Endevour has been given by PSPS team to get the data from RHD agencies. In absence of authentic data of culverts, a logical value for the canal invert levels have been assumed. Further, it is also checked that the minimum bed level shall be maintained at 0.45m-0.6m below the invert of drain. The average proposed invert of canals are given below.

Culvert on Nabiganj (Luhia) Khal

Culvert on Tipkini Khal

6.5 Canal Lining

Canal lining is an essential component in canal rehabilitation. It is proposed to be done by –

1) CC block pitching,
2) Geotextile-membrane lining.

Two types of concrete blocks are proposed to be used as lining (block pitching). Alternatively, geotextile membrane lining may also be used. Advantages and disadvantages are discussed below.

Plain Cement Hollow Concrete (PHCC) Blocks shall conform to BDS EN 197-1 : 2003 CEM- II/A-M 42.5N, sand of minimum FM 1.5 and 20 mm down well graded shingles/stone chips(LAA value not exceeding 35) to attain a minimum 28 days cylinder strength of 17 MPa (suggested mix proportion 1:2:4).Size recommended is 400mm x 400mm x150mm and 100mmannular hole diameter at the middle. It shall be pitched at the upper portion of the canal inclined slope, mainly in the free board portion. The hole will allow vegetation growth, as shown in the figure below. The vegetation will address environmental sustainability in compensating the carbon emission attributed due to cement production for concrete.

Plain Cement Concrete (PCC) Blocks shall be pitched at the portion which will be in touch with water. It shall conform to to BDS EN 197-1 : 2003 CEM- II/A-M 42.5N, sand of minimum FM 1.5 and 20 mm down well graded Shingles/stone chips(LAA value not exceeding 35) to attain a minimum 28 days cylinder strength of 17.00 MPa (suggested mix proportion 1:2:4). Recommended size is 400mm x400mm x150mm.

Concrete Block Pitching

Geotextile Grid

Geotextile is an ideal protection from erosion of earth embankments by wave action, currents or repeated drawdown.It is ideal to prevent two soil layers of different particle sizes from mixing with each other. It acts as an interface for reverse filtration in the soil. It can be is used to reinforce earth structures bymeans of fill materials.

Due to high soil fabric friction coefficient, high tensile strength and good elongation property of Geotextile, they are an ideal reinforcement solution. It has high tensile strength in contrast to concrete block, so will

able to resist tension caused due to wave action. Though it is handy and renders less time consumption in laying, it requires absolutely good surface dressing which is not an essential activity for block pitching. It is generally made of HDPE geomembrane and presently not available in the country. NCC is also not used to it.

Comparative matrix –

Sl. No.	Parameter	Geotextile Grid	Concrete Block	Remarks
1	Availability	From outside country	Local	
2	Lining	Easy	Comparative tough	
3	Time requirement	Less	More	
4	Robust	Comparatively less robust	Robust	
5	Cost	Less (500 BDT/sqm approx.)	More	
6	Longevity	Less	More	
7	Environmental Sustainability	More	Less	
8	Maintenance	More	Less	

Giving due weightage to local availability Concrete block is preferred. For the estimation purpose concrete block pitching/lining has been considered in the present context. It is further recommended to replace by geotextile in future.

6.6 Canal/Khal Re-excavation

Canal re-excavation is a process of removing accumulated sediment and debris from a canal or waterway to restore its original depth and width and improve its flow capacity. This depth is basically muck and sludge deposited in long period. It reduces canal capacity. Generally 0.45m to 0.6m is considered as cleaning of muck and sludge deposition.

The material excavated during canal re-excavation can be recycled or reused for other purposes, thereby reduces waste and environmental impact. Some ways that the material can be recycled are discussed:

- Restoration - The sediment and debris can be used for environmental restoration projects, such as wetland restoration or shoreline stabilization. The material can be used to create new habitats for wildlife, or to prevent erosion and sedimentation.
- Landscaping - The sediment and debris can be used as a topsoil or fill for landscaping projects. The material can be screened and sorted to remove any large debris or contaminants, and then used to level or reshape the terrain.
- Agriculture - The sediment and debris can be used as a soil amendment for agricultural land. The material can be processed to remove any contaminants or organic matter, and then mixed with soil to improve its fertility and structure.

If the material cannot be recycled or reused, it may need to be disposed off. The material should be disposed of in accordance with local regulations, such as in a landfill or a designated disposal site.

The recycling or reuse of material excavated during canal re-excavation can provide significant environmental and economic benefits. By reducing waste and conserving natural resources, these practices can help to promote sustainability and reduce the impact of canal re-excavation on the environment.

6.7 Landscapping

Every effort was made to provide greening works at appropriate locations on the drainage system. Main khal will have pathways with shrubbery on each embankment and any khal relining will be made using modern materials which support grass growth as shown in Figures below.

6.8 Proposal on Wetland Integration

6.8.1 Integration of Lakes/Ponds

In drainage (or canal) system wetland integration acts as an active role in optimizing the system. Wetland (or lakes or bid ponds) acts as a buffer or a shock absorber in the system. It reduces the size of drain. It also elevates the invert level of the drain outlet to the canal or river.

In Narayanganj and its adjoining areas there are numerous small and big water bodies. These can be utilized as an absorber unit in a drainage system[24]. Drains (carrying storm flow) can be connected to the ponds/ wetlands/ lakes and the overflow from these water bodies shall be conduited through an organized canal/drain system. Its advantages is shown below through a schematic longitudinal view.

Figure 46 - Wetland locations in NCC and its adjoining areas (from GoogleMaps)

[24] Also recommended in DAP

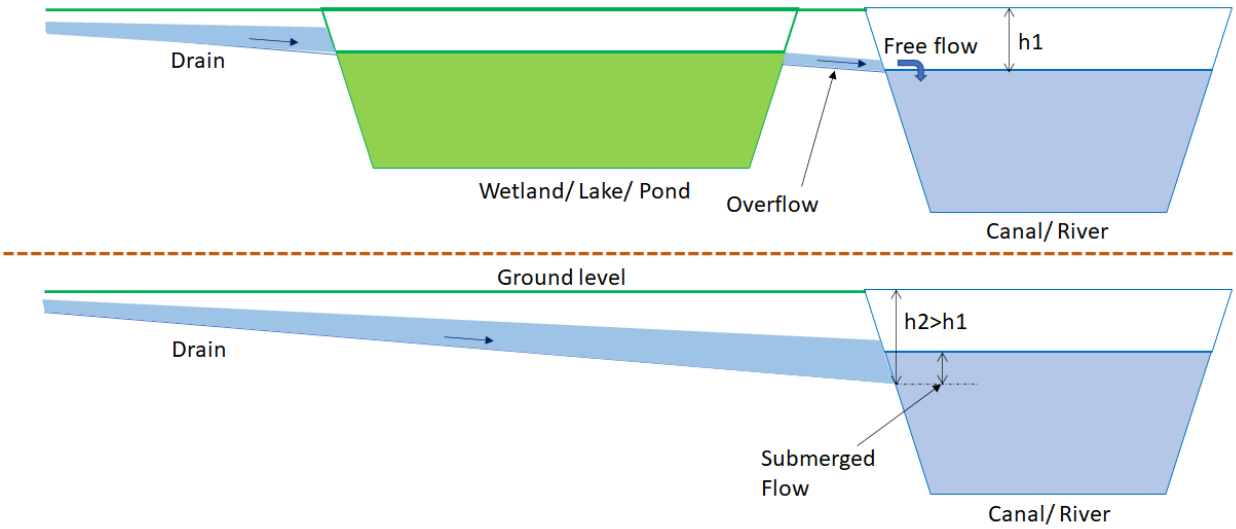


Figure 47 - Schematic Diagram showing advantages in integrating Wetlands in Drainage system

Hence conservation of wetland, in the perspective of integrating with the drainage system network, is an essential move to support a sustainable drainage system. It has also been recommended in DAP.

Figure 48 - Integration of Lakes/Ponds to the Drainage System

6.8.2 Nature based solution - Restoration and Construction of Water Bodies

LGED is creating a water body along the Narayanganj-emra Road (or locally, Adamjee Road). The water body was earlier existing as the borrow pit for construction of Adamjee road which is predominantly an embankment road. It was transformed to an organized water body. These type so water bodies will act as a shock absorber during unusual rainfall events. It is proposed to create similar water body, rather extend the exiting one towards south as far as possible. It has also been recommended in DAP.

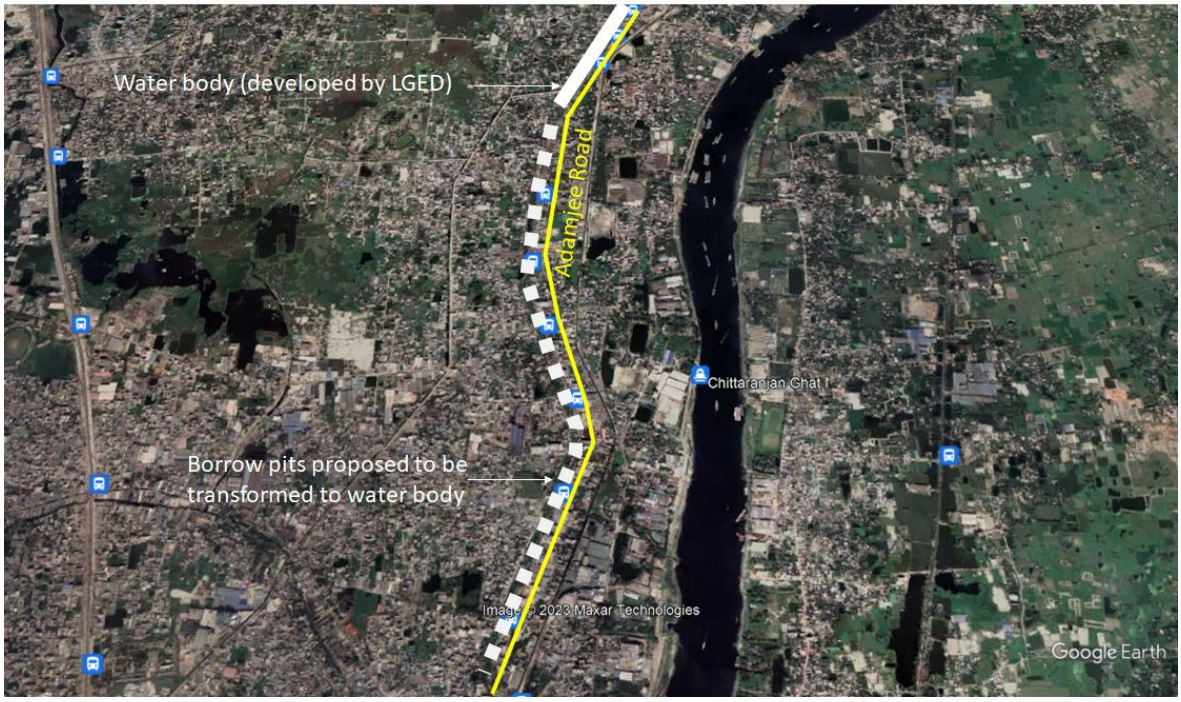


Figure 49 –Restoration of Water Bodies

6.9 Proposal for Canals Connection

In Zone 4 the canals are proposed to be connected. It will create a looping system which will allow the canals to act as a single unit. It will reduce surge on the one which would expect to be of inadequate size and could not be reshaped due to urbanisation. It is proposed to connect from Mahammadpur to Haripur, integrating other 7 canals en-route. Its route shall be along the west flank of Bandar-Madanpur Highway, parallel to the highway, with the length of approximately 10km.. The connection can be by open channel. If there is any future provision of expansion of road width, the connection may be by sewer pipe.

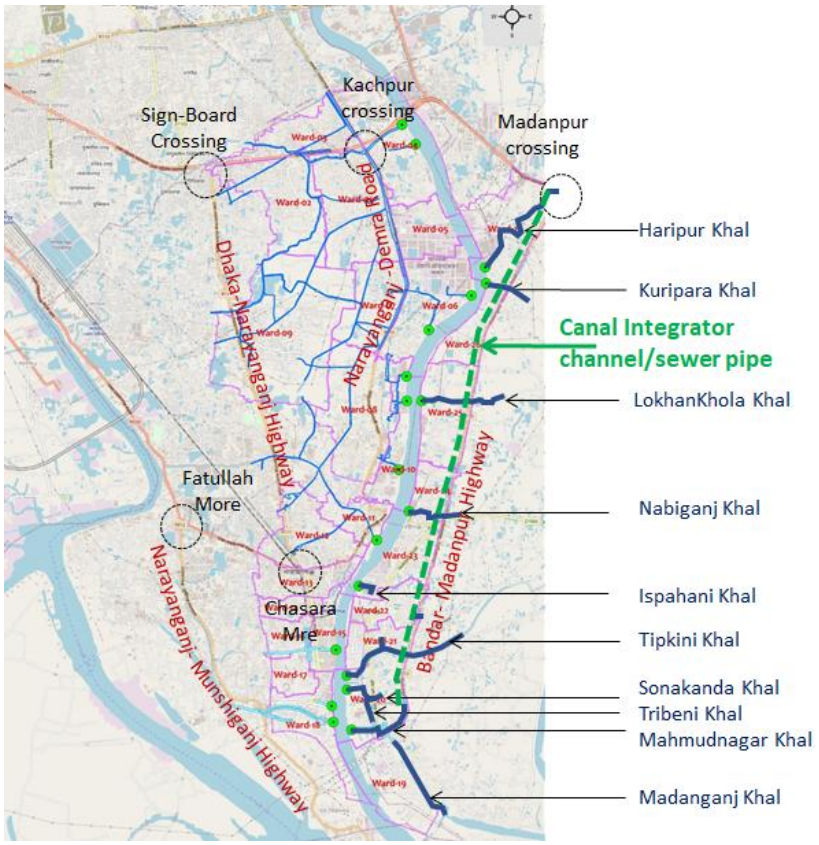


Figure 50 – Canal Integration

6.10 Proposal for Raising River Embankment

From the previous record it has been observed that Sitalakshaya river at Narayanganj flowed above danger level (5.50 m) for 25 days during monsoon 2020 and attained at monsoon peak of 5.87m PWD on 6th August, which was 37 cm above danger level. Under this treat it is prudent to propose the requirement to construct a raised embankment all along the eastern and western banks of the river. BITWA has taken up a project of developing an embankment road all along the banks. Due to climate change effect the high water level may increase and overtop the embankment. It is proposed to consider increasing the embankment height in long future.

6.11 Transformation of Canals/Khals to Navigation Channel

Water navigation is the most effective way of transport for reducing pollution. It has been proposed to transform this canal network, mainly in Zone 2, as a navigation channel.

7 WASTE WATER MANAGEMENT

7.1 Requirement of Tor

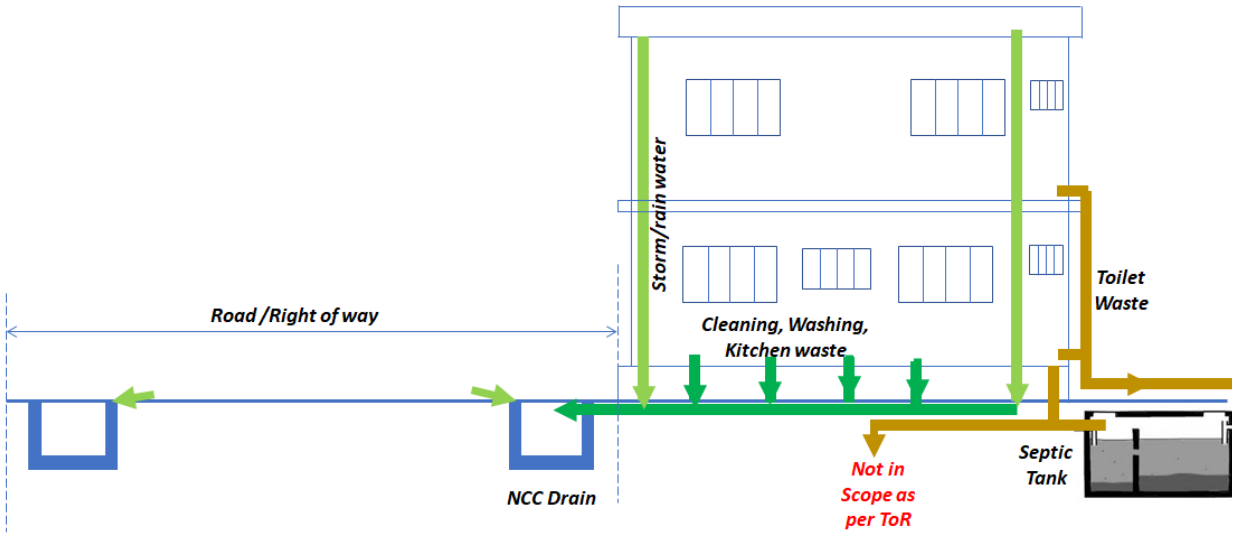
The Sub-Clause no. 5.3 of ToR requires that the drainage master plan should:

'*include investigation and analysis of quality of currently conveyed water by the drainage system and define onsite treatment* process *for its safe disposal by combining several outfalls into one*'

while Sub-Clause 12.4 states that:
The TA loan Consultant will conduct situation analysis of the existing sanitation system of Narayanganj city including storm/grey water drainage, wastewater (domestic and industrial wastewater), septage/ fecal sludge management situation. The TA loan Consultant will investigate the quality of water to be drained out, and based on that, define the appropriate treatment process for its safe disposal by possible integrating several outfalls into one.

Sub-Clause 17.9 states:
Prepare Drainage ***Master Plans for storm water/ grey water drainage system*** *for NCC having different suitable options including treatment process with cost involvement including technical, social environmental and institutional aspect consistent with the NCC's policies and acts, identifying potential areas for drainage network and different treatment options before safe disposal;*

It is pertinent to interpret that the Tor expects a Master plan to address storm and grey water management proposal for the same, whereas its expectation on wastewater, septage/fecal sludge management situation is limited to situation analysis.



On discussion with NCC it was revealed that NCC has a policy to promote on-site sanitation solution for blackwater. It was believed that during preparation of ToR for storm drainage master plan NCC considered only storm water and grey water to seek solution, as NCC has separate approach for blackwater.

7.1.1 Environmental Hazard

The wastewater discharged into the open drainage system causes the drainage system to function as a combined sewer i.e. conveying both foul and stormwater. This constitutes a huge environmental hazard.

7.2 Discharge of Wastewater/Sewage to Drains

A situation analysis of wastewater has been done. On discussion with NCC it was known that wastewater from the household is being discharged to the canals through storm drainage system. There is no separate system to manage wastewater. It means that the black water is also getting mixed into the drainage system. Wastewater being pollutant in general, it is not advisable to mix with the storm drain water which ultimately flows to the river. There is another separate school of thought within NCC which claims that septic tank effluent does not come into drains and hence impact of pollutant is limited. In this dubious situation the consultant endeavoured to get a survey of the households on sample basis to know the nature of internal household plumbing. This has helped to know the actual facts, i.e. discharging scenario of septic tank effluent, and make a situation analysis of the blackwater and faecal management system. Accordingly, a survey was conducted as analysed below.

7.2.1 Survey at Household level

Sl. No.	Date of Survey	Ward No.	Name of Household Head	Details	
				Sullage Effluent	Septic Tank Effluent
1	20.07.22	17	Salma Begum	Common pipe to drain through septic tank	Septic tank to same drain
2	20.07.22	18	Shakil Ahmed	Separate pipe to drain	Septic tank to same drain
3	20.07.22	15	Ahmed	Separate pipe to drain	Septic tank to same drain
4	20.07.22	15	Didar Hossain	Separate pipe to drain	Septic tank to same drain
5	20.07.22	16	Md. Liton	Common pipe to drain through septic tank	Septic tank to same drain
6	20.07.22	14	Krishna Saha	Separate pipe to drain	Septic tank to same drain
7	20.07.22	13	Sarder Hossain	Separate pipe to drain	Septic tank to same drain
8	01.08.22	09	Sabbir Ahmed	Separate pipe to drain	Septic tank to same drain
9	01.08.22	09	Babul Vaskor	Separate pipe to drain	No connection with drain
10	01.08.22	09	Deputy Director office, Family Planning	Separate pipe to drain	Septic tank to same drain through Sockwell
11	04.08.22	09	Kohinur Akter	Separate pipe to drain	Ring Slab (soak pit) , No connection with drain

Sl. No.	Date of Survey	Ward No.	Name of Household Head	Details	
				Sullage Effluent	Septic Tank Effluent
12	04.08.22	09	Md. Malabar	Direct to ditch through pipe	Direct to ditch through pipe
13	04.08.22	09	Md. Rashedul Islam	Separate pipe to drain	Septic tank to same drain
14	10.08.22	08	Md. Nasir Uddin	Separate pipe to drain	No septic tank, direct to drain
15	10.08.22	08	Md. Mofiz	Separate pipe to drain	No septic tank, direct to drain
16	10.08.22	08	Jayeda	Separate pipe to drain	No septic tank, direct to drain
17	10.08.22	08	Md. Roni	Separate pipe to drain	No septic tank, direct to drain
18	10.08.22	08	Md. Nur Nobi	Common pipe to drain through septic tank	Septic tank to same drain
19	14.08.22	04	Md. Alomgir Hossain	Separate pipe to drain	Septic tank to same drain
20	14.08.22	04	Md. Sulaiman	Separate pipe to drain	No septic tank, direct to drain
21	14.08.22	04	Md. Dulal Mia	Separate pipe to drain	No septic tank, direct to drain
22	14.08.22	04	Zia	Direct to ditch through pipe	Ring slab (soak pit) to ditch
23	16.08.22	06	Md. Mostafa	Separate pipe to drain	No septic tank, direct to drain
24	16.08.22	06	Md. Hossain	Separate pipe to drain	No septic tank, direct to drain
25	16.08.22	06	Md. Liaqut Hossain	Separate pipe to drain	No septic tank, direct to drain
26	16.08.22	06	Md. Joni	Separate pipe to drain	Ring slab (soak pit) to drain
27	16.08.22	06	Md. Shamsuddin	Separate pipe to drain	Septic tank to same drain
28	16.08.22	06	Md. Sharif Uddin	Separate pipe to drain	Septic tank to same drain

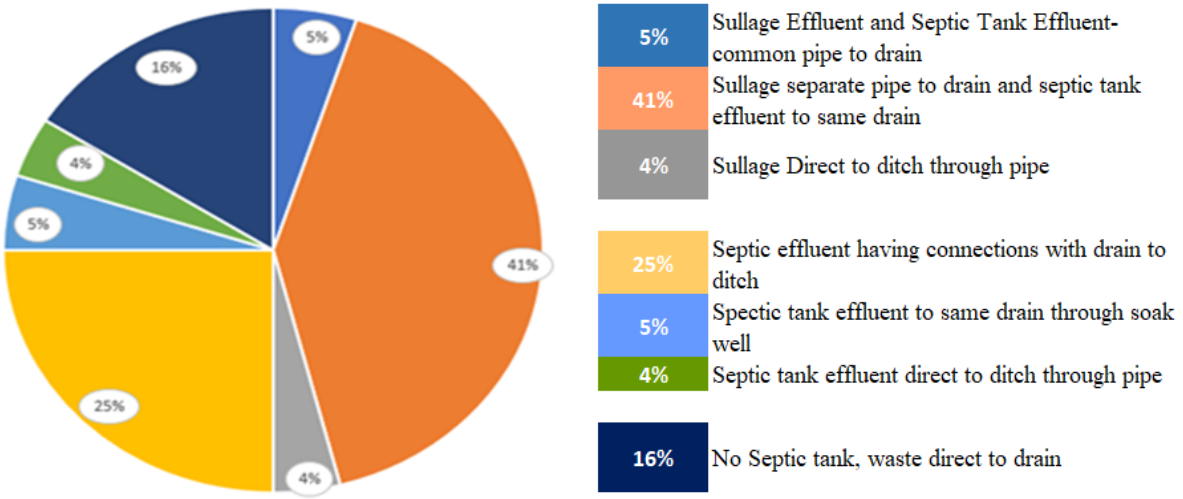
Discharge of Household waste to Canals

7.2.2 Situation Analysis of Wastewater

From the above result is evident that 95% septic tank effluent waste is being discharged to drains, ditches, canals, etc. and the rest 5% is being discharged to soak well. There is no organized management system of blackwater.

1	Sullage effluent and Septic tank effluent to drain via a common pipe	5%
2	Sullage effluent and Septic tank effluent to drain through separate plumbing system	41%
3	Sullage directly discharging to nearby ditch through pipes	4%
4	Septic tank having connection both with drain and ditch	25%
5	Septic tank effluent to drain via soak well	5%
6	Septic tank effluent directly to ditch via pipe	4%
7	No septic tank, waste discharging directly to drains	5%
		100%

Table 46– Household Survey for Black Water Situation Analysis



7.2.3 Wastewater Quality Parameters

Samples of wastewater collected from the drains and khals have been sent to BUET laboratory for analysis and testing. Results are given in the Chapter on Survey and Investigations

7.3 Faecal Management

There is no faecal sludge management, whether it is organized or unorganized. When the septic tanks become full, the owners make their own arrangement to clean it off and dispose the faecal sludge to nearly ditch or drains or even to the rivers if household is on the bank of the river. This is in no way an acceptable practice. NCC do not have any organized setup to manage faecal collection and disposal.

7.4 Sewerage Master Plan

A sewerage masterplan for Narayanganj will be coming up in future. Wastewater generated from the households (and other institutions) within NCC are being conveyed by the existing drainage system and finally gets discharged to Sitalakshya river through canal system (which is meant for storm water conveyance system). It is untreated and is not allowed to get discharged as per Bangladesh permissible norms. There is no organised sewerage system to take care sanitation issues. The sewerage master plan is expected to propose for handling and managing sewage (or wastewater).

7.5 Recommendations

The issue of wastewater treatment should be considered to the upcoming sewerage masterplan. The Consultant sees no merit in perpetuating the outdated environmentally-unfriendly solution (even hazardous to public health) of conveying domestic sewage in the drainage network. Such an arrangement could never succeed in moving Bangladesh along the human development index.

In the interim, NCC should take strong enforcement action to disconnect all illegal connections to the drainage network.

7.6 Wastewater Sources

Wastewater sources are from:

(i) Domestic activities,
(ii) Industrial activities,
(iii) Institutional activities,
(iv) Hospital and medical wastewater,
(v) Waste from market.

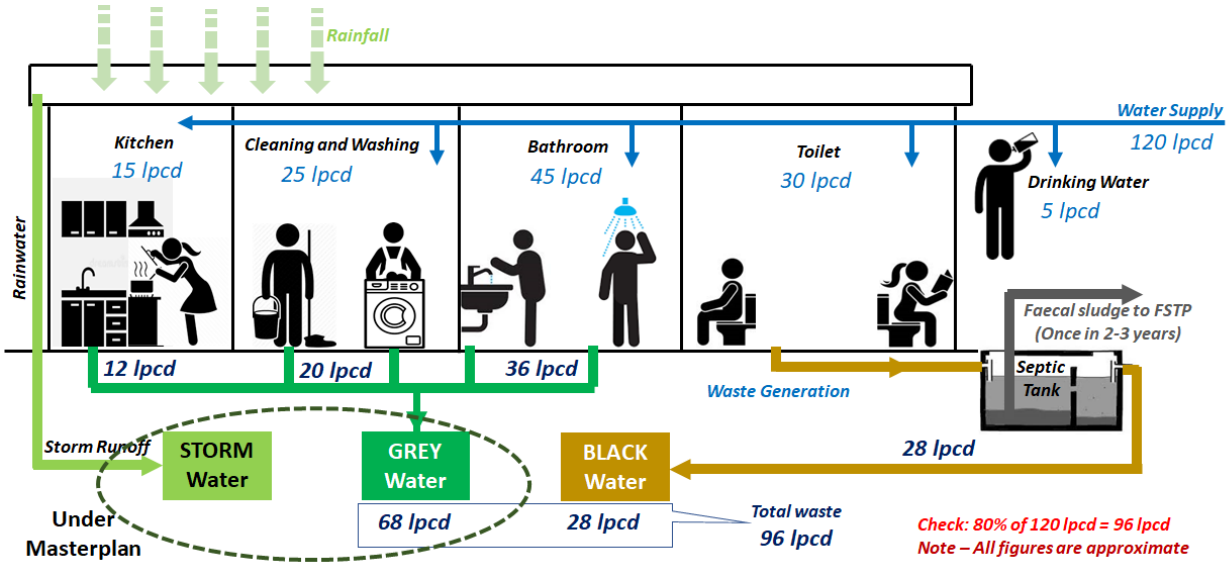


Figure 51 - Schematic Indicating Wastewater generation sources within a Typical Household

Domestic water demand is about 83% of total[25] demand. Hence in order to keep consistency, waste generation from residential areas is assumed to be 83% of total waste generation. It is also validated from the Action Area Plan that 82.1% is residential units.

Average water supply for 1 equivalent person has been considered as 152 lpcd (as per water supply report) for domestic + non-domestic demand, without considering fire demand. Domestic demand is 120 lpcd. It is a standard practice to consider wastewater generation as 80% of water supply. A basic calculation on wastewater/sewage generation from each typical household is shown in a sketch below.

7.7 Contributing Population

Location	Zone	Wards	Population		
			2031	2036	2046
West Bank	Siddirganj	1-9	56,461	68,926	112,352
	Narayanganj	10-18	532,412	621,720	847,789
East Bank	Kadam Rasul	19-27	309,175	361,035	492,314
TOTAL			**1,306,596**	**1,525,768**	**2,080,567**

Table 40–Ward wise Contribution to Grey Water Generation

7.8 Calculation of Flow

The Grey water generating at the household and due to arrive at plant inlet can be calculated as follows:Q (m3/d) = Population x daily per capita wastewater production

Wastewater (Greywater) generation-

Administrative Zone/Area	Wards	Water supply to consumers end[26]@120lpcd (in m3/day)			Greywater generation @ 80% (i.e. 96 lpcd) (in m3/day))		
		2031	2036	2046	2031	2036	2046
Siddirganj	1	10,217	12,109	16,512	8,174	9,687	13,209
	2	7,250	8,466	11,545	5,800	6,773	9,236
	3	9,272	10,219	10,582	7,418	8,175	8,466
	4	6,779	7,738	11,162	5,423	6,191	8,930
	5	5,220	6,096	8,312	4,176	4,877	6,650
	6	5,830	6,401	11,665	4,664	5,121	9,332
	7	6,203	7,243	9,877	4,962	5,794	7,901
	8	11,492	13,979	16,069	9,193	11,183	12,855
	9	8,605	10,504	17,122	6,884	8,403	13,698
Narayanganj	10	6,416	7,466	11,150	5,133	5,973	8,920
	11	7,262	8,810	12,983	5,809	7,048	10,386
	12	11,083	12,994	16,610	8,867	10,395	13,288
	13	13,036	14,969	19,720	10,429	11,976	15,776

[25] Source – FS Report on Water Sector

[26] The value does not contain fire demand (2%) and NRW (15%)

Administrative Zone/Area	Wards	Water supply to consumers end[26]@120lpcd (in m3/day)			Greywater generation @ 80% (i.e. 96 lpcd) (in m3/day))		
	14	8,035	9,282	11,756	6,428	7,426	9,405
	15	7,133	8,659	12,778	5,706	6,927	10,222
	16	9,471	10,806	14,042	7,576	8,644	11,234
	17	9,760	10,991	14,503	7,808	8,793	11,603
	18	8,943	10,773	15,660	7,155	8,619	12,528
Kadam Rasul	19	3,350	3,988	5,639	2,680	3,191	4,511
	20	5,009	5,850	8,129	4,007	4,680	6,503
	21	6,284	7,338	9,702	5,027	5,871	7,761
	22	8,403	9,559	12,342	6,722	7,647	9,873
	23	8,663	10,117	13,033	6,931	8,093	10,427
	24	5,755	6,720	9,011	4,604	5,376	7,209
	25	3,657	4,258	6,007	2,926	3,406	4,805
	26	2,083	2,559	4,217	1,666	2,047	3,373
	27	3,914	4,634	6,949	3,131	3,707	5,559
Total NCC		**199,125**	**232,527**	**317,078**	**159,300**	**186,022**	**253,663**

Table 41–Grey Water Generation

In may be noted that a large proportion of existing septic tanks are connected directly to the drainage system.

7.9 Wastewater Zoning

Wastewater Zoning has been kept same as Drainage zoning. 4 wastewater zones are proposed: Zone 1, 2, 3 are west of river Sitalaksaya and zone 4 is on the east side. Zone 1 is on the south of Chasara-More. Zone 2 and 3 are divided by the Narayanganj-Demra Road. An indicative figure is shown below.

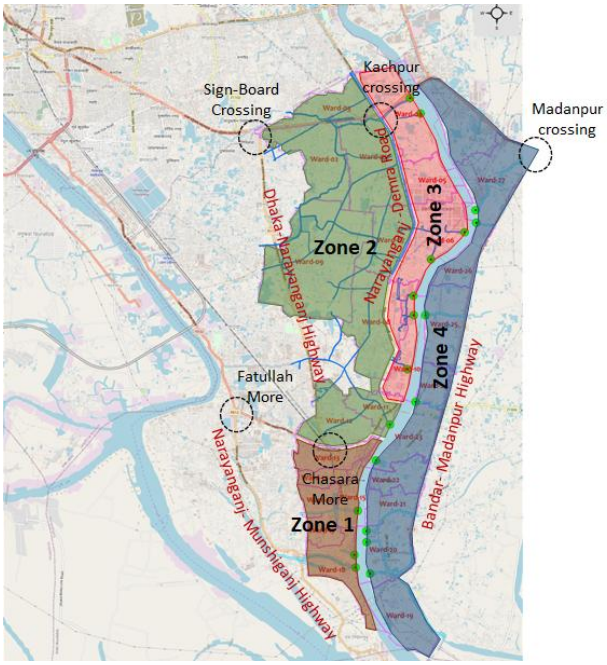


Figure 52 - Wastewater Zoning Diagram

Zone 1 – Narayanganj Zone (covering Narayanganj Area)	Wards - 13, 14, 15, 16, 17, 18
Zone 2 - DND Zone (covering DND's jurisdiction under Sidderganj area)	Wards- 1, 2, 3, 7(50%), 8(50%), 9, 11, 12
Zone 3 - Sidderganj Zone (covering Sidderganj Area)	Wards - 4, 5, 6, 7(p), 8(50%), 10
Zone 4 - KadamRasul Zone (covering Kadam Rasul Area)	Wards - 19, 20, 21, 22, 23, 24, 25, 26, 27

A calculation output of zonal wastewater generation (m3/day) is shown below.

Wards	Zone 1 (Narayanganj Zone)			Zone 2 (DND Zone)			Zone 3 (Sidderganj Zone)			Zone 4 (KadamRasul zone)		
	2031	2036	2046	2031	2036	2046	2031	2036	2046	2031	2036	2046
1	-	-	-	8,174	9,687	13,209	-	-	-	-	-	-
2	-	-	-	5,800	6,773	9,236	-	-	-	-	-	-
3	-	-	-	7,418	8,175	8,466	-	-	-	-	-	-
4	-	-	-	-	-	-	5,423	6,191	8,930	-	-	-
5	-	-	-	-	-	-	4,176	4,877	6,650	-	-	-
6	-	-	-	-	-	-	4,664	5,121	9,332	-	-	-
7	-	-	-	2,481	2,897	3,951	2,481	2,897	3,951	-	-	-
8	-	-	-	4,597	5,592	6,428	4,597	5,592	6,428	-	-	-
9	-	-	-	6,884	8,403	13,698	-	-	-	-	-	-
10	-	-	-	-	-	-	5,133	5,973	8,920	-	-	-
11	-	-	-	5,809	7,048	10,386	-	-	-	-	-	-
12	-	-	-	8,867	10,395	13,288	-	-	-	-	-	-
13	10,429	11,976	15,776	-	-	-	-	-	-	-	-	-
14	6,428	7,426	9,405	-	-	-	-	-	-	-	-	-
15	5,706	6,927	10,222	-	-	-	-	-	-	-	-	-
16	7,576	8,644	11,234	-	-	-	-	-	-	-	-	-
17	7,808	8,793	11,603	-	-	-	-	-	-	-	-	-
18	7,155	8,619	12,528	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	2,680	3,191	4,511
20	-	-	-	-	-	-	-	-	-	4,007	4,680	6,503
21	-	-	-	-	-	-	-	-	-	5,027	5,871	7,761
22	-	-	-	-	-	-	-	-	-	6,722	7,647	9,873
23	-	-	-	-	-	-	-	-	-	6,931	8,093	10,427
24	-	-	-	-	-	-	-	-	-	4,604	5,376	7,209
25	-	-	-	-	-	-	-	-	-	2,926	3,406	4,805
26	-	-	-	-	-	-	-	-	-	1,666	2,047	3,373
27	-	-	-	-	-	-	-	-	-	3,131	3,707	5,559
Total	**45,103**	**52,385**	**70,768**	**50,029**	**58,970**	**78,662**	**26,473**	**30,649**	**44,210**	**37,695**	**44,017**	**60,023**

Table 42– Zonal Grey Water Generation

7.10 Wastewater Collection and Conveyance

In this section Grey water is termed as Wastewater for easy understanding.

7.10.1 Interception and Diversion of Wastewater

Interception diversion arrangement has been proposed. In the dry period grey water will be conveyed to the treatment plant. In the monsoon period the surcharged load from storm water (diluted) will be discharged to the canals/rivers through overflow manhole. A self-explanatory concept figure is shown below.

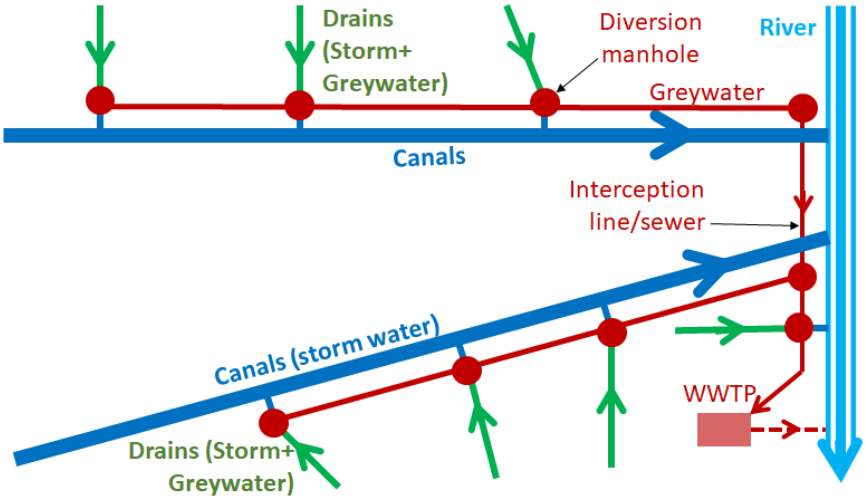


Figure 53 - Concept of Interception and Diversion of Wastewater

Separate Sewerage system is proposed for collection and transmission of waste water from the wastewater generation source to the treatment plant. Waste water will be collected from the household (premises) and will be conveyed to the treatment plant by sewers.

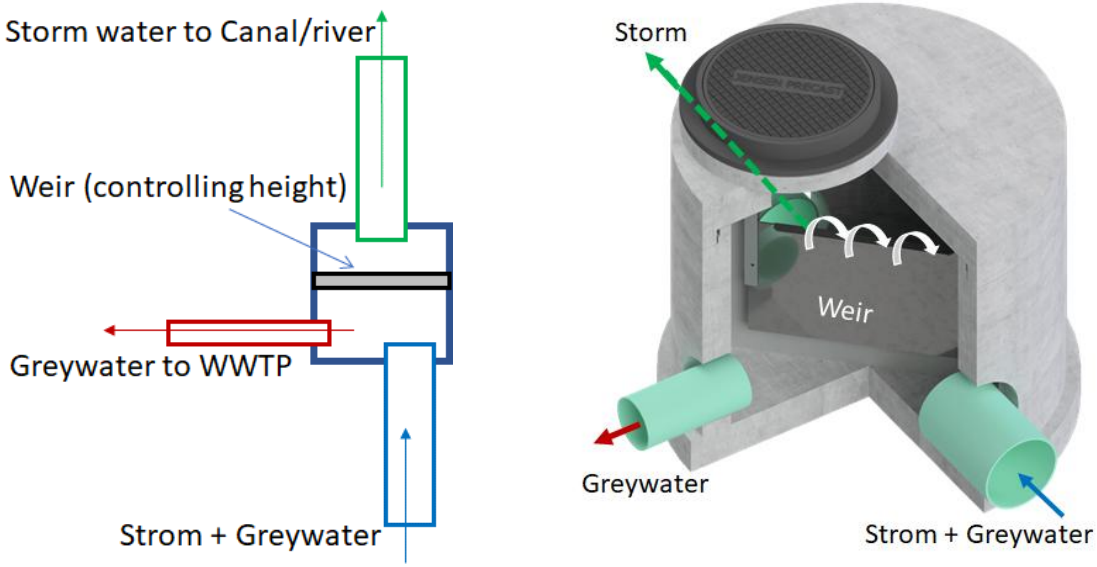


Figure 54 - Diversion Manhole (Schematic)

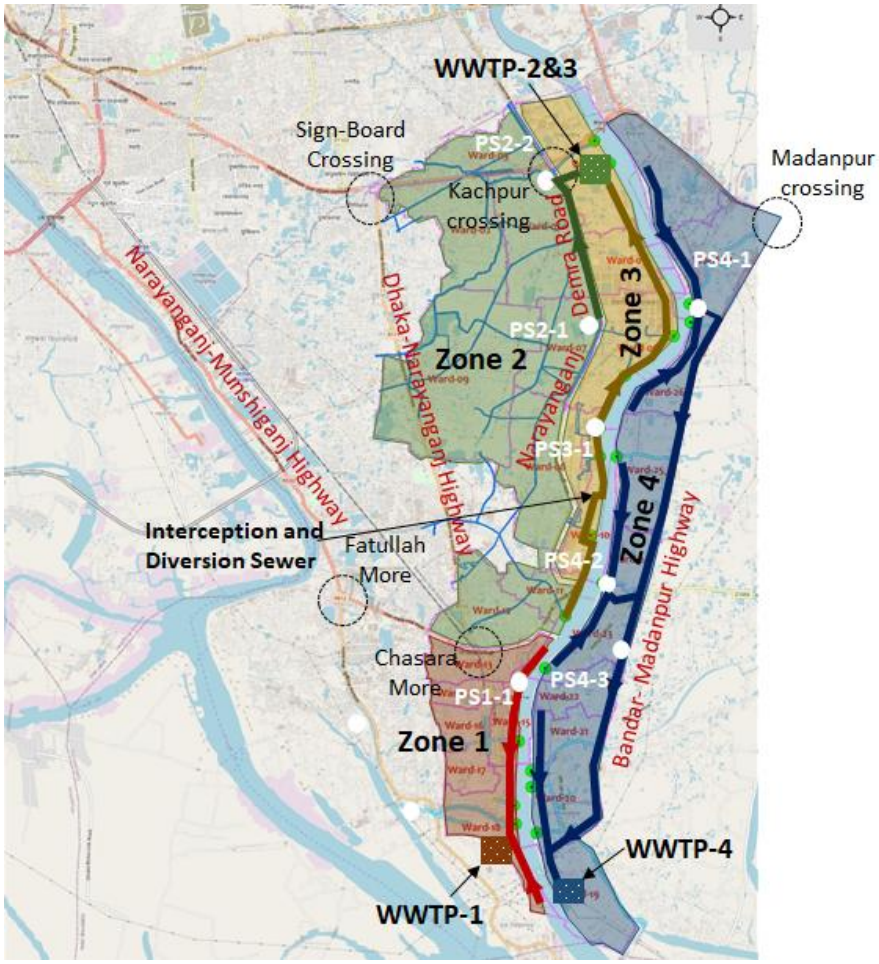


Figure 55 - Indicative Alignment of Wastewater Diversion Sewer

400-600mm	50 km
600-900mm	70 km
900 -1200mm	38 km
Total	**158 km**

7.10.2 Wastewater Lifting Pumping Station

Wastewater pumping station details

Sl. No.	Pumping station	Location name/ Landmark	Location Coordinate		Land area reqd. (m2)	Owner of land
			Easting	Northing		
1	PS1-1	BIWTC Office	90.505336	23.607052	1500	BIWTC
2	PS2-1	Adamjee Storm PS	90.515347	23.682378	400	DND
3	PS2-2	Shimrail Storm PS	90.509731	23.696613	400	DND
4	PS3-1	Chittaranjan Pond	90.516398°	23.651269°	400	Jute &Textile Dept.
5	PS4-1	H. Kuri-Para khelar Math	90.53371894	23.67599345	400	BIWTA

Sl. No.	Pumping station	Location name/ Landmark	Location Coordinate Easting	Northing	Land area reqd. (m2)	Owner of land
6	PS4-2	Near Sonakanda Hat	90.50865946	23.60279687	400	NCC
7	PS4-3	Qutub Bag	23.601327	90.518972	400	Private

Table 43– Proposed Pumping Station Location

Figure 56 - Location of Pumping Stations

Pumping Details

PS	Contri-butory Zone	% of waste	Total waste genera-tion (MLD)	Waste at PS (MLD for 2046)	Opera - tion hrs	Pump capacity (m3/hr)	Each pump capacity (m3/hr) @ 15m head	No. of pum ps	Wor king pum ps nos.)	Stand-by pump s (nos.)
PS1-1	Zone 1	50%	71	35.5	24	1479	400	4	3	1
PS2-1	Zone 2	50%	79	39.5	24	1646	400	4	3	1
PS2-2	Zone 2	50%	79	39.5	24	1646	400	4	3	1
PS3-1	Zone 3	40%	44	17.6	24	733	400	2	2	1
PS4-1	Zone 4	35%	60	21	24	875	400	2	2	1
PS4-2	Zone 4	35%	60	21	24	875	400	2	2	1
PS4-3	Zone 4	80%	60	48	24	2000	400	5	4	2

Table 44– Proposed Pumping Station Detail

7.11 Wastewater Treatment

In this section 'Grey Water' is termed as 'Wastewater' for easy understanding.

7.11.1 Wastewater Treatment Plant Demand

Waste water generated at the source point (i.e. household activities) shall be treated at the treatment plant, either at the household/local community level (i.e. decentralized system) or at centralized treatment plant.

In the urban setting of Narayanganj, which has got potential future for further development, it is not feasible to manage the wastewater at decentralised decentralize approach. Wastewater treatment at household level to achieve effluent standard of Bangladesh not possible. Most of the premises do not have any additional space to accommodate individual level treatment system which could bring down the wastewater quality below permissible limit. Operation and maintenance at each household level is also not a practical option.

Centralized treatment approach is proposed for the all three zones. 3 nos. wastewater treatment plants are proposed. Zone 1 and Zone 4 will have one treatment plant each. Zone 2+3 will have one treatment plant. Treatment process is not studied here and will be decided later.

Treatment Capacities (in MLD)-

Zone	Area covered	Yr. 2031	Yr. 2036	Yr. 2046
Zone 1	Narayanganj Zone(covering Narayanganj Area)	45.1	52.4	70.8
Zone 2	DND Zone (DND's jurisdiction in Sidderganj area)	50.0	59.0	78.7
Zone 3	Sidderganj Zone covering (Sidderganj Area)	26.5	30.6	44.2
Zone 4	KadamRasul Zone(covering Kadam Rasul Area)	37.7	44.0	60.0
	TOTAL	**159.3**	**186.0**	**253.7**

Table 45– Treatment Plant capacity for Grey water

7.11.2 Types of Wastewater

In general in the dry periods, the flow to be treated (known as 'dry weather flow' (DWF)) is calculated according to the contributing population while during rainfall events, the flow to be treated (known as 'wet-weather flow' (WWF)) is calculated based on the rainfall intensity and the contributing area.

To ensure economical sizing of wastewater treatment plants (herein grey water), it is exceeded (often by a factor of 6), the wastewater flow is allowed to overflow untreated to the receiving waters. The phenomenon attributed to limit the effluent quality within permissible limit is the dilution factor.

Wastewater can be treated to 3 stages as shown in Table below:

STAGE	Quality Parameters after Treatment	
	BOD (mg/l)	TSS (mg/l)
Primary (Mechanical)	35	70
Secondary (Biological)	20	30
Tertiary	10	10

A full biological plant can cost as much as 50% more than a primary plant while a tertiary plant will cost 10% more than a biological plant.
The range of operation costs for the 3 types are also similar. Municipal wastewater treatment is generally carried out using an activated sludge process where after initial sedimentation, air is injected into the sewage creating micro-organisms which in turn purify the pollutants.

The process diagram for the activated sludge prices is shown in Figure below;

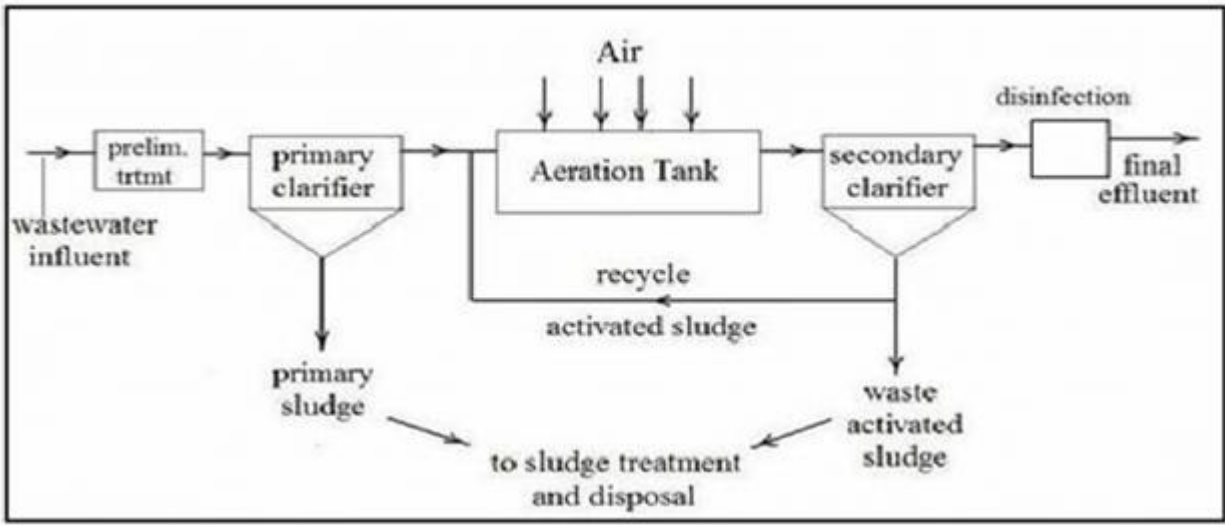


Figure 57 - Activated Sludge Wastewater Treament Flwo Diagram

A variation of this method is fixed bed activated sludge (FBAS) where growth of the micro-organisms is concentrated on physical surfaces. This results in smaller plant footprints.

7.12 Discharge to Shitalakashya River

The object of treating the wastewater is to reduce discharge of pollution to the Shitalakshya river. However, the Shitalakshya river is severely polluted at the current time. And although GoB has announced

programmes for the improvement of the river quality, until such time as this is executed, it can be argued that any investment in wastewater treatment facilities will have little impact.

7.13 Wastewater Treatment

7.13.1 Wastewater Treatment Processes

WWTPs can be conventional treatment systems requiring large concrete tanks and buildings in outdoor locations usually downstream of the corresponding population centre. Alternatively, modern WWTPs can be low footprint layouts accommodated within covered buildings but these are more expensive and require more skilled operators.
Package plants can be used for small flows and where limited space is available.

7.14 Waste Treatment Units

7.14.1 Scenario. No. 1 – Conventional WWTPs at Grouped Outfalls

Assume that each administrative area (Narayanganj, Siddirganj and Kadam Rasul will have a separate treatment plant. The DWF is then calculated as follows:

Taking Narayanganj area as the worst case scenario, and assuming a per capita wastewater production of 50 l/c/d (120 l/c/d/ in many developed economies) and a population of 400,000 persons. Further assume that 50% of the wastewater generated is discharged to the drainage network.

Plant Sizing

The design flow (Q) can be calculated as:

Q = 200,000 x 50/1000 = 10,000 m3/d

This constitutes a substantial plant and cannot be addressed using package STPs as a large number (25-50) would be required. A customised in-situ WWTP would be required, parameters for a 10,000m3/d plant are given in Table below:

STAGE	Cost (Million USD)	Site Area (Ha)
Primary (Mechanical)	4	3
Secondary (Biological)	5	4
Tertiary	5,5	4

By extrapolation, we can conclude that the cost of 3 separate primary WWTPs (one in each administrative area) would cost in the region of 12 MUSD rising to 15 MUSD for biological treatment.

7.14.2 Scenario No. 2 – Package WWTPs at each Khal Outfall

If we assume that the largest khal accommodates 10% of the estimated 1 million population of Narayanganj (using 50% connectivity), then we can calculate the design flow as follows:

Q(m3/d) = 50,000 x 50 l/c/d /1000 =2,500 m3/d.

This would require a series of 10 package STPs running in parallel. The parameters for such an arrangements are given below:

TYPE	No. in Parallel	Cost (MUSD)	Site Area (Ha)
Package STP (250 m3/d)	1	0.4	0.05
	10	3	0.4

By extrapolation, we can conclude that treatment of the full wastewater flow on all khals would cost a total of USD 25 and the land requirements would range from 0.1 Ha to 0.4 Ha.

7.14.3 Scenario No. 3 – Centralised STPs for Each Zones

Zone 1 – WWTP 1
Zone 2 – WWTP 2&3
Zone 3 - WWTP 2&3
Zone 4 – WWTP – 4

In total 3 WTPs are proposed at different locations. The land parcels belongs to Bangladesh Inland Water Departments.

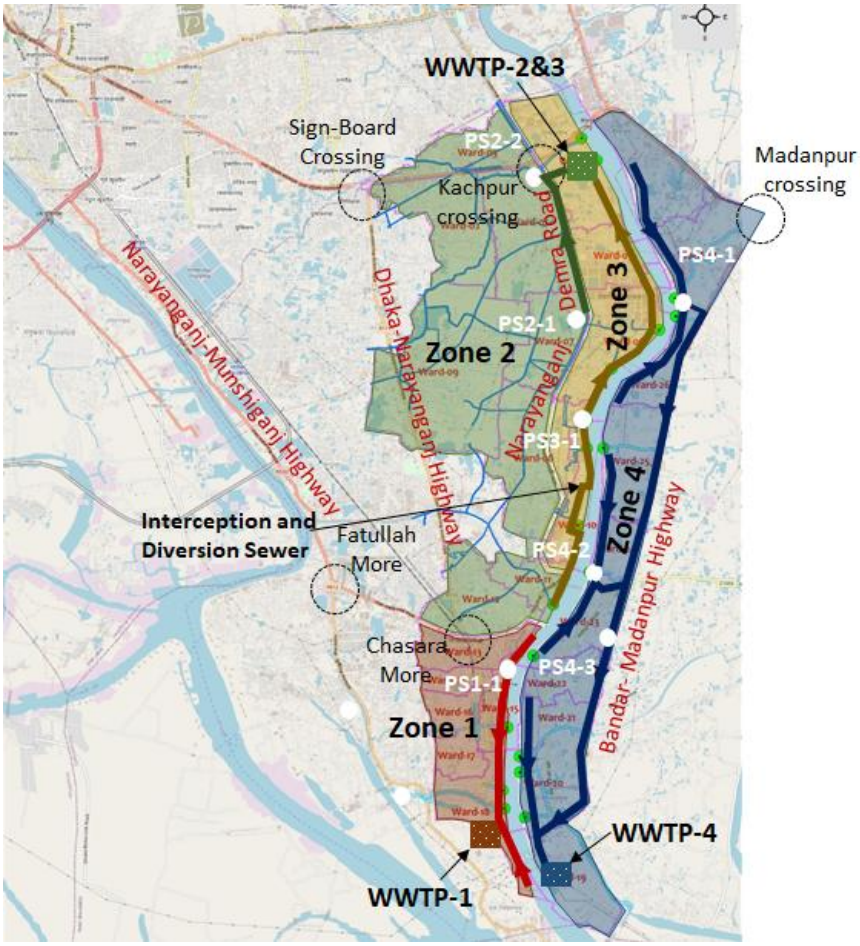


Figure 58 – Locations of WWTP (waste water Treatment Plants)

		Capacity MLD			Location	Coordinates		Land Owner
		2031	2036	2046		Northing	Easting	
1	WWTP 1	45	52	71	Koylaghata	90.50846	23.5903	Govt Department
2	WWTP 2&3	50+26	59+31	79+44	Siddhiganj, beside BWDB office shimrail	90.51736	23.70026	BWDB
3	WWTP 4	38	44	60	Shantinagar abasik Area	23.58556	90.51855	BIWTA

Proposed Location od WWTP 1

Proposed Location od WWTP 2&3

Option 3 , i.e. Centralised WWTP approach is recommended. For each zone each WWTP is proposed.

Proposed Location of WWTP 4

7.14.4 Low Footprint Alternatives

Low footprint alternatives were not considered due to their higher costs, specialist design and complexity of operation.

7.14.5 Cost

The cost of providing a centralised arrangement of WWTPs (3 for 4 zones) is significantly less than providing separate package WWTPs at each individual khal.

7.14.6 Return on Investment

The impact of any investment made in treatment facilities (whether individual or grouped) is minimal during rainfalls periods as the increased flow is allowed to bypass the plant and discharge directly to the receiving water.

In periods of dry weather, where the influent can be more appropriately treated, it is difficult to see if it can contribute to a reduction in pollution in the Shitalakasjya river due already seriously polluted state.

Furthermore any investment in treatment facilities will not succeed in reducing the environment hzard of foul sewage being conveyed in open drains. The only manner in which this can be achiened is for proper enforcement action to be taken by NCC and all illegal connections to the drainage network disconnected.

Even if investment in treatment facilities could not be justified on an economic or environmental basis, because a sewerage master plan will soon be carried out leading to future provision of full sewage collection and treatment, such investment would be of a short term nature only (until the new collection network and WWTP were complete) and would not be justified.

8 BLOCK COST ESTIMATION

The block cost estimate has been done based on LGED current Scheduled of Rates 2023. Component wise costs are discussed below.

8.1 Cost of Drainage System Rehabilitation

8.1.1 Cost of Drain Rehabilitation

Sl. No.	Drains Components	Length (m)	Cost (in BDT)
	Cleaning of existing drains, Renovation of inadequate drains, Proposed new drains.		
1	Zone 1	98999 m	881,994,139 BDT
2	Zone 2	296620 m	1,658,989,442 BDT
3	Zone 3	94242 m	820,724,538 BDT
4	Zone 4	134942 m	761,606,301 BDT
	Total	**624802 M Say, 625 km**	**4,123,314,421 BDT**

Table 47– Block Cost for Drainage System Rehabilitation

8.1.2 Cost of Canal Rehabilitation

Sl. No.	Drains Components	Length (m)	Cost (in BDT)
	Cleaning of existing drains, Renovation of inadequate drains, Proposed new drains.		
1	Zone 1	2259 m	112,186,703 BDT
2	Zone 2	- m	By DND project
3	Zone 3	5174 m	193,102,883 BDT
4	Zone 4	12404 m	531,273,319 BDT
	Total	**20462 m Say, 20 km**	**836,562,905 BDT**

Table 48– Block Cost for Canal Rehabilitation

8.1.3 Maintenance Cost

Maintenance cost has been estimated for drains and canals. LGED rates have been adopted. For drain the major cost for maintenance involves cleaning and replacement of cover slab if it gets damaged during cleaning operation. For drains the cleaning of muck/sludge is the most important factor. Cost of this is dominated by disposal cost.

Drains

Assumption –
Unit Length – 600 km

Cleaning of drain – once in 2 years
Silt/muck to be cleaned – 150mm
Average width of drain – 1.0m
Cover slab to be replaced in 2years – 0.25% of total
Disposal of sludge – within 2km

Cost for 2 years is134,136,858 BDT. Annual maintenance cost has been estimated to **67 million BDT**.

Canals

Assumptions-
Unit length – 10 km
Cleaning interval – 5 years
Muck/sludge cleaning (through mechanical equipment) – 300mm
Average width – 15m
Disposal- Above 5km

Cost for 5 years is 70,983,014 BDT. Annual maintenance cost has been estimated to 14 million BDT.

8.2 Cost of Wastewater (Greywater) Handling

8.2.1 Cost of WWTP

Total WWTP capacity for 2046 has been estimated to 253 MLD. It shall be constructed in phases in modules. An assessment on Modular Treatment Plant (in MLD) is given below.

Zone	**Yr. 2031**	**Yr. 2036**	**Yr. 2046**	**Yr. 2031**	**Yr. 2036**	**Yr. 2046**	
				WWTP Capacity (in MLD)			**Total**
Zone 1	45.1	52.4	70.8		25 x 2 module	+ 25 x 1 module	75 mld
Zone 2	50.0	59.0	78.7		30 x 2 module	+ 30 x 1 module	120 mld
Zone 3	26.5	30.6	44.2				
Zone 4	37.7	44.0	60.0		20 x 2 module	+ 20 x 1 module	60 mld
	159.3	**186.0**	**253.7**				

Module size (mld)	**Unit cost of WWTP BDT/mld**	**Cost of 1 module (BDT)**	**No. of module 2036**	**Additional Module 2046**	**Cost for 2036 (BDT)**	**Additional cost for 2046 (BDT)**
20	22,000,000	440,000,000	2	1	880,000,000	440,000,000
25	20,300,000	507,500,000	2	1	1,015,000,000	507,500,000
30	18,500,000	555,000,000	3	1	1,665,000,000	555,000,000
		TOTAL			3,560,000,000	1,502,500,000

Total cost is estimated to be approximately **5,060,000,000 BDT**.

8.2.2 Cost of Interception System

Total intercepting sewer is 100 km,

- Length along the length of canal (both sides) - 60km
- Length along the both sides of the river – 35km
- Length along highway (Adamjee road) – 5km

Size of sewer will vary from 600mm to 1000mm. Average cost of sewer laying is considered as 50,000 BDT/m length, inclusive of manhole, road restoration and all other associated works. Total cost is estimated to about 5,000,000,000 BDT.

8.2.3 Cost of Pumping Station

It is envisaged that 6 nos pumping station will be required. 5 Pumping station is estimated to be around 20,000,000 BDT, which includes civil, mechanical and electrical costs. One pumping station will be combined PS. Total pumping station cost is **230,000,000 BDT**.

8.2.4 O&M for Wastewater Handling

Annual O&M cost shall be as:
WWTP – 15% of capital cost
Interception system – 2% of capital cost
Pumping station – 5% of capital cost

8.2.5 Gates at outfalls

Flap gates are considered at the outfall locations, which are susceptible to have submerged gravity flow from the drains. It will require a robust RCC structure to resist scouring effect of the river. Gate size will vary. For the estimation purpose average size is assumed as 1.2m x1.5m. Numbers of gates required will be in the tune of 150nos. Cost of each gate is estimated to be 1,500,000 BDT per gate structure with gate. Total cost for gates at outfall locations is **224,400,000 BDT**. Maintenance cost will be 1% of capital cost.

8.2.6 Cost of Wetland Restoration and Integration

Wetlands (or lakes/ponds) are proposed to be restored and construct as appropriate where land will be available. It is assumed (from Google map) 100 ha of existing water bodies (or marshy land) can be integrated. It can be done by drains of 1.2 depth and 0.6m width of 30km length (assume).

In addition to it a landscaping along both sides of the canals with parks and plantation of trees has been considered for a length of 55km canal length.

- Cost of Wetland restoration(100 Ha) –**300,000,000 BDT**
- Cost of wetland integration (30km) –**900,000,000 BDT**
- Cost of landscaping, tree planting and canal side parks along canals –**275,000,000 BDT**

Maintenance cost will be 01% of capital cost.

8.3 Cost of River Embankment

Considering the climate change effect the embankment height needs to be raised. It is assumed that embankment can be raised by 1m above the existing level. A walkway will be provided after raining of the level.

- Eastern bank of the river – 17.5km
- Western bank of the river – 16.5km

Cost of such activity (@ 9000 BDT/m) is estimated to be in the tune of **306,000,000 BDT**. Maintenance cost of river embankment will be o.5% of capital cost.

9 INSTITUTIONAL ARRANGEMENT

9.1 Key Drainage Issues

Drainage is an important municipal service. However, the service provided by NCC is considered as sub-optimal. There exists substantial scope for improvement in the services provided by NCC. The key constraints are:

- Drainage networks and the drainage infrastructure in the NCC area are not maintained properly, creating "hot spots" of water logging and over spills
- Lack of O&M machinery, equipment and tools
- Inadequate staff and lack of attention to skill development
- Encroachments of natural canals
- Indiscriminate disposal of solid waste into khals (minor drainage canals) and drains
- Absence of effective surface drainage system
- Inadequate sewerage network and only one Sewerage Treatment Plant for the whole of NCC area. This creates contamination of drainage flow with untreated sewage

9.2 Harmonization of Drainage System with Strategies

The pronounced vision, mission and strategic objectives of NCC, as described below, provide a contextual connect to the proposed drainage infrastructure improvement investments under ADB funded UIIPF-PSPS. The Vision, Mission and Strategic Objectives are clearly articulated in the Narayanganj City Corporation Action Area Plan, 2016.

9.3 Strategic Objectives

NCC is committed to developing inter-link transport and drainage network and improving drainage infrastructure, as spelt out in its strategic objectives. The strategic objectives that link with drainage services are summarized in the table below:

Strategic objectives	Rationale
Develop inter- linkage of transport and drainage network	Transport and drainage sector (particularly IWT) are related to each other. In NCC area proper co-ordination between these two components is missing
Improve drainage network for solving water logging problems in case of sewerage and storm water	Drainage networks of NCC area are not maintained properly. They create water logging and over spill. Only part coverage of sewerage network. Only one Sewerage Treatment Plant in the entire NCC area

Source: Narayanganj City Corporation Action Area Plan, 2016

9.4 Institutional Capacity Assessment of NCC

Over the past two decades, Narayanganj city has evolved into an industrial and commercial growth hub with many industries and establishments commencing operations. As a consequence of this growth, in 2011 Narayanganj witnessed organizational transformation by becoming a city corporation. NCC has a lower

order organizational set up, which follows a Pourashava (municipality) model. This falls short of providing good governance and basic urban services to the citizens of the city. The current NCC structure is also constrained by inadequate staff skills and sub-optimal capacities to match the demands of modern city. Therefore, there is a need to evolve the municipal service functions to the level of City Corporation. A concise of institutional capacity assessment[27] is given in **Annexure X**

9.5 Institutional Capacity Development Plan

Strengthening Institutional Capacity and its Development Planning is now a days more inclined to satisfy United Nation Sustainable Development Goals. It is more on policy formulation, implementation, localization, financing, monitoring, evaluation, reporting and outreach of SDGs in Bangladesh. To achieve this there is requirement of a strong sectoral governance, adherence to policy and regulation framework, institutional setup, and setting up some specific policies considering local context.

9.5.1 Sector Governance

A good sectoral governance is required by virtue of which power is exercised in the management of NCC on the respective sector for the development in an efficient and transparent way. A good governance shall address to develop an understanding of perspectives, issues and concerns and analyze the current situation, diagnose the major obstacles on the path for the good, and to suggest some policy and institutional measures to be undertaken in an effort to improve the drainage sector.

It shall include NCC's institutional matrix, in which individuals, firms, social groups, civic organizations and policy makers interact with each other to implement and enforce public policies and to improve private sector coordination.

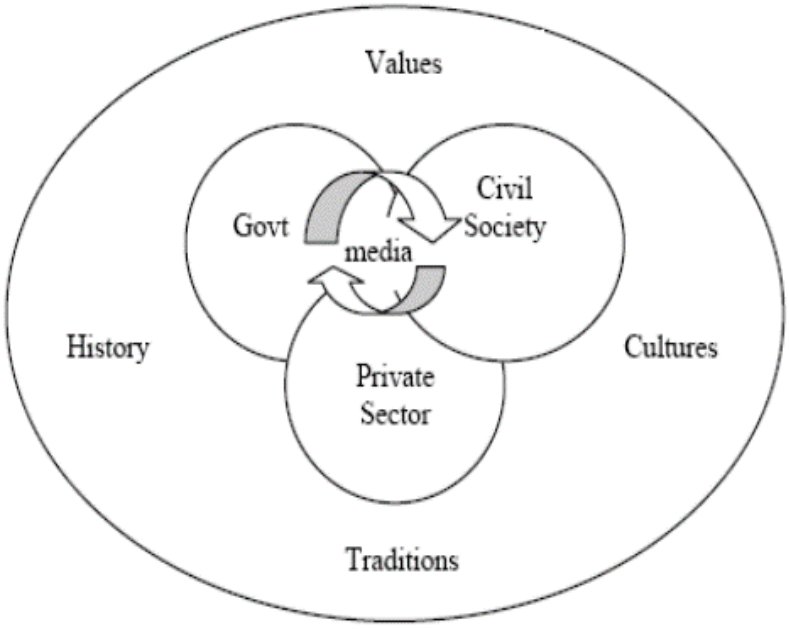


Figure 59 - Proposed Approach for Sectoral Governance in NCC

[27] Source: Institutional and Capacity Assessment of NCC, prepared by PSPS, Feb 2022

9.5.2 Institutional Set Up and Organogram

The Drainage wing in NCC is a part of the Engineering department. In the existing engineering department, Superintendent Engineer is the operational head. Currently, drainage service is prominently absent in NCC. The SE (civil, power and mechanical) manages this responsibility, by default.

Under the proposed new organizational arrangement (yet to be ratified by the NCC council), it is proposed that the Engineering department will be headed by a Chief Engineer. Two Superintending Engineers (one for Civil, Power & Mechanical) and the other for Water Supply and Drainage) will report to him as shown in the figure below. The designation-wise break up of staffing numbers as estimated by the UIIPF-PSPS team is given in the table below. The staffing number are proposed based on the total drainage length to be covered for O&M and the general staffing norms followed by other similar sized municipal corporations in neighboring countries.

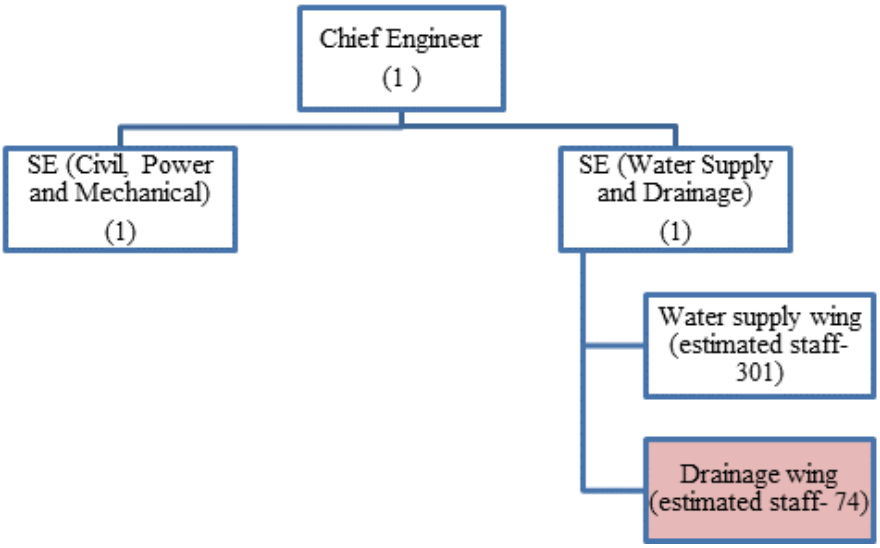


Figure 60 – Proposed Organogram of NCC Drainage Department

The designation-wise break-up of 74 drainage staff is listed in the table below. It is pertinent to note that drainage is a new wing that is to be established and the required staff members need to be recruited or posted new, using fresh recruitment, redeployment or deputation route.

Sl. No.	Staff designations	Number
1	Executive Engineer	1
2	Assistant Engineer	1
3	Sub- Assistant Engineer	2
4	Sewer Inspector	8
5	Maintenance Crew	17
6	Jetting Machine Operator	4
7	Winching Machine operator	4
8	Sewer/Drain Cleaners	34
9	Junior Engineer -GIS	1
10	Draftsman	2
	Total	**74**

Table 49– Proposed Drainage Manpower for NCC

In addition to new staff, the drainage wing will need the following equipment. The equipment also needs to be procured afresh.

Sl. No.	Equipment	Number
1	Jetting Machine - Small	2
	Jetting Machine - Large	1
2	Hand operated winching machine	2
3	Power Rodding Machine	2
4	Pull Through	1
5	CCTV equipment	1
6	Truck Mounted Jetting Machine	1

Table 50– Proposed Drainage Equipment for NCC

9.6 Institutional Action Points

As per the work plan prepared by the UIIPF- PSPS consultants, approval of the drainage infrastructure improvement feasibility report is expected by July 2022; detailed design will be completed by November 2022 and bidding documents and BOQ will be ready by December 2022.

Since drainage is a “brown field” project for NCC, it is necessary to keep the institution in a “fully ready” state latest by December 2022; i.e. six months prior to BOQ stage. Therefore, recruiting key engineering and must precede the task of procuring contractors. The recruitment of staff can be planned in two phases:

- Phase 1-recruitment of 1 EE, 1 AE and 2 Sub-AEs by September 2022 (three months prior to bidding), and
- Phase 2-recruitment of other staff spread over a period of succeeding 18 to 24 months (timed with commissioning of new drainage systems).

Equipment as listed above are necessary for efficient functioning of the drainage wing. Therefore, procurement of equipments needs to be timed with the commissioning of new drainage network. Equipments need to be procured through competitive bidding, using domestic or international suppliers. Training and capacity building of the existing civil wing staff and the newly recruited drainage wing staff also need to commence, immediately after their positioning. Training of drainage staff will become an integral part of the proposed capacity building plan.

10 POLICY AND REGULATORY FRAMEWORK

The success of the project is generally governed by relevant national laws and state's environmental rules, regulations, and standards, and social rules as well. These regulations impose restrictions on activities to minimize and mitigate likely impacts on the environment and community and setting standards to regulate the functioning of the system. Compliance is required in all stages of the project's implementation, operation and and maintenance. Some of the applicable National Policies and Notifications are as:

10.1 National Policies and Notifications

- **National Environmental Policy of 1992**: The Bangladesh National Environmental Policy, approved in May 1992, sets out the basic framework for environmental action together with a set of broad sectoral action guidelines.
- **National Environmental Management Action Plan of 1995 (NEMAP, 1995**): Itidentifies the main national environmental issues, including those related to the drainage sector. The main national concerns include flood damage, riverbank erosion, environmental degradation of water bodies, increased water pollution, shortage of irrigation water and drainage congestion; various specific regional concerns.
- **National Policy for Safe Water Supply and Sanitation (1998):** Policy aims at accessibility to all of water and sanitation within the shortest possible time at a price that is affordable to all. The Policy will be achieved through strategies formulated at various levels in consultation with the Ministry of Planning. Policy objectives are: (i) to improve the standard of public health, and (ii) to ensure an improved environment.
- **National Water Policy (NWP) (1999)**: Endorsed by the GoB, it aims to provide guidance to the major players in water sector for ensuring optimal development and management of water. According to the policy, all agencies and departments entrusted with water resource management responsibilities (regulation, planning, construction, operation, and maintenance) are required to enhance environmental amenities and ensure that environmental resources are protected and restored in executing their tasks and hence is applicable to the project. Storm water is one of the potential sources for water resource.
- **National Water Management Plan, 2001 (Approved in 2004):** The Plan envisions to establish an integrated development, management and use of water resources in Bangladesh over a period of 25 years. Water Resources Planning Organization (WARPO) has been assigned to monitor the national water management plan. Wetland is one of the potential sources for water resource.
- **National Biodiversity Strategy, and Action Plan (2004**): It aims to conserve, and restore the biodiversity of the country for well-being of the present and future generations; maintain and to improve environmental stability for ecosystems; ensure preservation of the unique biological heritage of the nation for the benefit of the present and future generations; guarantee the safe passage and conservation of globally endangered migratory species, especially birds and mammals in the country; and stop introduction of invasive alien species, genetically modified organisms and living modified organisms. Project has assessed the terrestrial, aquatic and avian life biodiversity present in the project area by using Integrated Biodiversity Assessment Tool (IBAT) tool and none of the biodiversity risk areas are within 10km radius of the project area.
- **National Adaptation Program of Action (NAPA), 2005**: Ministry of Environment and Forest (MoEF)promulgated this program as a response to the decision of the Seventh Session of the Conference of the Parties (COP7) of the United Nations Framework Convention on Climate

Change (UNFCCC). The basic approach to NAPA preparation was along with the sustainable development goals and objectives of the country where it has recognized the necessity of addressing climate change and environmental issue and natural resource management.

- **Bangladesh Climate Change Strategy and Action Plan (BCCSAP) 2009:** The BCCSAP is built on six pillars (i) Food security, (ii) Comprehensive disaster management, (iii) Infrastructure, (iv) Research and Knowledge management, (v) Mitigation and low carbon development,and (vi) Capacity building and Institutional strengthening. Out of these 6 pillars, the drainage sector is related to (ii), (iii) and (vi). Infrastructure shall be robust enough to ensure that the assets are well maintained and fit for purpose and that the infrastructures put in place is capable to combat likely impacts of climate change.

10.2 Proposed Regulations

10.2.1 Policy for cutting Domestic sewage

It is evident to have a police in place for cutting off domestic sewage from being mixing into the drainage system of the city. Here, sewage is mainly referred to black water (or foul water). It is the effluent from septic tank outlet and/or toilet.

Capturing sewage at source and preventing from being mixed with storm water shall be the prime focus, followed by the transmission system from source (domestic household) to treatment plant via pumping stations, if required, by sewerage system and finally the treatment. This shall be enforce by law.

If in future NCC intends to consider grey water under sewerage system, i.e. capturing grey water along with black water at source, then it would have been ideal approach towards policy formulation.

The policy shall also include:

- Cleaning of Sewer - cleaning Frequency, Procedures for Cleaning of Sewers, Mechanical/manual
- Emptying septic tank – frequency, procedure
- Emergency preparedness – example, gas emergence
- Precautions – protective gears and safety devices
- Selection of sewer/septic tank cleaning modality – staff/employee, contracts/agencies, etc.
- Maintenance – types of inspection and examinations of sewer
- Roles and responsibilities
- Funding and its source allocation
- Society integration, local participation, policy dissemination and discussion.

10.2.2 Policy for cutting Industrial Waste

A policy on industrial waste treatment shall be in place. It shall not allow any industrial waste to mix in the drainage system and mandatory cutting of industrial waste to come into the system. Industrial waste treatment before discharging to corporation drains or canals or river is essential. Different industries have different types of waste. The policy shall also guide on the limiting parameter of treated waste to be complied upon. A common treatment plan for different industrial waste may be an option, but it will require additional conduiting arrangement to convey waste from different industries to a common point.

10.2.3 Policy for Amendment for Codal provision

A policy shall be in place which will allow monitoring and validating the design output with the site situation and amendment of the codal provisions accordingly. The designs are normally guided by drainage guidelines and standard codal provisions. In case the situ situation does not does not matches to the design utput, it should be addressed through amendment of guidelines under provisions enacted by the policy.

Some of the examples are dicussed below.

1) If it is observed that the city/town site condition does not allow provisions for adequate outfalls, then design codes/guidelines may be amended to suit where there will be provision for more green area development to reduce runoff .
2) The codal provision shall allow and make it mandatory to explore options for nature based solution. It shall address possibility of reduced runoffs through nature based solutions for the future drainage development (after the coming project). This the idea may be new in NCC.
3) Development and setting flood risk mapping after the coming project.
4) Establishment of early warning system

10.3 Guiding Principles for Plan and Policies

- Environment friendly sustainable development of the area.
- City function to develop as per major landuse zones.
- Effective drainage through minimum hindrance to Flood Flow zones.
- Safe residential areas at proximity to place of work or major communication routes.
- Smooth and effective functioning of industries, especially export oriented industries.
- Safe yet faster connectivity.
- Develop to serve the surrounding hinterlands.

10.3.1 Relevant Structure Plan and Policies

Narayanganj Paurashava and its adjoining areas are composed of established urban areas and urbanizing areas. The Structure Plan policies for the areas were framed earlier. It is expected that the structural policies are applicable to City Corporation. A list of policies are given below[28].

1) Urban Area Policy UA/1 seek to optimize land resources within the defined established urban area by encouraging the infilling of vacant, under-utilized land by allowing vertical development up to four-six floors by redevelopment or re-subdivision of land within lower density communities.
2) Urban Area Policy UA/2 promotes densification at community level accompanied by infrastructure consolidation.
3) Urban Area Policy UA/3 emphasizes community led initiatives through participation in the land development process.
4) Under Sectoral Plans, Policies and Proposals Policy SE/1 seeks to designate Narayanganj area as a Special Rehabilitation Incentive Zone to revitalize the manufacturing sector to recover from decline of the jute sector.

[28] DAP 1995

5) Sectoral Policy SE/4 advocates for an integrated policy of the incremental environmental upgrading and relocation, where necessary, of Dhaka's polluting industries, in a manner commensurate with sound environmental practice and cost-effectiveness.
6) Sectoral Policy SE/5 seeks to promote the gradual dispersal of commercial activity to the existing suburbs and new growth areas.
7) Sectoral Policy SE/10 envisages augmentation of the city's existing stock of major recreational facilities by means of exploiting the resource of vacant and/or under-utilized government land within established urban area.
8) Sectoral Policy SE/11 intends to identify and secure sites for major recreational use in all DMDP priority areas.
9) Infrastructure Policy IN/2 promotes for incremental network development in the transport sector in order to conserve resources and responsive to proven demand for the service being offered.
10) Infrastructure Policy IN/5 promotes incremental flood protection strategy to employ means of implementation of components of FAP-8A which will spread costs over time and capture benefits for other development sectors.
11) Rural and Special Area Policy RS/4 envisages river pollution control for environmental protection to prevent pollution of Sitalakhya river and its tributary, Balu river, in order to ensure that it remains viable, long-term source of potable water.
12) Policy RS/5 proposes flood retention ponds for retaining water at times of flooding. The Structure Plan states that ponds have to be maintained primarily by landuse controls since acquisition of retention ponds areas is unfeasible.

10.4 Preferred Development Strategies

Hydrological aspects dominated the issue of development of a suitable strategy for the physical development of the area so near to the heart of the capital city. All the higher level plans and studies carried out at varying points of time converged to the same conclusion that the drainage function that low lying areas and several rivers carryout, must not be obstructed by any development. The area is experiencing a tremendous development pressure with complete disregard to drainage requirement. As per DAP some effective strategy/policy for various issues had been worked out to ensure a desirable living environment. These are described under some basic heads[29]:

1) Non-continuous smaller rural settlements above flood level surrounded by ample low lying areas (agriculture, flood flow) allowing uninterrupted flow of water to pass through.
2) Minimize obstruction of flood water as is practicable.
3) Appropriate connectivity by roads having sufficient openings to ensure needful flow of water across them as well as uninterrupted traditional water based connectivity by keeping appropriate navigation clearance at the bridges. This would help maintain the biodiversity of the area and contribute to sustainable environment in turn.
4) Retention of excess water in the canal system in the DND area.
5) Strictly preserve the zone area as per the higher level plans
6) Promote agricultural and passive recreational use of the area during dry season
7) Strictly protect canal networks as per the DAP.
8) Make provision for open spaces and water body at the neighbourhood level.
9) Strictly protect the river fronts and open it to city dwellers for serene passive recreation.

[29] DAP 2010

10) Make city scale open space with easy accessibility especially for people of densely populated areas with meagre scope for open space.
11) Ensure provision of central effluent treatment plant in case of industrial clusters
12) Ensure own treatment plant in case of individual facilities.
13) Prohibit high hazard industries within the area.
14) Relocate industries from predominantly residential zones in phases
15) Provide essential support facilities for effective functioning of the industries
16) Strictly protect canal networks as per the DAP.
17) Make provision for open spaces and water body at the neighbourhood level.
18) Strictly protect the river fronts and open it to city dwellers for serene passive recreation.
19) Make city scale open space with easy accessibility especially for people of densely populated areas with meagre scope for open space.
20) Grouping of Hazardous Industries
21) Establishment of Common Effluent Treatment Plant
22) Adoption of Neighbourhood Concepts for New Residential Development
23) Waste Water Treatment Plant

11 SUSTAINABILITY OF DRAINAGE SYSTEM AND MANAGEMENT

11.1 Strategic Goals

NCC's strategic goals shall be aligned with the United Nations sustainable development cooperation framework for Bangladesh for 2022–2026 and the eighth five-year plan (covering the period July 2020–June 2025) of the Government of Bangladesh. One of the strategic outcomes interprets that by year 2026, vulnerable communities in Bangladesh shall be made more resilient to shocks and natural disasters owing to enhanced national disaster management capacity programmes. However, the aim of the strategic goals will be to progress towards the 2030 Agenda for Sustainable Development.

11.2 5-Yr Plan and Performance Target

In order to achieve the goals an infrastructure development in drainage sector is proposed. It is the output of a comprehensive drainage master pan. A successive 5-year plan has been proposed for sectoral improvement through component wise implementation with a predefined performance target.

The design period of the project is 2046. The implementation is expected to start in 2024 and outcome is been perceived to be from 2026. Hence the 5-yr slot has been divide accordingly.

5-Yr Plan	Drainage Sector Components	Target	Remarks
2026-2031	Drains and Canals rehabilitation	100% coverage	In phases
	Wastewater (grey water) transmission and treatment	40% interception and diversion	
	Landscaping, tree planting and canal side parks along canals	25% canals	
2031-2036	Wastewater (grey water) transmission and treatment	60% interception and diversion	
	Landscaping, tree planting and canal side parks along canals	75% canals	
	Wetland integration, , Construction and restoration of Water Bodies	50%	
	Augmentation of drainage system	100% additional coverage	Cope up with new developed areas with NCC
2036-2041	Wetland integration, , Construction and restoration of Water Bodies	50%	
	Augmentation of drainage system	100% additional coverage	Cope up with increased urbanization and new developed areas
	Transformation of Canals/Khals to Navigation Channel	100%	
2041-2046	Augmentation of drainage system	100% additional coverage	

Table 51– Proposed 5-Yr Phasing

11.3 Consultation with Govt/Non-Govt. Agencies

UNSDG has set a guidelines and the Govt. needs to give effort for its compliances in phases. NCC shall coordinate and consult with other government and non-government agencies forproper functioning of the system and comply towards achieving the sustainable goals. Some of the main topics of consultation are:

- strategy formulation
- project implementation,
- operation & maintenance,
- monitoring,
- system performance evaluation,
- strategy modification,
- compliance to rules and regulation

Sl. No.	Consultation with Govt/Non-Govt Agencies	Consultation on	Remarks
1	City Level Committee	Project disclosure, Project implementation,	
2	Community based organisations	Project implementation and performance feedback through community participation,	
3	NGOs	KPI Monitoring, Feedback, Data accumulation compilation and analysis,	
4	Local government departments	Project implementation, System performance evaluation,	
5	Government of Bangladesh	Strategy formulation, strategy modification	
6	UNSDG local committee	Non-Compliance resolution, Discussion on specific issues	

11.4 Assessment of Indicators

11.4.1 Performance Indicators

A list of key performance indicator (KPIs) are discussed, based on the storm drainage only. Assessment for each indicator has been done through gradation (point system). An overall assessment can be evaluated for the total system.

Sl. No.	Indicators Identified	Performance Indicators	Weightage	Assessment / Gradation	Score
1	Coverage of storm water drainage network	100%	10	100% - Good 90-100 – Fair 80-90- Average <80 -Poor	10 8 6 0

Sl. No.	Indicators Identified	Performance Indicators	Weightage	Assessment / Gradation	Score
2	Household plumbing (or drain) connection to corporation drain with respect to drainage network coverage	100%	10	100% - Good 90-100 – Fair 80-90- Average <80 -Poor	10 5 1 0
3	Population coverage with respect to drainage network coverage	100%	8	100% - Good 90-100 – Fair 80-90- Average <80 -Poor	10 9 8 7
4	GIS integration and information system	100%	5	100% - Good 90-100 – Fair 80-90- Average <80 -Poor	5 4 3 2
5	Collection of charges, if any	90%	3	>90% - Good 90-100 – Fair 80-90- Average <80 -Poor	3 2 1 0
6	Efficiency in redressal of complaints	80% within 24 hours and 100% within 48 hours	9	80,100% - Good 70,100 – Fair 50,100- Average <100 -Poor	3 2 1 0
7	Maintenance (cleaning of drains)	Once in 2 years	7	Once in 2 yrs Once in 3 yrs Once in 4 yrs	7 5 1
8	O&M staff	85% of proposed strength	3	>85% - Good 75-85 – Fair 65-75- Average <65 -Poor	3 2 1 0
9	Loss of human resource during maintenance	zero	5	=0 - Good >0 – Poor	5 0
10	Loss and damages due to urban floods	Zero	5	=0 - Good >0 – Poor	5 0
11	Occurrence of vector or waterborne diseases due to flooding	zero	5	=0 - Good >0 – Poor	5 0
12	Aggregate number of incidents of water logging reported in a year	4 nos per year. Stagnant water for more than 4 hours of a depth more than 150mm, considering maximum of the following :	5	=<4 - Good 5-7 – Fair 8-10- Average >10 -Poor	5 3 1 0

Sl. No.	Indicators Identified	Performance Indicators	Weightage	Assessment / Gradation	Score
		(i) along a road length of 50 m or more, (ii) in a locality affecting 50 households or more.			
13	Plantation along canal banks	100%	5	100% - Good 90-100 – Fair 80-90- Average <80 -Poor	5 4 3 2
14	Restoration/Construction of Water bodies and integration to canal/drain system	10% of total area	5	10% - Good 7-10 – Fair 4-6- Average <4 -Poor	5 3 2 0
15	Policy compliance	75% - after first year of completion. 90% after 5 years of completion. 95% after 10 years of completion	5		5 0
16	Review/upgradation of system, policies and procedures	Once in a year	5		5 0
17	Stakeholders consultation/relation, cooperation and coordination	One meeting in a month	5		5 0
		TOTAL SCORE	**100**		

Table 52– Performance Indicator for Drainage System

11.4.2 Monitoring – Performance Indicators

Monitoring arrangements will be guided by the framework as given above. It should be parameter (Indicator) specific and allow understanding for all stakeholders. Data will be collected, disaggregated and analysed as per the indicators to enable evidence-based decision-making through an understanding of how and why betterment of the performance is required. Review the approach to performance and knowledge management, strengthening the links between monitoring and evaluation and vulnerability analysis, and will strengthen its evidence-generating efforts for the design and adjustment of interventions and advocacy with the NCC/government intervention. Outcome measurement, in addition to tracking the outcomes of interventions, will also be tracked and the contributions parameters shall be emphasized for further strengthening to ensure safety and compliance to government net programmes.

Overall Assessment - Each parameter/indicator shall be given an weightage to have an overall assessment of the system performance. Total weightage is 100, split in al parameters as given in the table above. Overall assessment will be based on the weightage average of all parameters.

11.5 Climate Change Adaptation

11.5.1 Environment and Background

The industries surrounding Narayanganj City Corporation have had significant impacts on the local climate, river, and canal systems. The discharge of untreated industrial effluents has led to increased water pollution in the Shitalakshya River, with the level of pollution increasing by 72% over the last decade. Moreover, the salinity levels in the canals have also increased by 50% in the same period, damaging the local agriculture sector. These impacts have been exacerbated by the city's climate, which is characterized by high temperatures and heavy rainfall. The industries operating in the area have also contributed to climate change through increased carbon emissions, deforestation, and the depletion of natural resources. For example, the textile and garment industries, which are major contributors to the local economy, are estimated to produce around 1.2 million tons of carbon dioxide emissions annually. The environmental degradation caused by these industries can have long-term economic consequences, such as reducing the availability of water for agricultural purposes and affecting the productivity of local farmers. Therefore, it is important for the Narayanganj City Corporation to regulate and monitor industrial activities in the area and promote sustainable industrial development to mitigate these negative impacts. The environmental degradation aggravates climate change effect on the city.

11.5.2 Previous Studies on Pollution

Some numerical data about the chemical compositions of pollutants found in industrial effluents in the Narayanganj City Corporation area, as reported by various studies:

- A study conducted by the Bangladesh University of Engineering and Technology found that the effluent from textile and garment industries in the Narayanganj area contains high levels of organic pollutants, with Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) levels reaching up to 357 and 1,985 mg/L, respectively.
- Another study conducted by the Department of Civil and Environmental Engineering at Shahjalal University of Science and Technology found that the effluent from the tannery industries in the area contains high levels of heavy metals such as chromium, lead, and cadmium. The study found that the chromium concentration in the effluent ranged from 44 to 2,688 mg/L, which is significantly higher than the permissible limit of 2 mg/L set by the Bangladesh Department of Environment.
- According to a report by the Asian Development Bank, the effluent from the pharmaceutical industries in the Narayanganj area contains a range of pollutants, including antibiotics, antifungals, and disinfectants. The report states that the levels of some of these pollutants in the effluent can exceed the permissible limits set by the World Health Organization.

These studies demonstrate the high levels of pollutants found in the industrial effluents in the Narayanganj area, highlighting the need for effective measures to regulate and monitor the discharge of industrial effluents in the area.

11.5.3 Climate Policies of Bangladesh

- Bangladesh Delta Plan 2100 (2018): economic growth, environmental conservation, enhanced climate resilience

- Perspective Plan 2021-2041: twelve chapters including power and energy, climate change
- Mujib Climate Prosperity Plan (Decade 2030): Climate-resilient, Environmentally friendly transportation, Climate-resilient well-being initiatives.
- Nationally Determined Contribution (NDC): Unconditional: emissions reduction 27.56 Mt CO2e; and, Conditional: emissions reduction 61.9 Mt CO2e.
- Eighth Five Year Plan: Sustainable development pathway (resilient to disaster and Climate Change).
- National Adaptation Plan (NAP): eight distinct sectors, which are, water resources; disaster, social safety and security; agriculture; fisheries, aquaculture and livestock; urban cities; ecosystem, wetlands and biodiversity; policy and institution; capacity development, research and innovations.

11.5.4 Remedial Measures

There are several remedies that can be implemented to mitigate the negative impacts of industrial effluents on the environment and public health in the Narayanganj City Corporation area. Some of these remedies are:

Sl. No.	Regulation	Remedial Action Plan
1	Regulating and enforcing environmental laws	The Narayanganj City Corporation can establish and enforce strict environmental laws and regulations to monitor and control the discharge of industrial effluents. This can include setting strict effluent discharge limits, monitoring effluent quality, and imposing penalties for non-compliance.
2	Promoting sustainable industrial practices	The city can encourage industries to adopt sustainable practices by promoting the use of clean technologies, reducing water consumption, and minimizing waste generation.
3	Establishing industrial effluent treatment plants	The city can establish industrial effluent treatment plants to treat the effluent generated by industries before releasing it into the water bodies. This can help reduce the level of pollutants in the effluent and prevent water pollution.
4	Encouraging public participation and awareness	The city can involve the local community and stakeholders in the decision-making process and raise awareness about the impacts of industrial effluents on the environment and public health. This can help create a sense of responsibility and encourage people to take action to reduce pollution.
5	Encouraging green infrastructure	Green infrastructure like parks, rain gardens, and green roofs can help to absorb and filter stormwater runoff, reducing the impact of runoff pollution on the city's waterways.

11.5.5 Overall Effect due to Climate Change

The Bangladesh Climate and Disaster Risk Atlas states that minimal change in the spatial distribution of rainfall is expected throughout the 4-decade period from 2011 to 2050. However, minor changes in precipitation will be experienced by districts in the north-western and eastern parts of Bangladesh, while the rest of the country is unlikely to experience any significant change in annual average rainfall.

Accordingly, the annual average rainfall in the project area (Narayanganj) is expected to remain in the range of 3.01 – 5.21 mm/day for the project duration i.e. next 30 years.

Annual Extreme Rainfall is likely to exhibit a wide variation in rainfall with respect to base year 2011 i.e. a decrease in 2021, an increase in 2031, and a decrease again in 2041–2050 for central and western Bangladesh. Accordingly, it is expected to remain range bound between 11.02 and 16.20 mm/day in the project area for the project duration i.e. next 30 years. However, an increasing trend in rainfall from the north-western to the southern portions of Bangladesh is expected. Likewise, and consistently, significant increase in annual extreme rainfall is anticipated for the districts in northeast Bangladesh.

11.5.6 Climate Adaptation Measures through the Project

The Climate Strategy 2030 vouches on:

- Tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability
- Promote green growth and climate resilience

The project addresses the climate strategy and National adaption plan (NAP) through the interventions as discussed below. These will ensure:

- protection against climate change variability and induces natural disaster,
- climate resilient livelihood and improved urban environment

Raising of river embankment – There is a possibility of water level rise in the river during peak monsoon in distant future. The master plan proposes raising the level of embankment to avoid spilling in river water to the countryside. It also proposes installation of gates at strategic outfall location which will be potentially under the threat of submerged flow. It would likely to improve the resilience of the system. Raising of embankment will be for 1.0m in phases, 0.5m in each decade.

Planation of tress along canal has been proposed considering the pollution created by the industries throughout the city. It will address the environment impact due to climate change. Planation shall be done both sides of the canals and also along the bank of the rivers. Length of stretch of planation will be 110m approx. for the canal sides and 40m for river banks. Trees shall be at an interval of 30m ideally. Industries along the canal/riven bank shall also be encouraged for planation of trees.

Wetland integration to reduce pumping of storm water – Storm Drainage system has been proposed to be integrated with the wetland. This technical solution will not only reduce the drain size but also depth of drain, which will finally reduce the possibility of increased pumping stations. This will attribute to less Carbon footprint.

Construction and restoration of Water Bodies– Presently there is more than 100Ha within the city corporation area which can be developed to an organized water bodies. Restoration of water bodies has been proposed along with construction of new water bodies, if possible. It will reduce possibility of storm flooding. It is one of the most resilient measures with low investment. Promotion of pisciculture in these water bodies shall be encouraged. Further to this it will allow more ground water infiltration and reduce ground subsidence which is presently 6mm/year. These water bodies will also reduce runoffs and can be accepted as a naturebased solutions for the future drainage development in near future.

Transformation of Canals/Khals to Navigation Channel – Water navigation is the most effective way of transport as far as pollution is concern. It attributes to least carbon footprint. It has been proposed to transform these canal network, mainly in Zone 2, as the navigation channel.

Adopting surface covered drains for storm water – For storm water system surface drain (with cover slab)has been proposed over piped/sewer network. In this case minimum depth of conduit at start will be 0.6m instead of 1.5m for pipe/sewer storm drain system. Earthwork will be greatly reduced which will reduce pollution. It will also reduce the possibility of discharging out storm to rivers/canals from the system through pumping. This also satisfies in reducing carbon footprint.

The drainage master plan proposals covered climate-resilient urban drainage or stormwater management facilities and are fully aligned with NAP with fully compliance to Climate Change adaptation

11.6 Risk Assessment

Assessment of the risk of the city due to drainage issues was made, considering two scenarios:
- without project, and
-with project

It is evident the risk to the city will reduce drastically with the project.

	Without Project				With Project			
Hazards	**Likeli-hood**	**Conse-quence**	**Score**	**Risk Category**	**Likeli-hood**	**Conse-quence**	**Score**	**Risk Category**
Water Logging	4	4	16	High	1	4	4	Very low
Flooding during extreme rainfall	4	4	16	High	2	4	8	Low
Disposal of waste in river	5	4	20	Very high	0	4	0	Very Low
Water borne diseases	4	4	16	High	1	4	4	Very low
Pollution of canal/river	4	3	12	Moderate	2	3	6	Low
Effect on livelihood	4	2	8	Low	1	2	2	Very low
Pollution during construction	0	3	0	Verylow	4	3	12	Moderate
Effect due to Sea level rise	1	2	2	Verylow	1	2	2	Verylow

Note:

Very Low risk	<=4
Low risk	5-8
Moderate Risk	9-12
High rish	13-16
Very high risk	>16

Table 53– Risk Matrix

11.7 Requirement of Design guidelines for climate change

The importance of climate change impact studies on urban drainage becomes widely accepted. Conducting climate change studies on urban drainage is, however, extremely complicated, mainly because of the small, temporal and spatial scales of processes in urban catchments. The cumulative effects of gradual changes in hydrology due to climatic change are expected to alter the magnitude and frequency of peak flows over the service life of drainage infrastructure. Potential future changes in rainfall intensity are expected to alter the level of service of drainage infrastructure, with increased rainfall intensity likely resulting in more frequent flooding of storm sewers and surcharging of culverts. The expected effects of climate change necessitate a change in the approach used to plan for and design drainage infrastructure.

Design Life : Defining new design criteria in a Climate Change context implies that the expected lifetime of the infrastructure be taken into consideration and that a model describing the future evolution of intensity/frequency of extreme events be defined.

Design rainfall

Design parameters for urban drainage systems shall be revised considering climate change effect. The revision shall involve extrapolation of the design rainfall statistics, taking into account the current knowledge on future climate change trends till next 50 years. Uncertainties in these trend projections shall be assessed after statistically analysing and downscaling a broad ensemble set on Bangaladesh climate model runs. Following to this climate change scenarios shall be developed in such a way that it can be tailored for the application of drainage impact analysis in NCC. The impact of climate change on stormwater management therefore needs to be assessed based on a statistical analysis of past extreme precipitation events.

The analysis maybe:

- Statistical Analysis of Intense Rainfall in a Stationary Climate
- Statistical Analysis of Intense Rainfall in a Non-stationary Climate

Evolution of the return period over time is an important factor. Based on the climate scenarios and historical rainfall series, changes in intensity–duration–frequency (IDF) statistics and design storms shall be derived. General theory says that a design criteria for more return period will be wise decision from climate change. But it would lead to under utilization of the investment for the infrastructure.

Storage Capacity : Restoration of water bodies has been proposed along with construction of new water bodies, if possible. It will reduce possibility of storm flooding. It is one of the most resilient measures with low investment. Further to this it will allow more ground water infiltration and reduce ground subsidence. These water bodies will also reduce runoffs and can be accepted as a nature based solutions. It is found that increase in storage capacity of 10–50% would keep the overflow frequency to the current level even if there is change of storm frequency due to climate change.

Free Board: The storm drainage network is normally designed with an assumed initial value of free board. It is then simulated after the initial design run. The free board shall be kept adequately enough to absorb the additional storm runoff load due to climate change.

Time of Inlet (Ti) : There are some standard formulas available for calculating the time of inlet. Increase in Ti will reduce the size of drains. Storm Runoff, being dependent on Ti will be affected due the change in rainfall intensity Hence more green area is recommended to maximize relief from the climate change effect.

Runoff Coefficient: Although the runoff coefficient has been taken considering rapid urbanization which indicates future increase of impervious layers within project area however in the long run the design factors may act slight differently based on the urbanization, soil criteria modification, increase/decrease of greeneries. The type and condition of the soil play a significant role in determining the runoff coefficient. Soils with high infiltration rates, such as sandy soils, tend to have lower runoff coefficients as they can absorb more water. In contrast, soils with low infiltration rates, such as clay soils, have higher runoff coefficients as they have limited capacity to absorb water, resulting in more runoff.

System Volume: System volume shall be increased to accommodate surge effect within the network due to climate change. In case of proposing pipe/sewer, the manhole shall be of bigger size than traditional one.

Urbanization and Land Use: As the city develops and expands, changes in land use patterns, such as increased urbanization, can lead to alterations in surface characteristics and runoff patterns. For example, the conversion of natural areas into impervious surfaces like roads and buildings can result in higher runoff volumes and faster runoff velocities. These changes may necessitate adjustments to the drainage system design, including larger pipe sizes, additional storage capacity, or increased conveyance capacity.

Planation of tress: Considering the pollution created by the industries throughout the city, planation shall be done through out the city. This shall be strongly advocated to impose in the design guidelines.

Population Growth: An increasing population can lead to higher impervious surfaces, and additional stress on the stormwater drainage system. As the city's population grows, the design parameters may need to be adjusted to account for increased runoff and potential overloading of the system.

Raising of embankment : Due to climate change there is a possibility of water level rise in the river during peak monsoon. The design guidelines shall accommodate possibility for raising the level of embankment to avoid spilling in river water to the countryside.

Navigation Channel : Water navigation is the most effective way of transport as far as pollution is concern. It produces least carbon footprint with respect to means of transportation, thus attributed to climate change effect. It shall be proposed to transform canal network as the navigation channel.

Surface covered drains for storm water : For storm water system surface drain (with cover slab) shall be prioritized over piped/sewer network. In this case minimum depth of conduit at start point will be less than that of pipe/sewer storm drain system. Earthwork will be greatly reduced which will reduce pollution. It will also reduce the possibility of discharging out storm to rivers/canals from the system through pumping. This also satisfies in reducing carbon footprint.

Introduction of solar power : In storm water network system there may be requirement of pumping station. The energy consumption shall criteria shall be poised wit solar power applications.

It is thus concluded that climate change is a reality that planners and designers of drainage infrastructures must consider.

The performance level of a given urban drainage system evolves with time. Many factors can modify the level of performance and the corresponding risk of system failure. The evolution of the performance level is assessed through two parameters according to the proposed approach: (i) the reference year and (ii) the critical return period. These parameters are useless in a context of stationary climate. However it shall be validated based on the three main factors:

(i) expected lifetime of the infrastructure,
(ii) magnitude and uncertainties of the expected changes in intense rainfall, and
(iii) overall adaptation strategy.

12 SOCIAL AND ENVIRONMENTA ASPECTS

12.1 Social Aspects – Resettlement Plan

This Project will support infrastructure development in the City of Narayanganj by building upon infrastructure and capacity building initiatives. The Project will also continue strengthening capacity for project development, sustainable services delivery, and community awareness. Narayanganj is the fourth most populated urban area in Bangladesh. The city is facing many challenges from unplanned and uncontrolled development. To address these problems, the project aims at improving the urban infrastructure and increasing urban services for the citizens with sustainable services delivery.

The short note on Resettlement Plan[30] is given below. A concise of the same is given in **Annexure VIII**.

Resettlement Plan

During implementation, this draft resettlement plan will be updated based on final detailed design and on detailed impact assessment. The resettlement plan is prepared in accordance with the ADB Safeguard Policy Statement (SPS), 2009, the policy of the Government of Bangladesh, i.e. the Acquisition and Requisition of Immoveable Property Act (ARIPA), 2017, and the resettlement framework adopted for the Project. It will be updated by resettlement specialist, based on detailed design during implementation. The relevant authorities will review and clear the revised RP during detailed design, and prior to commencement of works. As the impact of the subprojects would be minimal and no land acquisition will be required, the project has been categorized as Category B in the Environmental Categorization applied by ADB.

Socioeconomic Profile of the Affected Population	An IoL survey and a socioeconomic survey were carried out using detailed structured questionnaires. A Focus Group Discussion (FGD) checklist was also used for public consultation. For the socioeconomic survey an assessment of 1458 households in Zone 1 (of 4 zones total) of the whole subproject area was conducted which covers 100 percent of the entire affected property/households. Later an extrapolation of the data for rest of the zones were done. Secondary data have been collected from official sources including Census and records/reports of the NCC.
Information Disclosure Consultation and Participation	Goals and objectives of the project have been disclosed to stakeholders (including, beneficiaries, affected persons, elected representatives and institutional stakeholders) through consultation meetings and focus group discussions. A program of continuous consultation and disclosure is proposed.
Grievance Redress Mechanism (GRM)	The mechanism includes evaluations of its effectiveness, procedures, complaints receive, timeliness to resolve issues/ complaints and resources provided to solve the complaints. Special attentions should be given if there are complaints received from the affected people or communities.
Policy and Legal Framework	The legal framework for the Project is based on applicable legal and policy frameworks of the Government of Bangladesh, namely the Acquisition and Requisition of Immovable Property Act, 2017 (ARIPA) and Safeguards Policy

[30] Source – Resettlement Plan for Drainage Component, Jan 2023

Statement (SPS), 2009 of the Asian Development Bank (ADB). Under the law, the owners affected by the acquisition will be eligible to receive assistance for:

i) structures permanently impacted and trees; and
ii) any other impact and damages caused by it.

Entitlements, Assistances and Benefits	An entitlement matrix has been developed towards compensating the affected household for their loss. NCC will provide adequate and appropriate compensation as per the entitlement matrix in the draft resettlement plan. Income restoration assistance to the affected persons includes both short and medium-term strategies. The government will provide all funds for resettlement in a timely manner.
Resettlement Budget and Financing Plan	There is no scope for LA as all the land required for the Project is Government land.
Institutional Arrangement and Implementation Schedule	The works will be managed and implemented through a Project Implementation Unit (PIU) at Narayanganj City Corporation with overall support and guidance of the Project Management Unit (PMU). The PMU will be supported by institutional consultants under the supervision and control of Project Director, PMU. The PIU will implement the resettlement plan with support from the PMU and project consultants. NCC is both the Executing Agency (EA) and the Implementing Agency (IA) for the project.
Monitoring and Reporting	RP implementation will be closely monitored to provide an effective basis for assessing resettlement progress and identifying potential difficulties and problems. Monitoring reports will be disclosed on the website.

12.2 Environmental Aspects – IEE

The jurisdiction of NCC, having urban to peri-urban setting which has continuously developed through the years and is still expanding and changing. There are no land-based critical habitat within and immediate vicinity of the subproject sites (for both stationary and linear structures). Further, the alignment of the drainage lines (drains) is to be located within the existing rights of way of street/ roads and/or government-owned lands. There is no protected area, wetland, mangrove, or estuary in or near to the subproject location. There is no forest area within or near to NCC area. The vital river system, known as the Shitalakhya, Dhaleshwari and Meghna River system, borders Narayanganj city in the east and west sides and are the crucial water sources for the project.

In order to account for improved stormwater drainage system within NCC area, the city corporation has been broadly divided into Zones. The proposed project ensures short-term response to waterlogging conditions in Zone 1, 2, 3 and 4 and proposes to improve stormwater drainage system by – a) desilting of existing blocked drains; b) rehabilitating existing inadequate drains; (c) constructing new roadside drains, and d) rehabilitating the natural canals, and; (e) supply of operation and maintenance equipment. All the activities, will involve civil work resulting into temporary and localized impacts on the environment, labours working at site and population residing in or visiting the project sites. Thus, an environmental impact assessment has been carried to identify adverse impacts that may arise from the civil activities and thereby plan to avoid, reduce and mitigate those impacts. This Initial Environmental Examination (IEE)

report is related to all activities relevant against implementation and operation of infrastructures under stormwater drainage system.

The short note on Initial Environmental Examination[31] is given below. A concise of the same is given in **Annexure IX**.

The impacts are expected to be localized, temporary in nature and with mitigation measures can be reduced to insignificant level. Nature of impacts will be during pre-construction, construction and post construction stages. Impacts were identified in relation to the different phases of project implementation — pre-construction, construction, and operation of the built infrastructure. Based on this evaluation, mitigation measures have been developed to reduce all negative impacts to acceptable levels. In order to ensure that the assessment of impact is robust, a biodiversity assessment has been undertaken relative to the subproject locations. The Integrated Biodiversity Assessment Tool was initially used to screen and assess potential risks on the protected areas or critical habitat that may exist around the project sites (default area of analysis of 50 km radius).

The project will lead to following positive impacts of against:

- severe waterlogging which has direct linkages to resurgence of malaria spread,
- the spread of diarrhea diseases,
- damage to housing and property,
- disrupted communications,
- lost income and environmental degradation.

An IEE has been undertaken, which assesses in more detail the likely environmental impacts of the project and provides the corresponding mitigation measures to ensure these impacts are managed to acceptable levels. The assessment was also carried out within the policy, legal, and administrative frameworks of the government relevant to sewerage and sanitation projects in the country. Following activities at site level were carried out:

- Air and Noise monitoring was carried out between January and February 2023, sampling all project sites capturing two different activity conditions – during a working day and during a non-working/ holiday.
- The public consultation program has been undertaken both formally and informally throughout the study to ensure that the knowledge, experience, and views of stakeholders and the general public are taken into account during the IEE work.

All potential impacts were identified in relation to preconstruction, construction, and operation phases. Planning principles and design considerations have been reviewed and incorporated into the site planning process whenever possible; thus, environmental impacts as being due to the project design or location were not significant.

The EMP will assist the PMU, MDMSC, and contractors in mitigating the environmental impacts, and guide them in the environmentally sound execution of the proposed project. The EMP will also ensure efficient lines of communication between the implementing agency, project management unit, and contractors. A copy of the EMP shall be kept on-site during the construction period at all times. The EMP

[31] Source – IEE for Drainage Component, April 2023

shall be made binding on all contractors operating on the site, and will be included in the contractual clauses. Non-compliance with, or any deviation from, the conditions set out in this document shall constitute a failure in compliance.

There are no impacts that are significant or complex in nature, or that need an in-depth study to assess the impact. Thus, the drainage component under 1A will not cause significant adverse impacts. The potential adverse impacts that are associated with construction and O&M can be mitigated to acceptable levels with the specific mitigation measures discussed in the EMP.

Accordingly, the project is classified as Category B for environment per ADB SPS, 2009 as no significant impacts are envisaged. There are no impacts that are significant or complex in nature, or that need an in-depth study to assess the impact. Thus, the subproject as described under 1A will not cause significant adverse impacts.

13 PUBLIC AWARENESS

Public awareness is everything in enhancing awareness, attitudes, behaviors, opinions, and activities that comprise the relations between the general public or the society as a whole to NCC.

Public awareness enriches mainly through public consultation. Hence, public consultation is an essential element of modern planning. Public consultation helps to get the pulse about the aspirations of the stakeholders regarding spatial development. In order to prepare the Plan in line with the desire of the people several formal and informal meetings were arranged with the stakeholders. In the initial stage stakeholders were apprised about the techniques of the plan preparation process and in the later stage, discussions were made about the draft plan.

13.1 Approach and Methods of Consultation

NCC shall aim to spread awareness of the project, the approach and the results to a wide audience. Consultation may be of the following directions:

- Consultation with Local Government Authorities
- Consultation With Different Communities
- Public Hearing
- Videography for public awareness

13.1.1 Community Awareness Programme

The scope of the community awareness programme includes the following:

- Enable the community to understand the need for the drainage system and grey water collection,
- Enable the community to understand the need for proper storm drainage outlet and grey water treatment and disposal,
- Enable the community to participate in planning,
- Enable the community to appreciate that this service is not free because it is valuable and has direct impact on health and living environment,
- Enable the community to understand what they get (tangible/intangible, long-term/short-term benefits) in return,
- Inform and obtain approval of the community for various improvement measures thus creating a feeling of close participation.

13.1.2 Public Hearing

As per section 74 of Town Improvement (TI) Act 1953, NCC shall carry out a Public Hearing on the Detailed Plan. The Public Hearing was carried out through:

- Media Coverage - Print and Electronic
- Press Conference
- Web based Publication
- Display of Maps (Hard Copy)
- Explain different aspects of the Plan to the stakeholders by experts
- Plot level digital display in GIS Platform
- Collection of Complaints in prescribed format and preparation of checklist

- Collection of Complaints in the form of letter to NCC

13.1.3 Videography for public awareness

NCC shall make a video for public awareness. The video aims to not only raise awareness about the project, but specifically about the approach taken by the project. In this approach, NCC can engage with local stakeholders and including them in the project specifically in assessment and workplan development activities. The video also serves to further increase the general public awareness about the need for disaster risk reduction programs and their own general risk perception and awareness. These are the key objectives for requirements of the video that will be developed by NCC for the project.

13.2 Awareness on Climate Change Adaptation

Communities that are vulnerable to the impacts of climate change need to adapted to increase their resilience. Effective government policies and plans are a key component of this transition, but they are not sufficient in themselves without awareness programmes. The community needs to be made aware of the risks, acquire knowledge about the options that are available for a response, and be empowered to take their own actions. Effective public engagement is therefore key to success in planning for climate change. The importance of public engagement in climate change adaptation policy is also a key issue to be considered by NCC.

Public awareness shall be undertaken through drafting of an approach methodology. A systematic quantitative and qualitative review of the methodology dealing with the core themes of awareness, knowledge, and engagement in policy-making shall be acknowledged.

13.3 Awareness for Behavioural Change

Everyone within NCC is connected with the growing problems of storm water drainage and grey water. There should be an endevour from NCC to show a strong link between public knowledge and engagement that can be used to encourage and motivate the public by using behavioural change. This behaviroural change can be a mandate and target for NCC from behavioural economics perspective as a policy instrument.

13.4 Communication Method

A variety of media and communication methods exist for public awareness and each has its own advantages and disadvantages. The use of a combination of several methods at the same time can reinforce the necessary messages.

The following are some user-friendly measures that could be effectively used in Community Awareness Programme for attaining complete transparency in operations

- Door to Door Contact
- Use of Cinema Halls
- Use of Print Media
- Use of TV / Cable TV / Radio / Web Site
- Street Plays, Puppet Shows, etc.

- Posters, Pamphlets
- Use of Hoardings
- Use of Public Transport System
- Involvement of Religious Leaders and Medical Practitioners
- Communication through School Children and College Students
- Primary School Curriculum to cover the basics of drainage and its issues.
- Voluntary Organizations/NGO involvement

Person to person contact carried out through community members, who are already convinced of the truth of the message, is usually the most effective means of communication.

13.5 Listing out Messages to be Communicated

The following items shall be included in the list of messages to be conveyed:

- Health impacts due to lack of services
- Problems due t water logging
- Change in policy and launching of new schemes
- Adoption of Citizen's Charter containing objectives, mission statement, facts about NCC
- Project details, its major schemes to be implemented, service standards, assistance to residents, etc.
- Messages related to quality assurance
- Rehabilitation and repair works of drains
- Functioning of information and facilitation counters, customer assistance, grievances handling and redress system, feedback from community, consumer service
- Need for greywater separation and treatment

13.6 Formation of Public Relation Unit and Redressal System

The following services may be offered under public relations information and facilitation:

- Registration and redressal of public complaints with feedback from complainant with the help of reply cards, and maintenance of suggestion books for residents to record their suggestions/ remarks on the work done by the public relations counter and sewerage services provider;
- Guidance to the residents for new connections and assistance for connections;
- Guidance to the residents for assessment of new charges, if any, name changes, etc;
- Guidance to the residents for meeting the concerned officer to make their representations and redressal of their grievances;
- Supply of pamphlet on procedure related to complaint registration and redressal;
- Obtaining feedback from residents related to redressal of their complaints/grievances,
- Supply of Citizen's Charter, if available, to residents to offer knowledge about the service standards of the organization and assurances for adherence to such service standards,
- Creation of single window system for redressal of grievances (optionl)
- A separate telephone line should be available round the clock to record complaints and address them,
- Define service failure and service recovery measures.

13.7 Awareness on Enforcement of Penalty

While all efforts should be made to educate the people to effectively participate in the management of drainage and grey water, they also need to be told that they can be punished if they fail to discharge their civic duties. The provision of penalties may be made known to the people and details of those punished should be publicized widely to deter others. The enforcement should begin at the public places, market places, etc., and gradually extended to cover residential areas.

14 PHASING AND PRIORITY INVESTMENT PROGRAMME

The phasing and priority investment program is set out below:

Phase	Components	Costs (in Million USD)[32]	
Phase 1 Immediate Phase (Yr. 2024-2027)	Rehabilitation of existing drainage system; Rehabilitation of existing canals; Supply of Equipment (Hugh Pressure Jetters, Trucks, etc)		
2024-2025	Phase 1A (under ADB's allocated budget)		27.1
2025-2027	Phase 1B (remaining after Phase 1A)		19.4
Phase 2 Medium Phase (Yr. 2024-2027)	Augmentation of drainage system; Pumping station; Landscaping, tree planting and canal side parks along canals; Wetland Integration; Construction and restoration of Water Bodies; Canals Connectivity; Introduction of Gates at outfalls;		30.1
	Greywater management- Interception & diversion, Pumping stations, Wastewater (Greywater) Treatment Plants		113.1
Phase 3 Long term (Yr. 2035- 2046)	Augmentation of drainage system; Increasing height of River Embankment; Transformation of Canals/Khals to Navigation Channel; Augmentation of Wastewater (Greywater) Treatment Plants		7.9
	Greywater management- Augmentation of Wastewater (Greywater) Treatment Plants		12.4
	TOTAL		**210.0**

Table 54 – Phasing and Priority Investments

14.1 Proposed Investments

14.1.1 Immediate Requirements (2024-2027)

	Under ADB's Intervention	NCC/ Govt./ Other sources	Total
• Desilting of Existing Blocked Drains	330 km	188 km	518 km
• Construction of New Roadside Drains	40 km	29 km	69 km
• Rehabilitation of Existing Inadequate Drains	26 km	12 km	38 km
• Lining of Khals and Greening/ Walkways	7 km	13 km	20 km
• Supply of Equipment (Hugh Pressure/Jetters/ Trucks	4 nos	-	4nos

[32] 1 USD is assumed to be equivalent to 108 BDT

14.1.2 Medium Term Requirements (2027-2036)

Although it is considered that the immediate investments outlined above will restore the drainage network to proper function and will endure for up to 25 years (because stormwater production will not be affected by population growth during this period, an allowance of $33,000,000 has been made for additional works that will be required as a result of increased strormwater generation due to climate change.

- Augmentation of drainage system by constructing new drains
- Installation of Floodgates
- Landscaping, tree planting and canal side parks along canals
- Construction and restoration of Water Bodies, Wetland Integration to drainage system, Canals Connectivity
- Pumping station
- Interception & diversion for Grey water management and Pumping stations– OPTIONAL to be decided after commencement of Sewerage Master Plan
- Wastewater (Greywater) Treatment Plant - OPTIONAL to be decided after commencement of Sewerage Master Plan

14.1.3 Long Term Investments (2036-2046)

- Raising height River Embankment
- Augmentation of drainage system by constructing new drains
- Pumping stations
- Transformation of Canals/Khals to Navigation Channel
- Augmentation of Wastewater (Greywater) Treatment Plant capacities - OPTIONAL to be decided after commencement of Sewerage Master Plan

To provide for expansion of the drainage network into the adjoining area once NCC boundaries are extended, a provision of $50,000,000 is included in the investment plan.

14.2 Summary of Phasewise Investment with Costs

14.2.1 Stormwater+ Grey Water Management

Term	Implemen - tation period	Components	Quantity (approx)		Cost (in Million BDT)	Cost (in Million USD)[33]	Remarks/Major components
Phase 1- Immediate term (Yr. 2024-2027)	2024-2025	Rehabilitation of existing drainage system (stage-1)	396	km	2,600	24.1	Cleaning of existing drain, Renovate of inadequate drain, New proposed drain

[33] 1 USD is assumed to be equivalent to 108 BDT

Term	Implemen - tation period	Components	Quantity (approx)		Cost (in Million BDT)	Cost (in Million USD)[33]	Remarks/Major components
	2024-2025	Rehabilitation of existing canals (stage-1)	8	km	300	2.8	
	2024	Rehabilitation of existing canals under DND	35	km		-	Already undertaken by other department (DND project)
	2024-2025	Supply of Equipment (Hugh Pressure Jetters, Trucks, etc)	4	nos.	25	0.2	
		Total Phase 1A			**2,925**	**27.1**	
	2025-2027	Rehabilitation of existing drainage system (stage-2)	229	km	1,600	14.8	Cleaning of existing drain, Renovate of inadequate drain, New proposed drain
	2025-2027	Rehabilitation of existing canals (stage-2)	12	km	500	4.6	
		Total Phase 1B			**2,100**	**19.4**	
Phase 2 Medium term (2027-2036)	2027-2035	Augmentation of drainage system (stage-3)	25	km	875	8.1	New proposed drain
	2027-2035	Landscaping, tree planting and canal side parks along canals	55	km	275	2.5	
	2027-2030	Wetland Integration	30	km	900	8.3	
	2027-2030	Construction and restoration of Water Bodies	100	Ha.	300	2.8	
	2030-2035	Canals Connectivity	15	km	600	5.6	
	2027-2030	Introduction of Gates at outfalls	44	nos.	66	0.6	

Term	Implemen - tation period	Components	Quantity (approx)		Cost (in Million BDT)	Cost (in Million USD)[33]	Remarks/Major components
	2027-2030	Pumping stations (combined PS)	1	nos	230	2.1	
	2027-2030	Greywater management- Interception & diversion	158	km	7,900	73.1	
	2030-2035	Pumping stations	6	nos	600	5.6	
	2030-2035	Wastewater (Greywater) Treatment Plant (3 nos.)	186	M LD	3,720	34.4	To serve Yr. 2036
		Total Phase 2			**15,466**	**143.2**	
Phase 3 - Long term (Yr. 2036-2046)	2035-2046	Augmentation of drainage system (stage-4)	15	km	525	4.9	New proposed drain
	2040-2046	Increasing height River Embankment	34	km	306	2.8	
	2036-2040	Transformation of Canals/Khals to Navigation Channel	1	LS	20	0.2	
	2036-2046	Augmentation of Wastewater (Greywater) Treatment Plant (3 nos.) by	67	M LD	1,340	12.4	To serve Yr. 2046
		Total Phase 3			**2,191.0**	**20.3**	
		TOTAL			**22,682**	**210.0**	

Table 56– Summary of Cost for Storm water + Grey water Management

A break down of cost detail for drains and canals is given in **Annexure VII**.

15 IDENTIFCATION OF CHALLENGES AND SITE CONSTRAINTS

15.1 Traffic and Congestion

The drains are proposed to be aligned along the side of the roads. It some areas majority of the local traffic, like rickshaw, cycle, cars take some specific routes to commute locally, as being comparatively wider within the surrounding area. Hence during construction period, it will have major effect on the local traffic mobility and congestion will enhance. A traffic diversion plan shall be in place before taking up the works at site. Construction shall be done in stretches and as such its laying time is expected to be more than usual.

15.2 Community Consultation

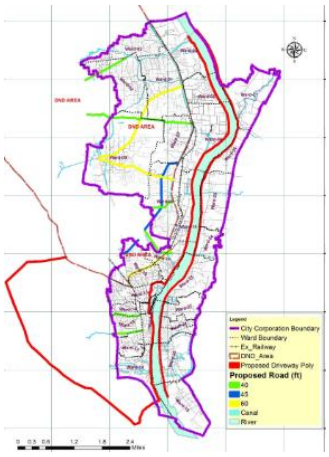
A thorough community consultation is essential. Many people is expected to get affected during drain construction/ laying works. A detail consultation and awareness program shall be conducted.

15.3 Keeping the existing drain active

The greatest challenge is to keep the existing drainage system alive during construction. It will be made defunct only after the proposed system of a catchment is complete in all respect.The construction phase shall be planned accordingly in phases and preferably catchment-wise. It is preferred not to take up two adjacent catchments at the same time.

15.4 Coordination with On-going BIWTA Works

Bangladesh Inland Water Transport Authority (BIWTA) has taken up the activity on retaining both side embankments of Sitalakshya river by constructing embankment roads. It ensures stability of slope by providing concrete block pitching.



Proposed Sitalakshaya Driveway[34]

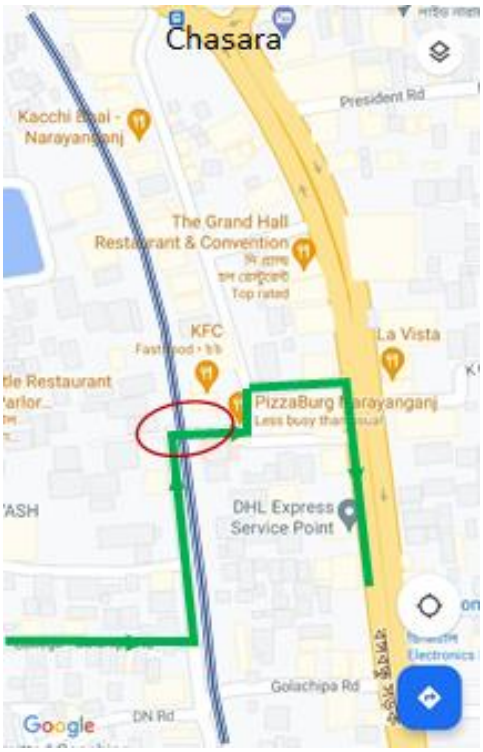
The Action Area Plan also indicates that there is a proposal of motorable roads all along the bank of the river, in the name of Silakshaya River Driveway, 40-62m width and a total length of 38km. This work is

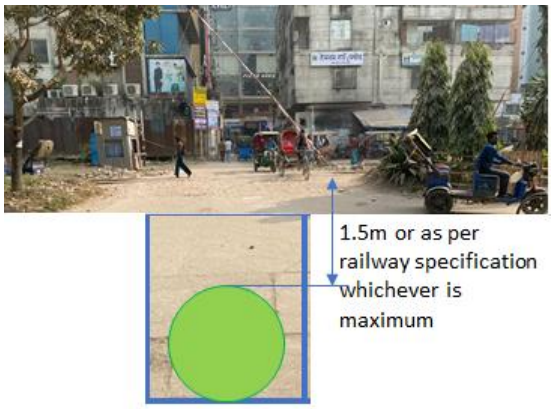
[34] Source – Action Area Plan for NCC 2016

likely to intervene the outfall construction of the drainage system. Close coordinate with the department will be necessary.

15.5 Railway Crossing

In Zone-1 within catchment 1256 there is a requirement of a new crossing through a culvert beneath the existing railway line. There is an existing culvert nearby the proposed location. Its existing invert depth and size does not support the proposed section. The size of the proposed drain at the crossing location is 1.8m. Permission from railway authority is required. However, for the costing purpose crossing the railway line is considered to be by jack pushing with an equivalent pipe size of 1800mm dia. Jack pushing will avoid open cut method for crossing railway line.





15.6 Government College Permission

In a catchment under Zone-1 (Catchment 1256) a few stretches are proposed for looping and diversion to optimize the system. The alignment of one specific stretch (length 35m) is along the entrance gate of a college (Narayanganj Government Women College). The proposed width of the drain is 900mm.

The alternate diversion route was also studied. It is along the land of railways, as shown in the photo. The space available will not be sufficient to allow for the work space. Hence aligning through college land is preferred. Permission from the respective authority is required.

15.7 Coordination with On-going DND Works

In Zone-2 DND is presently working on canal rehabilitation within and outside NCC areas. Canals are acting as the the outlets of the drains. It is expected that after canal rehabilitation works drainage works shall be taken up. Hence close coordination is very much required for successful implementation of this drainage project work.

Khal Rehabilitation by DND

15.8 Coordination with Roads & Highways Department

Within Zone-4 the RHD (Roads & Highways Department) has undertaken widening of Bandar-Madanpur highway road. Construction of culvert for canal crossing is under its scope. The department has already renovating and constructing culverts at canal crossings. This work will likely to influence the drainage design in fixing the invert levels of canals at the downstream side of the canals, i.e. the portion of the canals falling under NCC. Close coordinate with the department will be necessary.

15.9 Future expansion of NCC

In future the NCC area will be expanded, consequently the extended runoff volume will impact on the present existing area of NCC. As there is no defined plan for area expansion of NCC, so it was challenge to consider the impact in the present drainage network designing

15.10 Schedule of Other Projects

Some urban infrastructure projects have been taken up within NCC either by different authorities or by NCC itself. These projects will have direct and indirect impact of this drainage project schedule. The schedule of other projects, specially completion schedule, shall match with the activities under the proposal of this project.

- Canal rehabilitation project under DND area taken up by Army Department
- Bandar Highway widening by Road and Highways Department
- JICA funded project under NCC which includes a small portion of drainage rehabilitation.

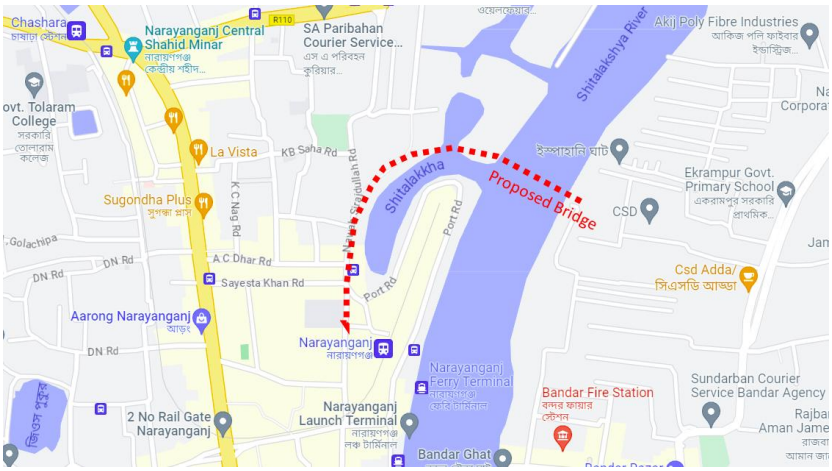
15.11 Laying Interception Sewer

River embankment road/path way is under construction. In some stretches there is no available land for contructing the embankment road. The department is making the walkway/pathway on the river as foot bridge to connect the challenging portions of the stretch. In this pocket laying of interception sewer will be a challenge. This can be overcome by rerouting the alignment of sewerline after detail investigation at the site.

15.12 Encroachment of river banks

Some of the industries at the bank of the river encroaches BITWA land. It will be a challenge in future during riverfront development and laying the drains/sewer lines along the river bank. From the photo as shown below it is evident that the industries has encroached the land of BITWA.

15.13 Proposed Bridge



There is a proposal for bridge across the Sitalakshya. It will have an indirect impact in design and implementation of the components as proposed in the drainage master plan. It will be a challenge if not addressed at the conceive stage of the projects. Adequate avenue shall be kept for future drainage system, mainly for interception sewer route.

Model of Bridge (Photo taken in NCC office)