BIRGANJ SUB-METROPOLITAN CITY
SECONDARY TOWNS INTEGRATED URBAN ENVIRONMENTAL IMPROVEMENT PROJECT (STIUEIP)
PROJECT IMPLEMENTATION UNIT (PIU)
BIRGANJ, PARSA, NEPAL

Ref.no. : 115/070/071

Date :

22 Sep, 201

To,
Mr.Mani Ram Gelal
Project Director
Project Coordination office
Babarmahal, Kathmandu

Sub: - ***Regarding Submission of Final Report on Sewerage and Drainage System Birgunj***

Dear sir,

PIU has received Final Report on Sewerage and Drainage System, Birgunj submitted by th consultants (SMEC and Associates) on dated 20 sept, 2013.While we are reviewing the report, copy of report has been sent to PCO for review and perusal.

Encl:

- Final Report- Sewerage and Drainage -Volume 1- 3 copies
- Final Hydrology Report -volume 1A- 3 copies
- Final Hydraulic Report -volume 1B - 3 copies
- Survey Report -volume 1C- 3copies
- Cost Estimates and BOQ- volume 1D - 3 copies
- Final Drawings- volume 1E:
    1. Appendix A – Sewerage
    2. Appendix B – Drainage part –I
    3. Appendix B – Drainage part –II

- Clarification notes on Draft Final Report on Drainage Works, Birgunj- 3 copies

Regards

Shailendra Shrestha
Project Manager

Project Manager

Ph. No. 0977-51-532186, 51-531900 Fax : 051-521220
E-mail:stiueip.birganj@gmail.com Website : www.birganj.gov.np

SMEC In Association with BRISBANE CITY ENTERPRISES BDA CEMAT

Ref. No. – STI – 143/070/071 Dates: 18 September, 2013.

TO,

Mr. Shailendra Shrestha.
The Project Manager, STIUEIP
Project Implementation Unit,
Birgunj Sub-Metropolitan City, Birgunj

Sub: **- Submission of Final Report on Sewerage and Drainage System.**

Dear Sir,

Please find enclosed herewith five copies of Final Report on proposed Sewerage and Drainage system for STIUEIP, Birgunj for your kind review and approval. This report has been updated and improved addressing all the comments made by PCO/PIU on our submitted Draft Final Report. The raised comments and our clarification notes have also been submitted together with this report. The Final Report has been prepared in separate volumes as follows:

1. Final Report; Sewerage and Drainage - Volume 1
2. Final Hydrology Report - Volume 1A
3. Final hydraulic Report - Volume 1B
4. Survey Report - Volume 1C
5. Cost Estimate and BoQ - Volume 1D
6. Final Drawings - Volume 1E
   - Appendix A - Sewerage
   - Appendix B - Drainage Part –I
   - Appendix B - Drainage Part -II

We will highly appreciate your kind cooperation in this regard.

Sincerely yours,

Nagendra Jha

Team Leader, DSC
STIUEIP,Birgunj
SMEC in association with
BCE/BDA/CEMAT

Birgunj Sub-Metropolitan City
STIUEIP
Birgunj
Reg. No. 138/070/071
Date: 2070/6/4

in association with

Brisbane City Enterprise Pty Ltd – Australia
Building Design Authority – Nepal
CEMAT Consultants – Nepal

Final Report: Sewerage and Drainage
Volume 1
Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP), Birgunj, Nepal

Birgunj Sub Metropolitan City, Nepal

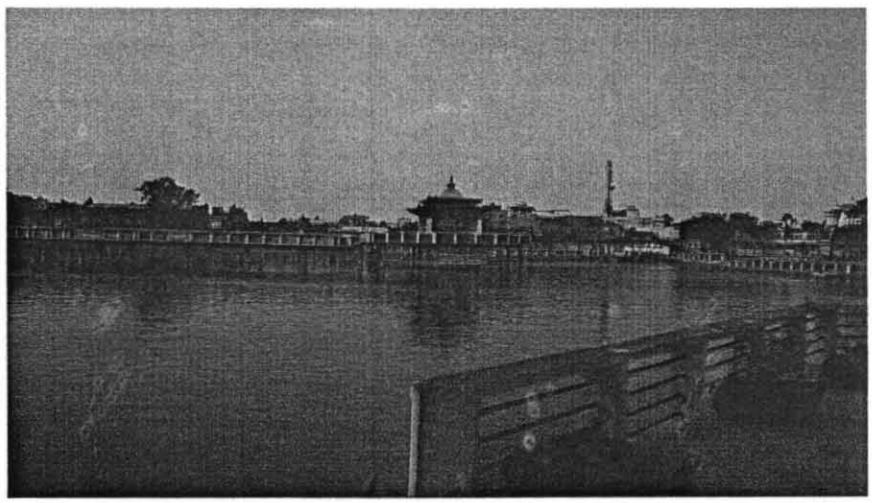
August, 2013

AUSTRALIA | ASIA | MIDDLE EAST | AFRICA | PACIFIC

in association with

Brisbane City Enterprise Pty Ltd – Australia
Building Design Authority – Nepal
CEMAT Consultants – Nepal

Final Report: Sewerage and Drainage
Volume 1
Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP), Birgunj, Nepal



Birgunj Sub Metropolitan City, Nepal

August, 2013

AUSTRALIA | ASIA | MIDDLE EAST | AFRICA | PACIFIC

Project Name:	Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP), Birgunj, Nepal
Project Number:	5064024
Report for:	Birgunj Sub metropolitan City, Birgunj, Nepal

PREPARATION, REVIEW AND AUTHORISATION

Revision #	Date	Prepared by	Reviewed by	Approved for Issue by
1	August, 2013	Nagendra Jha, Yves Andre Raoul MAYEUX and others	Pramod Kumar Mafuzur R Khan	Mohiuddin Mahmud

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Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP), Birgunj, Nepal

For: Birgunj Sub metropolitan City, Birgunj, Nepal

AUGUST, 2013

Volumes of Final Report

Volume 1 – Final Report: Sewerage and Drainage

Executive Summary

1. Project Background
2. Objectives of this report
3. Project Site Profile
4. Sewerage
5. Drainage
6. Surface Reinstatement
7. O&M of the sewers system
8. Construction Schedule
9. Tender Documents - Budget

Volume 1A- Hydrology Report

Appendix to Volume 1A

- A- Rainfall Birgunj
- B- Final Discharge at each sub station

Volume 1B-Hydraulic Report (Sewerage and Drainage)

Appendices to Volume 1B

- A- Existing Drainage networks
- B- Inventory of lines – nodes and sections
- C- Softwel calculations (Drainage)
  - *C1-Rectangular Drain*
  - *C2-Pipe Drain*
- D- Structural Calculation
- E- Flow generation by Ward
- F- Flow generation to node
- G- Calculations results – SWMM (Sewerage)
- H- Softwel calculations (Sewerage)

Volume 1C – Survey Report

Annex to Volume 1C

Volume 1D - Cost Estimated and BOQ

Appendices to Volume 1D

- A- Analysis of Rates
  - *A1: Parsa District Rate*
  - *A2: Rates analysis for external materials*
  - *A3: Rate Analysis (Break down)*
  - *A4: Unit Price*
- B- Quantity estimate of Sewerage

- *B1-Assumptions*
- *B2-Main collectors*
- *B3-Branches to main collectors*
- *B4-Summary of costs*

- C- Quantity estimate of Drainage
  - *C1-Surface Drains*
    - *C1A-Assumptions*
    - *C1B-Calculations*
  - *C2-Pipe Drains*
    - *C2A-Assumptions*
    - *C2B-Calculations*
  - *C3-Natural Drains*
    - *C3A-Assumptions*
    - *C3B-Calculations*

- D- Cost estimate of Drainage
  - *D1-Surface Drains*
  - *D2-Pipe Drains*
  - *D3-Natural Drains*
  - *D4-Outfall*
  - *D5-Overflow chamber*
  - *D6-Recreational Park*
- E- Engineer's Estimate for Tender Document

Volume 1E – Drawings Sewerage and Drainage

Appendices to Volume 1E

- A-Sewerage
- B-Drainage
  - *Part I*
  - *Part II*

Volume 2 – Final Report – Waste Water Treatment Plant

Appendices to Volume 2

- A- Cost Estimate
- B- Drawings

Volume 3 – Final Report - Road and Lanes

Appendices to Volume 3

- A- Cost Estimate
- B- Drawings

ACRONYMS

3R	Reduce, Reuse and Recycle
ADB	Asian Development Bank
APs	Affected Persons
BoQ	Bill of Quantities
CBS	Central Bureau of Statistics
CDP	Community Development Plan
CDTA	Capacity Development Technical Assistance
DDC	District Development Committee
DSC	Design and Supervision Consultant
DUDBC	Department of Urban Development and Building Construction
EIA	Environmental Impact Assessment
GESI	Gender Equality and Social Inclusion
GIS	Geographic Information System
GoN	Government of Nepal
IEE	Initial Environmental Examination
MIS	Management Information System
MPPW	Ministry of Physical Planning and Works
MoE	Ministry of Environment
NGO	Non-Governmental Organization
NLSS	Nepal Living Standards Survey
O&M	Operation and Maintenance
PCO	Project Coordination Office
PIU	Project Implementation Unit
pph	people per hectare
PPTA	Project Preparatory Technical Assistance
QA&QC	Quality Assurance and Quality Control
STIUEIP	Secondary Towns Integrated Urban Environmental Improvement Project
SWM	Solid Waste Management
TDF	Town Development Fund
ToR	Terms of Reference
UEIP	Urban Environmental Improvement Project
UNDP	United Nations Development Programme
VDC	Village Development Committee
WWSP	Waste Water Stabilization Ponds

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

An Agreement dated 26th October 2010 was entered into between the Secondary Towns Integrated Urban Environmental Improvement Project (STIEIP), Project Implementation Unit, Birgunj Sub metropolitan City, Birgunj Nepal (the Borrower) and the Asian Development Bank (ADB) to provide funding for the provision of consulting services and implementation of urban infrastructure, as well community and institutional development and related activities.

A contract was entered into on 16th January 2012 between the Borrower and SMEC International Pty Ltd., Australia (the DSC Consultant) for the provision of consultancy services. The agreed start date is 17th February 2012.

Contractual deliverables

Under the contract as scheduled in Appendix B to the contract, Reporting Requirements, The contractual deliverables of the project to be submitted by the DSC are:

- Inception report
- Design Criteria Report
- Catchment Concept Plans
- Interim Report
- Draft Final and Final Design Reports (including tender documents)

Present report

The present report is the last stage of the contractual deliverables and the main objective of this report is to present the Final Detailed Engineering Design of the proposed Sewerage and Drainage collection scheme for the city of Birgunj.

Birgunj highlights

Birgunj Sub-Metropolitan City is situated in the Narayani zone and the district of Parsa in the central development region of Nepal. It is one of the business economic and industrial zone of central region, covering an area of 23.37 km^2. The city lies at 27°02'30" to 26°57'45" North and 84°55'00" to 84°52' 15" East.

The eastern part of this city is bordered by another district – Bara whereas the southern and south western part by Bihar State of India. Birgunj is one of the major gateway towns to India.

There is no separate sewerage system in Birgunj but most of major existing storm drains are carrying wastewater and sludge from the core area of city and hence there is no centralized or decentralized sewage treatment facility in the City. Today House hold septic tank effluent is directly discharged to open surface drains made for storm water flow.

In general with the lack of sewerage network and/or septic tanks, there is a high risk of the foul water is introduced into the drainage sewer by inhabitants and contaminated water send through the rivers [dry pond may be planned] increasing the risk of health hazard.

Accordingly without appropriate measures and actions, the new drainage will certainly become a stinky/unhygienic drain with all related risks including malfunctioning due to uncontrolled discharge and stagnation of foul water in a scheme which has not been designed for this purpose.(low gradient)

Design - General Considerations

The method of approach for the design follows the methodology utilised in the other projects by the Consultant. The design methodology follows internationally accepted procedures [such as those embodied in *BS EN 752: Drain and sewer systems outside buildings]* with parameters adapted to suit the demographic and hydro-climatic features of Nepal. Design criteria were discussed and approved by the Client after the submission of the Design Criteria Report followed by the Concept Report in early august 2012. These will be used and accommodated during the preparation of the interim, draft and final design process.

Sewerage:

As per PPTA study, the design of the sewerage system will serve the core area only. But it will not serve the basic objective to remove the wastewater from the major area of city, but only the western part of the city in the designated Core Area.

As per Concept Master Plan prepared by DSC and topographical survey, there is two major sewerage catchments divided by the TRP Highway, one is whole western part of whole Birgunj city under Sirsiya catchment and other one is eastern part of whole Birgunj city under Singha River catchment. Major core area falls under western part (Sirsiya) catchment.

The Consultant has prepared the planned scheme for sanitary sewerage system. It mainly consist of network of main trunk sewer with main, branch and lateral sewers and serves the area west of TRP highway and half of the area in east/south from TRP highway.

In 2035 the total flow to be generation toward the Chhapkaiya STP is 9.87MLD for a total population of 140.219 in the area served.

The EPA SWMM (Version 5.5.1) software package was used to build the sewerage network model of the Birgunj sewerage system. SWMM is a hydraulic modeling and data handling software package. The use of the software "EPA SWMM" for hydraulic modeling is good, but the DSC has also carried out the calculations using SoftWel Software [main collectors and branches] in order to cross check the output of SWMM and to prepare the files for the generation of long sections. The cross check of output has been made in the following calculations results: pipe size, gradient, velocity, water depth etc.

The Consultant has carried out the final design of the collection system of the areas covered in the core area using the mathematical model described previously, the total length of the gravity collection network in the present scheme has been determined to be around **15,3 km** as per following table.

Collector	Unit	7,019 m	Branches	Unit	8,197 m	15,216m
SW1	m	4,857	Branches SW1	m	7,528	12,385
SW3	m	2,162	Branches SW3	m	669	2,831

Summary of length of collection system per material and depth is summarizing hereafter:

Sewerage Collectors Length v/s depth (in m)							
Depth in m	**0 - 2**	**2 to 3**	**3 to 4**	**4 to 5**	**5 to 6**	**above 6**	**Total**
200				0.00	0.00	0.00	0.00
200 PE	5,078.98	3,217.03	150.90				8,446.91
250	0.00		0.00	0.00	0.00	0.00	0.00
250PE		310.47					310.47
300	0.00	0.00	221.02	188.90	0.00	0.00	409.92
350	0.00	0.00	0.00	0.00	0.00	0.00	0.00
400	0.00	339.20	550.77	682.57	200.82	0.00	1,773.35
450	0.00	0.00	828.54	930.51	0.00	0.00	1,759.05
500	0.00	0.00	0.00	509.74	332.00	0.00	841.74
600	0.00	0.00	0.00	0.00	850.59	0.00	850.59
700	0.00	0.00	0.00	0.00	0.00	0.00	0.00
800	0.00	0.00	275.32	548.81	0.00	0.00	824.13
	5,078.98	**3,866.70**	**2,026.55**	**2,860.53**	**1,383.41**	**0.00**	**15,216.16**

For a planned length of the scheme of 15.2 km, the potential population to be connected is approximately 33.000 inhabitants with approximately 6,500 connections. The average flow at the inlet pumping station of the STP will be 4.41MLD or 51l/s.

The detailed arrangements of the drains and components of the scheme are presented in Volume 1E Drawings

The total cost estimates for the sewerage scheme as designed at Final Design stage is given in the following table for the main collectors and associated branches of the sewerage scheme.

Summary of costs - Sewerage Scheme				NRs	Cost/m
Collectors, branches and laterals		unit	Qty	Total Cost	Avg
SW1	All works	m	4,857	152,466,110	31,394
SW3	All works	m	2,162	86,131,544	39,833
Branches of SW1	All works	m	7,528	115,649,837	15,363
Branches of SW3	All works	m	669	10,970,939	16,393
	Total		**15,216**	**365,218,431**	24,002

The total cost of the sewerage system as proposed by the DSC at Final Design stage has been estimated to the total amount of **NRs 365,218,431.00**

Drainage

Birgunj municipality has only storm drainage system. The total length of the drain was found to be about 71.3 km. The length of Brick Masonry (BM) drains, RCC drains and main drain MD1 were found to be 56.5 km, 9.9 km and 4.9 km respectively.

In Birgunj, there is an acute lack of appropriate drainage system. The existing drainage system in several locations in place does not function well as these have. Natural surface drainage patterns in Birgunj have altered due to differential filling of allotments and roads as well as the conversion of natural wetlands into urban settlements and associated back fillings.

The existing drains to be reconditioned are in general in road where the new drainage shall not be constructed, the lines to be abandoned refer to some drains in parallel of new drains which therefore become unnecessary. The replaced drains are drains on the route of the new drains.

The selected option and proposed system includes a complete new separate sewerage and drainage system using partially the existing drain where appropriate. This option was also presented in the Concept Plan report prepared by the DSC and dated august 2012.

In order to fulfill the allocated budget, some priorities have been discussed and particularly for Drainage main collectors and branches line will be developed in priority areas where severe flooding occurs. The densification of the tertiary network shall be constructed during the next phase of the project.

In general due to the slight slope and relatively important flow to collect/discharge, drains are from three (3) types, **surface rectangular in the town and covered with precast concrete slabs**, **pipe circular drains** for the drainage of new road to be constructed, **existing natural drains** of trapezoidal or rectangular sections. Rectangular shallow depth drains are to be constructed in brickwork. Deeper drains are designed individually in reinforced concrete (RCC) such as rectangular or pipe drains. The detailed arrangements of the drains and components of the scheme are presented in Volume 1E Drawings

The level of protection for flooding is define by the performance criteria for design flooding frequencies **[2 years return on rain]** or design storm events used in calculation including the site conditions [gradient, levels,...]. The surface water drains and sewers are dimensioned in order to limit flooding based on the design's assumption. **It is usually impracticable to avoid flooding** from very severe storms.

The runoff generated within the different catchments of Birgunj is drained to two rivers – Sirsiya in the west and Singha in the east. The prevailing features of the catchments and corresponding outfall are identifies and the area has been divided in **11 catchments**.

The discharge calculations for each catchment is presented in separate Volume 1A hydrology calculations of the report and the hydraulics computation of all the drains are presented in Volume 1B Hydraulics Calculations from SOFTWEL Data/Results.

The Summary of length of the drainage scheme for each catchment and per component is summarizing hereafter in the table below:

All Catchments **Final Design**

Catchment	Drain	Pipe	Nat.drain	Total	Comment	Design	
Name	Rect.	Circular	Trapez.	Drains	Main drain	Interim	Draft
1	0	-		0	Postponed	798	0
2	0	-		0	Postponed	5,554	0
3	6,086	-		6,086	Including Diversion 4	13,608	13,124
4	2,670	-		2,670		2,728	2,670

4A	3,847	-	1,120	4,968	Natural drain Shreepur	5,510	4,968
5	2,087			2,087	Overflow MD1	3,135	3,305
6	5,127	2,267		7,394	Including Diversion 12	12,453	11,381
7	0	1,682		1,682	Including Diversion 13A	3,190	1,682
8	4,938	1,248	357	6,543	Including Diversion 13 and natural drain	9,296	9,013
9	11,548	0	4,919	16,467	Natural drain MD1	24,156	16,467
10	5,567			5,567	-	9,985	5,567
Total	**41,869**	**5,196**	**6,395**	**53,461**		**90,413**	**68,176**

The total cost estimates for the Drainage scheme as designed at Final Design stage is given in the following table for the main components of the scheme

Summary Drainage scheme – All Catchments – 3 to 10 **NRs '000**

Schedule	Drain type	unit	Qty	Total	Cost / m
1	Surface drains	m	41,869	1,282,253.93	30.6 NRs/m
2	Piping drains	m	5,196	133,007.27	25.6 NRs/m
3	Natural Drains	m	6,395	178,879.61	28.0 NRs/m
4	Outfall	No	6	6,599.48	1099.9 NRs/No
5	Diversion Chamber	No	1	3,714.75	-
6	Recreational Park	LS	1	13,494.41	-
		Total	**53,461**	**1,617,949.45**	

The total cost of the Drainage system as proposed by the DSC at Final Design stage has been estimated to the total amount of **NRs 1,617,949 450.00**

Operation and Maintenance (O&M)

After the construction works one year of O&M of the installation (STP and Sewers) shall be carried out by the Contractor. Equipments and staff shall be required for this activity. The cost estimate has been evaluated to NRs 14,980,000.00 for O&M Equipments and Machineries, and NRS 15,000,000,000.00 for the O&M for one year.

Tentative Schedule

With a final completion by end of 2016 and one year of Defect Liability Period (DLP) the provisional acceptance of all works has be made by end of 2015 given little bit more than two years says 26 months in total for the implementation of all projects activities.

Project cost –Sewerage and Drainage *(the Bill no refers to the Tender doc's BOQ)*

Bill	Designation	Amount (NRs.)
2B	Sewerage – Civil works	365,218,431.00
2C	Drainage – Civil works	1,617,949,434.19
5	O&M Equipment and Machineries	14,980,000.00
7	O&M for one year STP & Sewer	15,000,000.00

Source: BOQ Section 4B of the Tender Document

Salient features of the project

The Salient features are given to describe the details of Sewage and drainage scheme including some general features of Birgunj are presented on the table given below

S.N.	Designation	Features
1	Total Ward	19 wards , smallest ward of 5.61 ha (Ward No. 8) to 507.79 ha (Ward No. 19)
2	Area (ha)	2,37 ha, north-south length of 8 km and east-west width of 4 km
3	Altitude	From 78m in the south near the border area to 87m in the north.
4	Population survey	In 2011 population 135, 924
5	Households	In 2011 24,164 No
6	Annual growth rate	2.06 %.
7	Population Design Year	"20 years period - 2035

8	Existing storm drains Km	The length of Brick Masonry (BM) drains, RCC drains and main drain MD1 are 56.5 km, 9.9 km and 4.9 km respectively
9	Existing Sewerage line km	NA
10	Existing Roads Km	115 km of black toped road, 83 km graveled and 82 km earthen roads and a number of trails

Proposed New Sewerage

S.N.	Designation	Features
	Total Flow Generation 2035	Average flow 114 l/s or 9.87 MLD
	Potential connection	12140 No
	Main collectors, branches and lateral	RCC pipes 300 – 800 mm length 15,216m
	Manholes RCC and Bricks	447
	Sewers inlet	614 No
	House connection (HC) planned	6.088 No
	Service pipe and H.C planned	uPVC 26,379m

Proposed new Storm Drain

S.N.	Designation	Features
	Drains type	Surface covered drains, pipe drains and
	Drains material/size	Masonry and RCC from 0.40 m to 2.5 m
	Catchments	11 catchment No : 1, 2, 3, 4A, 4 5, 6, 7, 8, 9,
	Main and branches lines	Masonry 29.810m and RCC drains 12,058
	Natural drains lines	Trapezoidal or rectangular drains
	Pipe drains	RCC 700/900/1200/1400 length 5,196m
	Manhole for pipe drains	83 No
	Inlet chamber	For drains 1,400 No, for pipe drains 170 No

1 PROJECT BACKGROUND

The Department of Urban Development and Building Construction (DUDBC), under the Ministry of Physical Planning and Works (MPPW), through the Government of Nepal, has received Loan 2650-NEP: Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP, or the Project), from the Asian Development Bank (ADB). MPPW is the executing agency for the Project, working through DUDBC, and Biratnagar, Butwal and Birgunj and Kavre municipalities are the implementing agencies (IAs).

For the Birgunj Project urban environmental improvements will be implemented on an integrated basis to include sewerage and drainage, solid waste management and urban roads and lanes. Along with and in support of the infrastructure components, equally important to be implemented are the following:

- Community development programs such as awareness-raising on health and hygiene;
- 3R (reduce, reuse, and recycle);
- Investment in small-scale community facilities in the municipalities; and
- Capacity strengthening of the municipalities and central government in the field of project management and operation.

The project will be implemented over a five year period.

2 OBJECTIVES OF THIS REPORT

2.1 PROJECT OBJECTIVE

The expected outputs of the project in Birgunj are as follows:

- Improved drainage and sewerage systems.
- Improved urban roads and lanes.
- Improved solid waste management.
- Community development program undertaken, including health and hygiene education, 3R (reduce, reuse and recycle) of solid waste, promotion, skills training and investment in small scale community facilities.
- Capacity developments of Birgunj Sub-Metropolitan Office by strengthen its Financial, Technical and Institutional capacity.

With reference to the MS Project Gantt Chart in the Inception Report submitted on 16 April 2012, the deliverables for the above infrastructure improvements are listed as follows:

- Design Criteria Report
- Catchment Concept Plans
- Interim Report
- Draft Final and Final Design Reports (including tender documents with Draft Final Report)

After the submission of the Design criteria, the Concept Plan for Drainage and the Sewerage Schemes was submitted on July 31, 2012, presented on August 15, 2012 to the STIUEIP Birgunj decision-makers and generally approved and accepted from the exchange of comments between the PIU/PCO and DSC Consultants on October 10, and December 02, 2012. The Draft Report for Drainage and Sewerage was submitted in early April 2013 and presented to PIU/PCO.

The draft final reports for Sewerage and Drainage have been submitted on separate volume on 4 June, 2013 and May 23 June, 2013 respectively.

Objectives of this report

The main objective of this report is to present the Final Detailed Engineering Design of the proposed Sewerage and Drainage collection scheme for the city of Birgunj.

The Final Report is submitted in separate volumes per project component such as Sewerage Treatment Plant (STP), Sewerage and Drainage and Road. Under the DSC consulting services

contract, the objective of this Final Design Report is to prepare and submit the Final Engineering Design of the proposed scheme incorporating the result of discussion, comments and suggestions received from PIU office Birjung, PCO Office, Kathmandu. In parallel the Tender Documents have prepared and submitted to the Project in early July.

The Final Design report has been prepared in separate volumes as follows:

- Volume 1 - Sewerage and Drainage - Main Report
    - Appendices and Drawings in separates Volume 1A to 1E
- Volume 2 - Sewerage Treatment Plant (STP) – Main report and Appendices
    - Appendices and Drawings in attachment to the Volume
- Volume 3 – Road and Lanes – Report
    - Appendices and Drawings in attachment to the Volume

The specific objectives of these reports are the following:

- Define the various components of the gravity sewerage collection system and conveyance to the STP located in the southern part in Chhapakaiya area.
- Define the size of the components following the defined standard design criteria.
- Define the structural component of the system in relation to site and/or soil conditions
- Design all required accessories and structures for the collection network
- Prepare the details design drawings
- Prepare the cost estimates of the system based on quantities and rate analysis and available budget.
- Present a tentative schedule for the construction of the proposed scheme

In order to fulfill the allocated budget, some priorities have been discussed and particularly for Sewerage main collectors and branches will be developed as this stage. Lateral sewers shall mainly be constructed during the first phase in the commercial area of Aadarsh Nagar. The densification of the lateral in the core area shall be constructed during the next phase of the project.

For the Drainage Scheme, the main collectors and branches lines in critical flooded areas have been maintained as priority in most of the Catchments but some tertiary lines have been postponed and shall be constructed during the second phase of the Project.

3 PROJECT SITE PROFILE

3.1 LOCATION, AREA AND POPULATION

Birgunj Sub-Metropolitan City is situated in the Narayani zone and the district of Parsa in the central development region of Nepal. It is one of the business economic and industrial zone of central region, covering an area of 23.37 km2. The city lies at 27°02'30" to 26°57'45" North and 84°55'00" to 84°52' 15" East. The eastern part of the city is bordered by another district called Bara whereas the southern and south western part by Bihar State of India.

The Pathlaiya to Birgunj corridor is one of the most important manufacturing centres in Nepal constituting many industries including among others steel, plywood, rice mills, sugar mill, agricultural equipment, tanning etc. Birgunj is one of the major gateway towns to India and more than 50% of total foreign trade is carried out via this town. In the future this will have a bearing on the change in municipal solid waste generation rates as well as the municipal waste characteristics of Birgunj as it starts to progress to being possibly a light industrial centre with a progressive population's potential to earn excess disposable income.

Political Division and Boundaries

Birgunj Sub-metropolitan City is the leading business centre of the central Tarai region of Nepal. By virtue of its proximity to the Indo-Nepal border, it functions as an outlet for Nepalese exports and an inlet for imports. The town can be termed as a primary gateway town as it has developed in site of considerable transport significance as the break-of-bulk point in the Tarai region along the Indo-Nepal boarder. The city borders India, Sirsiya dry port and Bishrampur VDC in the south, the Sirsiya River, Ramgadh VDC in the west, Parwanipur and Bahundangi VDC in the north, Parsauni, Itahari VDC and the Singha River in the east.

According to the latest Nepal Central Business Statistics census, the population of Birgunj Sub-metropolitan City in 2011 was 135,924 with annual growth rate of 2.06 %.

Birgunj sub-metropolitan city has a total area of 2,337 ha, divided into 19 wards with their areas in a range from the smallest ward of 5.61 ha (Ward No. 8) to 507.79 ha (Ward No. 19). Ward locations are shown in Figure 1. The city has an elongated shape with a maximum north-south length of 8 km and east-west width of 4 km. The altitude ranges from about 78m in the south near the border area to 87m in the north.

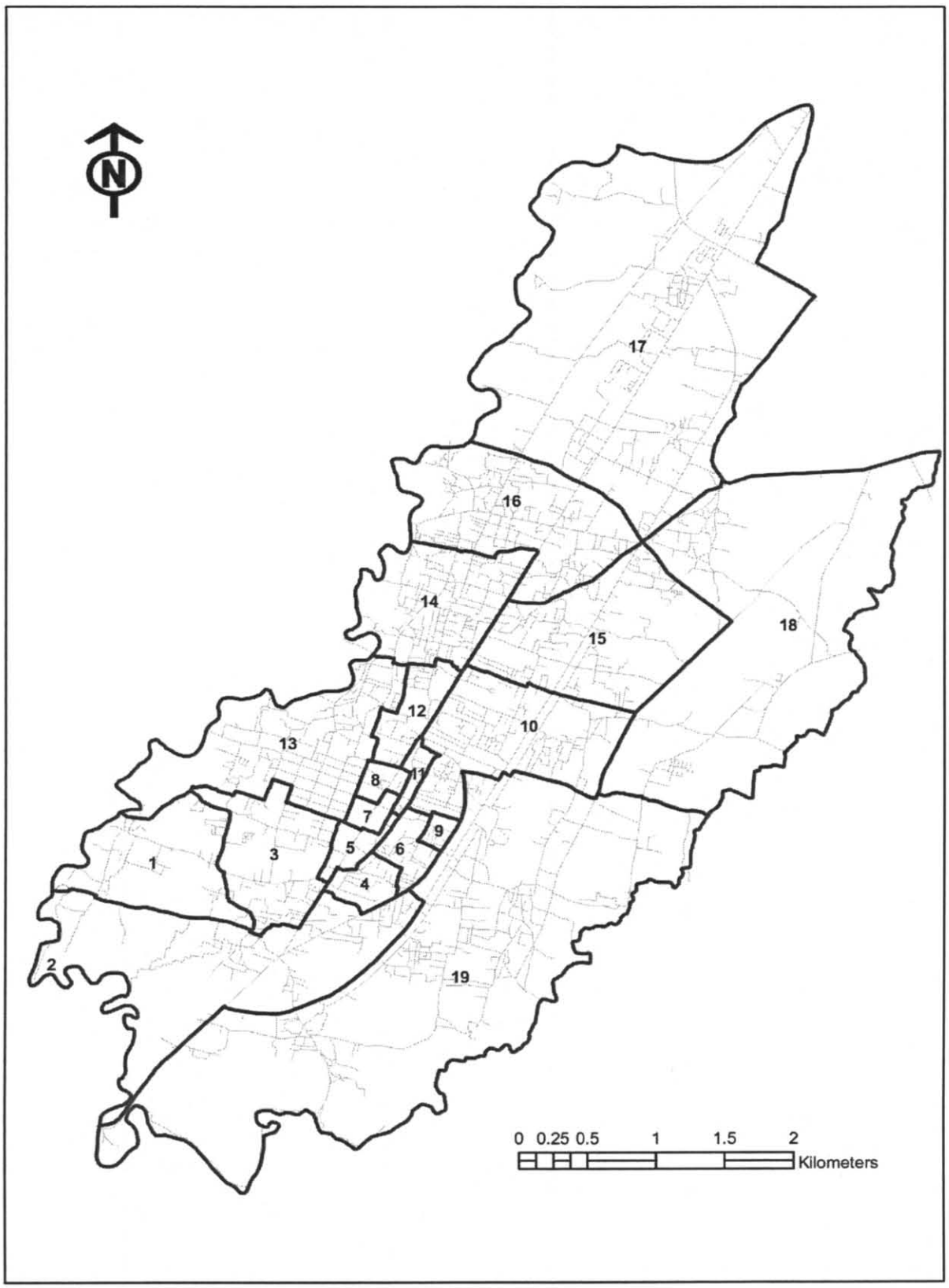


Figure 3- 1: Ward Locations in Birgunj

On August 24, 2012, a meeting among the ward leaders, ward secretaries and NGO representatives and the DSC team was held to resolve the poverty clusters and social mapping of the project. During the meeting the ward boundaries were discussed and verified. It was found that the ward boundaries needed updating as well as the corresponding populations and household densities. The new boundaries are reflected in Figure3-1.

The composition and organization of the wards will be very important in designing the municipal sewerage and drainage system for Birgunj. The improvement of the 3Rs (reduce, recycle and re-use) will only be realized if the population is ready for the required change in behaviour in segregating waste right from the source even before it even enters the municipal solid waste stream. The ward leaders and even the tole organizations will be the instrumental in implementing waste reduction at the source by practicing waste minimization methods starting from the household level, and making sure that the ward and tole leaders lend a pro-active stance towards their constituents in minimizing waste generation at the source.

Cultural and Socio-economic Aspects

Birgunj sub-metropolitan city is an old city, inhabited by the Muslim, Tharu, Kurmi, Yadav, Kanu, and Teli.

There are more than 70 caste/ethnic groups. Among them 20 caste /ethnic groups have population size more than 1% in the total population. Those are Muslim (17.4%), Kanu (7.3%), Hill Brahamin (7.3%), Kurmi (5.9%), Newar (5.6%), Kalwar (4.5%), Marwadi (4.4%), Sonar (4.1%), Chhetry (3.9%), Baniya (3.3%), Kayastha (3.3%), Yadav (2.7%), Tarai Brahamin (2.7%), Teli (2.4%), Tharu (1.8%), Koiri (1.7%), Rajput (1.4%), Badhai (1.4%), Dhanuk (1.3%) and Nuniya (1.2%).

About 52% of the population above 10 years of age is economically active. Majority of the economically active population is engaged in agriculture followed by trade, service and labour. Total literacy rate is 69.5%, comprising of 79.21% among male and 57.72% among female. The town is experiencing a high level of in-migration. This has resulted into the emergence of squatter settlements in several areas of the town.

The town is experiencing a high level of in-migration. This has resulted into the emergence of squatter settlement in several areas of the town.

Photo 1: Gahawa Mai Temple, Maisthan Chowk, Birgunj City

Photo 2: Ghadiharwa Pond, Birgunj City

Population

According to the Central Bureau of Statistics Census and of Birgunj Sub-Metropolitan City town profile, the population of Birgunj from 1991 to 2011 were as follows:

Table 3- 1: Population of Birgunj Sub-metropolitan City

Census Year	Population	Households
1971	12,999	
1981	43,642	
1991	68,764	
2001	112,484	19.910
2011	135,904	24,164

Source: National Population Census (Central Bureau of Statistics) 2048 and BSMC town profile

The Population in Birgunj by ward are presented in Table 3-2

Table 3- 2: Classification of Population on the Basis of Household

Ward No.	Area (ha)	Household No.		Population	
		Year 2001	***Year 2011***	***Year 2001***	***Year 2011***
1	146.46	985	1,323	6341	8005

Ward No.	Area (ha)	Household No.		Population	
2	149.30	1008	1,605	6694	9012
3	57.15	983	1,706	5510	7083
4	18.92	497	353	2537	2297
5	9.48	370	313	1940	1807
6	15.63	1064	694	5453	3685
7	9.92	360	272	2367	1648
8	5.61	257	203	1721	1115
9	13.43	810	923	4486	4597
10	42.91	1175	1,539	6163	6535
11	6.63	375	347	1913	1656
12	26.41	685	806	3357	3302
13	109.26	2393	3,225	13030	14720
14	95.60	2031	2,653	10647	12372
15	56.77	1440	1,736	7732	8493
16	129.22	1362	4,098	6833	10903
17	454.33	1162	1,366	7684	8550
18	482.20	1004	1,593	5832	9540
19	507.79	1939	6,207	12278	20584
Total	**2337.02**	**19,910**	**24,164**	**112484**	**135,904**

Source: National Population Census (Central Bureau of Statistics) 2011.

The Population Projection has been carried out by Consultant and is approved by Department. The Approved projected population is given in Annexure-1.

The Urban population density is in Table 3-3.

Table 3- 3: Urban Population Density of Birgunj, 2011

Density	Less 100 pph	100-200 pph	200-400 pph
Ward No.	1,2,16,17,18,19	3,4,5,7,8,10,12,13,14,15	6,9,11

Population Growth

The current population growth rate for year 2001-2011 is estimated to be 1.91% in Birgunj. This rate is lesser than average growth rate (5.04%) for year 1991-2001 and the average urban population growth rate of 3.4 % of the in Nepal.

3.2 CLIMATE

Volume 7 – Major Environmental Issues of the ADB PPTA Report mentions the following trends in temperature and climate in Nepal with specific reference to Birgunj on climate Trends.

Temperature

The climatic condition is sub-tropical monsoon with very hot and wet summer. The mean annual temperature ranges from 23.8^{0}C to 24.5^{0}C. The maximum extreme daily temperature recorded is 41.6^{0}C in May and minimum is 4.5^{0}C in January. The annual rainfall ranges from about 1300 mm to 2800 mm with an average of 1800 mm. More than 82 % precipitation occurs in 4 summer months (June to September). Average sunshine duration ranges from 7.26 -7.50 hr/d and average wind speed ranges from 1.95-2.31 km/hr.

Temperature Trends in Nepal

The history of meteorological observation in Nepal has not been historically significant. But an analysis of about 30 years of observed temperature in Nepal has shown that maximum temperatures in Nepal are increasing at an alarming rate. An analysis of 49 stations in Nepal found that the warming was consistent and continuous after the mid-1970's. The average warming in annual temperature between 1977 and 2000 was 0.06^{0}C yr-1.

The warming was more pronounced in the higher altitude regions of Nepal such as middle-mountain and the Himalayas, while the warming is significantly lower or even lacking in the Tarai and Siwalik regions. Further, warming in the winter is more pronounced compared to other seasons. Analysis of daily temperature data for 36 year from 1971 to 2006 using RClimDex

software also shows that days and nights both are becoming warmer and cool days and cool nights are becoming less frequent.[1]

The projections of temperature by the Organization for Economic Co-operation and Development (OECD) show a significant and consistent increase in temperature in Nepal for the years 2030, 2050 and 2100 across the various models.

This analysis also shows more warming increases in the winter months than the summer months. The projected change above the baseline average is 1.2° C for 2030, 1.7°C for 2050 and 3.0°C for 2100.

Precipitation trends in Nepal

Analysis of precipitation data from station records all over Nepal does not reveal any significant trends. However, an analysis of daily precipitation data for 46 years from 1961-2006 shows an increasing trend in precipitation extremes. About 73 per cent of the stations (out of 26 total stations selected for the study) exhibited an increase in the annual count of days when precipitation is greater or equal to 50 mm[2]. Table 4 shows rainfall data for the STIUEIP project municipalities.

Table 3- 4: Annual Rainfall in STIUEIP Project Municipalities

Municipality/ Station	Average (1971-2000) (mm)	2001 (mm)	2002 (mm)	2003 (mm)	2004 (mm)	2005 (mm)	2006 (mm)
Biratnagar (airport)	1881	2279	1923	2108	2144	1596	1300
Birgunj (Simara Airport)	1806	1850	2321	2260	1807	1797	1669
Butwal (Bhairawa Airport)	1673	2016	1269	1953	1524	1768	1214

Source: Central Bureau of Statistics, 2009. Environment Statistics of Nepal 2008, Kathmandu

[1] Baidya, S K, Shreshta, M L ,and Sheikh, M M, 2008. Trends in Daily Extremes of Temperature and Precipitation in Nepal. Journal of Hydrology and Meteorology, Vol. 5, No. 1, 38-53.

[2] Ibid.

3.3 NATURAL CHARACTERISTICS

Topography and Geology

The topography of Birgunj exhibits a gradual slope of about 1:900 from north to southeast resembling Tarai plain (northward extension of Indo-Gangetic plain). The altitude ranges from about 78m in the south near border area to 87m in the north. However there is high micro-topographical variation. Two major rivers are features of Birgunj, namely, the Sirsiya River to the west and the Singha River to the east. In addition to these two rivers there is Gandak Canal in the north. The land is fertile soil with mix of clay, silt and sand.

The geology of the Birgunj area consists mainly of quaternary sediments. It is composed of very fertile soil mixed of clay, silt and sand.

Seismicity – Seismic Hazard

Recorded earthquakes of up to 6.5 on the Richter scale will be taken into consideration in the design, evaluating any potential hazard.

Land Subsidence

Subsidence, although anticipated to be of limited scale relates to underground excavations

Surface and Ground Water

The area is drained by two rivers – the Sirsiya River in the west and the Singha River in the east. On the north, there is Gandak Canal running along Gandak Road from the northwest to the southeast. This canal prevents surface runoff from the areas to the north of Gandak Road flowing into Birgunj. The Singha River originates about 4 km upstream from the northern border of the municipality whereas the Sirsiya River originates from far northern area.

These rivers are flooded during summer monsoon and river bank cutting particularly at the meander bend during flooding is common. The water in the river during dry period is very low. Groundwater table depth is estimated to be between 3.5-4.5 m deep with fluctuation during wet and dry season. It is expected that there will be seepages of groundwater which has to be taken into consideration in the design stage and should be further investigated.

Infiltration Capacity

The soil is clayey and the rate of natural percolation is particularly slow; flooded areas remain submerged for many months. With regard to an existing system of primary drains, over the past twenty years there have been several fully consultative planning exercises and implementation

activities. However, the works remain incomplete and suffer from many inadequacies, including the natural growth of dense vegetation in some of the earthen drains. The drainage system of the eastern part of the city in particular is not capable to efficiently drain off the surface run-off because of capacity constraints and absence of outlets.

Safety Measures during Construction

The soil along the drain alignment is loose clayey silt to soft silty fine sand. The soil's allowable bearing capacity is 50 kn/m2 and permissible settlement as 65 mm. During construction, safety measures are to be of paramount importance to safeguard adjacent buildings from damage due to sub-soil erosion undermining permanent structures and trench sides

3.4 URBANIZATION AND LAND USE

Urbanization in Birgunj

Birgunj Sub-Metropolitan City is Nepal's principal trade centre. The city has experienced rapid growth especially in the past decade, due to migration to the city from peripheral districts and VDCs for security reasons, or other reasons such as for seeking better livelihoods. There is consequently environmental deterioration resulting from inadequate sanitation and drainage, uncollected and indiscriminate dumping of solid waste, and increasing traffic congestion mainly in the main roads.

These dire environmental conditions consequently lead to the poor air quality in the city. The individual institutional efforts of both the sub-metropolis and sectoral agencies in addressing these issues, has remained uncoordinated and grossly inadequate. Most of the fertile agricultural fields are rapidly converted into residential and commercial areas. There is uncontrolled land use construction due to the non-implementation of zoning laws to implement land use and zoning plans.

The eastern part of the sub-metropolis which lies in the flood-prone area of the Singha River is also being changed to residential and commercial areas due to the pressure of increasing population in the sub-metropolitan city. Wards 18 and 19 have the highest applications for new housing construction permits. The infrastructural facilities such as roads, sewer and storm-water drains and water supply, need to be developed to match the current rate of other development, which remains a major future concern.

Building Permit

Recent studies shows that the majority of building constructions in the last three years are taking place in Ward No. 19, 18, 13, 14, 3, and 15. Few building constructions are expected in Ward No. 5, 6, 7, 8, and 9 as these wards are small and well developed. Areas in these wards are considered as the core area of Birgunj.

Urban Density

The average urban density in Birgunj sub-metropolitan city in 2011 is around 58.15 pph. The lowest density is 18.80 pph in Ward No. 17, whereas the greatest density of 342.30 pph lies in Ward No. 9. More construction activities can be expected in Ward No. 19, 18,15,13,14, and 3 whereas few construction activities in Ward Nos. 4, 5, 7, 8, 11 and 12 as these wards are small and well developed for business activities.

Planning Efforts in Birgunj

A number of planning documents have been prepared for development of Birgunj city, such as Structure Plan, Integrated Action Plan and concept of Greater Birgunj. The latest development is the Periodic Plan of Birgunj Sub-Metropolitan City.

Development Concepts of Birgunj

The Birgunj Municipality has prepared its Periodic Plan to guide the development of Birgunj in the planned way in different sectors and defined its VISION "Birgunj as Main Gate to Nepal, Clean, Prosperous, Progressive is our identity". To achieve its aforementioned vision, a number of programs are put forward in the periodic plan and has adopted the following objectives and strategy for environmental development of physical Infrastructures.

- Development of Birgunj as per land use
- Development of Sewerage and drains
- Proper management of solid waste
- Public awareness building on environmental issues
- Adopt approaches in waste reduction
- Ensure that raw sewerage gets into drains after it passes through septic tanks
- Protection of rivers banks
- Reduce municipal investment in solid waste and encourage private sector

Proposed Land Use Plan

A new land use plan has been prepared to guide the future development of Birgunj based on current predominant land use. Besides the existing land use, new areas have been designated for different purposes as follows:

- The industrial area has been extended in the west side of the current industrial area
- Further new residential and commercial development in the east side of Bypass Road in Ward No. 18 and 19. Sprawl development is already taking place in these areas which can be found from building permit data of the last few years.

Urban plan for drains and roads

The proposed drains and roads will lay the basis for future urbanization of Birgunj, which is presently spatially constrained by the tendency to flood, particularly in wards 18 and 19. There needs to be a comprehensive urban development plan integrating with existing services and infrastructure, including roads, water supply, electricity, solid waste, sewerage and sewage treatment, and drainage; this will guide the future development process.

3.5 MUNICIPAL INFRASTRUCTURES

In order to avoid difficulties during construction, it is required that all public utilities and services be known in the latest form possible. This includes the traffic network and underground utilities such as electricity lines, telephone lines, water supply lines and sewerage networks if any. Knowledge of the irrigation network in the Project areas is also necessary. Information on the storm drainage network (if any) of the communities and/or municipalities included in the project area is also a requirement.

Transportation

Birgunj is accessible by land from almost all part of the country. It is linked with different places via the Tribhuvan Rajpath and East-West Highway. It is also connected with Kathmandu by air via Simara Airport which is located about 22 km to the north of the city.

Birgunj has also Dry Port facilities, which is connected with Kolkata, India with both Railway and Road services. The Dry Port is not in operation these days but talks are underway within the Government of Nepal and the Government on India to bring it in operation. Kolkata is the nearest International Port/Harbour from where Nepal has got the tread and transit facilities from other countries.

There are 115 km of black toped road, 83 km gravelled and 82 km earthen roads and a number of trails within the municipality. Overall roads in Birgunj are in a poor condition. There are more than 5,200 Riksha, 313 Tempu and 456 Tanga in Birgunj providing transportation services. There are about 12 locations with major traffic congestion in the city centre.

Water Supply

The main source of drinking water in Birgunj is the deep tube well ground water. At present there are four pumping stations operated by Nepal Water Supply Corporation that supply 8 million litters of water to the sub-metropolitan city. Nearly 6,067 households have piped water supply facility, 1,210 households have drinking water facility from public shallow tube wells and 7,819 households have drinking water facility from shallow tube wells. The water quality from deep tube wells is reported to be safe for drinking water but from shallow tube wells is usually contaminated by surface water and seepage of wastewater.

The detail information about the underground pipelines is available with the consultant based on the GIS Map. The total length of the underground pipe is about 80 km varying in size from 25mm diameter to 250mm diameter. These data will be further verified and will be taken into consideration for the preparation of the construction drawings.

Storm Water Drain

According to Municipality Profile (2007), there are approximately 4.7km main storm water drains MD1 and 40.5km secondary storm water drains in Birgunj. Open drains have been constructed in all the wards except in the areas from Ghantaghar to the Sub-Regional Hospital and Ghantaghar Link Roag areas where drains are covered.

The main drains referred as MD1 run in a general direction from the north to the southwest in the core area to the west of Main Road in Birgunj. Most secondary drains in the core area to the west connect MD1. The drainage networks in areas to the east of Main Road in Birgunj have inadequate hydraulic capacity to drain surface runoff effectively during monsoon seasons and they end up swamp areas without drainage outfalls.

Most open drains in Birgunj do not function properly due to the lack of maintenance as well as their misuse by the local people as waste dump sites. These drains are fully filled with debris and wastes all the time and overgrown weeds are covered entire cross sections in most earthen sections.

Sewerage and Sanitation

There are neither public centralized sewerage network systems for sewage collection nor sewage treatment plants for sewage disposal in Birgunj. The open drains have been used for waste water collection and disposal. The on-site sanitation with septic tank and soak pits has been adopted for the sewage disposal from settlements. About 51% households have modern toilets, additional 24% households have ordinary toilets but 25% households do not have any toilets.

Though most of the houses have septic tanks, but very few have soak pits. As such, the septic tank effluents from most houses are directly discharged into the open road-side storm water drains. The municipality does not have facilities for the collection and disposal of septic tank solids. Generally the private operators provide these kinds of services and they have been found to dispose the solids in the road-side drains or on the vacant land.

As reported in the Birgunj Initial Environment Assessment, the town is seriously short of public toilets. Based on a copy of the Birgunj Facilities map, there are only seven public toilets in the city. Most of the residents living in settlements belong to slum and squatter areas without toilet facilities have to sort to defecating either in the open fields or in open drains. Most of the existing public toilets have not been maintained after their constructions.

Solid Waste Management

Solid waste is collected by Birgunj Municipality. It provides waste collection and sweeping services. The containers/bins are placed at different strategic locations which are used by households, institutions and the commercial sector in the town. There is no organized door-to-door collection system in Birgunj.

Majority (78%) of the households dispose their wastes to public places and only 10.5% households use fixed places or containers. Wastes are transported using tractors and open trailers. In the absence of a permanent sanitary dumping site, about 60 tons of garbage a day are being dumped haphazardly along river banks, ponds, by-pass road and open spaces. Nearby areas of those places are prone to serious health hazard.

Telephone

Underground Telephone Lines have been proposed on most of the important roads in Birgunj The selected routes are from Shankaracharya Gate to Gangak Chowk along Main City Road (TRP), Main Bypass Road from Inarwa Chowk to Gandak Chowk, Ghantaghar Link Road, Padam Road from Kalaiya Chowk to Powerhouse Chowk, Panitanky Hulak Road,

Aadarshnagar area, Shreepur area and Ranighat area. As based on the preliminary information some of the proposed lines are already been laid underground.

Prior Information about the underground laid cables is of prime importance. Information about its type, diameter, led depth and its location along the road lane are very important for the construction of storm drains. The consultant is trying to obtain more information from the concerned authority which will be included finally in the Final Design Report.

Electricity

No information regarding the underground electric cable is available to the Consultant at this stage. The Consultant is trying to contact the concerned authority for collection of the available data. Request to PIU has also been made for necessary help in this regard.

3.6 DEVELOPMENT OF INFRASTRUCTURES

Storm water and Drainage systems

Birgunj is located on the flat land of Tarai Region which suffers from chronic water-logging problems caused by inadequate capacity of drainage channels due to ad-hoc construction of the drainage system in general and poor maintenance worsened by obstructions from solid waste dumping. Storm water drainage systems will be improved together with wastewater management systems, as storm water drainage is currently being used as open sewers, causing bad odors, health risks and pollution of the watercourses. Sanitary landfill site will be developed for processing of solid waste of Birgunj Municipality.

Wastewater treatment plants will be constructed in Chhapkaiya ward No. 2 of Birgunj Sub-Metropolitan Office. This treatment plant will treat the domestic household waste being generated from the various Wards of Birgunj Sub-Metropolitan City. Ward No. 7,8,12,and14 will be highly benefitted from this Wastewater treatment plant whereas, Ward No.3,10,11,15 and 16 will only be partially benefitted. Urban roads and lanes will be reinstated or upgraded where drainage and sewerage pipe networks work will be undertaken. All works will occur within the right-of-way (RoW) of the road and no additional land acquisition is required. Mitigation measures to limit impacts during construction are included in the environmental management plan.

Roads

Roads along the proposed Diversion drains are proposed to be newly constructed. These roads are existing earthen roads and require only further improvement and upgrading. No additional

land will be required for acquisition or to be procured. Diversion Drains 13A has been proposed to be constructed along Canal Road which is earthen at present.

Road widening and improvement has been proposed along this road. One more earthen road exists which starts from Pratima Chowk and runs parallel to the main By Pass Road and ends at Nagua area (ward No.19). This part of road is 3.83 km long where Diversion Drain 12 and 13 are proposed. This section of the road will also be improved and black topped. Birgunj Municipal office wants to extend this road to Tribhuvan Raj Path from its both ends so that this road could be used as a Second Bypass Road in future. This road will be helpful to reduce the heavy traffic load on the existing By-Pass Road.

The existing road to the proposed Waste water treatment plant passes from Narrow Street and cannot be widened due to old and dense settlement. Hence, a new alignment has been proposed starting from close to the Custom Office to the proposed Waste water treatment plant. The proposed length of this road is about 1.63 km.

Public utilities and services

The concerned related authorities were contacted to provide the information on electricity, telephone and water supply networks (underground utilities) which need to be taken into consideration during the design process. This data is also important as all physical information regarding the contract area must be included in the tender documents. Data received and as-built drawings provided in paper format include the following

Table 3- 5: Summary of Drawings/Documents Obtained

Type of Underground Utility	Drawing/Document Obtained	Source
Water supply	Underground network map for water supply	GIS Map and NWSC, Birgunj
Telephone	Underground network map for telephone	Telecommunication office, Birgunj

4. SEWERAGE SYSTEM

4.1. DESIGN CRITERIA AND NORMS

4.1.1 General Considerations

In order to design of sewerage network, a number of design considerations and parameters shall be adopted. To proceed with the design of the sewerage scheme of the town, the following aspects and references have been followed:

i) Prudent Engineering Practices in SAARC Countries and guiding principles for Design and Construction of Sewers in other similar projects in Nepal

ii) Nepalese Standards and Practices including relevant International Codes

iii) Consultant's experience: Consultant's experience as well as according to local, national and international practices and standards.

iv) Category of town: Whether the town is Urban /Rural/Literacy and income of the dwelling population.

v) Present Scenario: This deals with the present condition of town and condition of financial condition of governing body, infrastructure, land use pattern and the potential and scope of growth.

vi) Future Scenario: This deals with the future prospects for the town as per the private/government participation which are indicative of the gradual change of face of the town.

vii) Cultural Requirement: This is a major influencing factor that is required at the planning stage as well at the stage of execution. The scheme should not include any material, process or method of execution that interferes with the culture of people. Neglecting this aspect can cause delay/failure of scheme.

The method of approach for the design follows the methodology utilised in the other projects by the Consultant. The design methodology follows internationally accepted procedures [such as those embodied in *BS EN 752: Drain and sewer systems outside buildings]* with parameters adapted to suit the demographic and hydro-climatic features of Nepal. Design criteria were discussed and approved by the Client after the submission of the Design Criteria Report followed by the Concept Report in early august 2012. These will be used and accommodated during the preparation of the interim, draft and final design process.

4.1.2. Design Criteria for Hydraulic Computations

Design Flow – Average daily flow

As per PPTA, the water supply consumption rate has been considered 80 litre per capita per day (lpcd) and waste water production will be 80 % of water supply (Return Factor). About 10 % institutional and industrial wastewater will be added for sewerage system design [average daily flow]

Peak Factor (PF) for Contributing Population

The sewage flow in sewer varies considerably from hour to hour and also seasonally. Dry weather flow varies during the day with a major peak typically occurring in the early morning. This peak is dependent upon the number of inhabitants as well as on the size of the catchment area. As the catchment areas expands, the peak value decreases due to the superposition of different dry weather flow hydrographs and flow attenuation in the network. The methodology followed by the Harman formula takes this into account.

For the purposes of hydraulic design of design stretch, the estimated peak flow is to be adopted. The peak factor or the ratio of maximum to average flows depends upon contributory population and is then applied to the average daily flow.

Table 4- 1: Extreme Flow Factor

No	Contributory population for design stretch (capita)	Flow Factor
1.	Up to 20,000	3.00
2.	20,000-50,000	2.50
3.	50,000-750,000	2.25
4.	More than 750,000	2.00

Ground Water Infiltration

Estimate of flow in sanitary sewers have to include flows due to infiltration of ground water. Estimate of flow in sanitary sewer may include certain flows due to infiltration of ground water through joints. The quantity will depend upon workmanship in laying the sewers and level of ground water table. In agreement with the Client for design of sewerage system, iinfiltration flow will be taken as ***10,000 liter/hectare/day*** as Birgunj water table is high during monsoon season.

With improved standards of workmanship, quality and availability of various construction aids the infiltration should tend to the minimum rather than the maximum.

The use of HDPE pipe with less jointing of better quality than RCC pipes could further reduce the infiltration factor. Based on prudent engineering practice.generally 2 to 5% of dry weather flow is considered as for infiltration into the sewer network

4.1.3. Design Criteria for Gravity Scheme

Velocity of Flow

The flow in a sewer varies widely from hour to hour and also seasonally but for purpose of hydraulic design, estimated peak flow has been adopted.

Minimum velocity of flow in sewer shall be a self-cleansing velocity, which shall be achieved at least once in a day during peak flow at ultimate peak flows. The maximum velocity is restricted to just below the scouring velocity which is 3 m/sec as recommended.

- Minimum velocity: 0.75 m/s for gravity pipes flowing full.(0.60 m/s for partial flow)
- Maximum velocity: 3.0 m/sec

In the Initial stretches of sewer network, it may happen that the velocity be less than self-cleansing velocity due to flat gradient and also less sewage flow. In order to get self cleansing velocity in the starting stretches of the sewers, the design requires sewers to be laid at greater depth, which is uneconomical. Therefore self cleaning velocity may not be always achieved at initial stretches and flushing may be required more frequently at this part of the scheme.

From consideration of ventilation in waste water pipes, sewers shall not be designed to run full. The maximum permitted depth adopted in sewers sewer is 0.80% of the pipe high peak flow.

The minimum gradient/slope for sanitary sewers for several diameters is summarized in the following table.

Table 4- 2: Extreme Flow Factor –Full Flow (RCCP)

Pipe Diameter [nominal diameter]	*Minimum slope for gravity*	*Flow l/s*	*Velocity m/s*
200 mm	*0.49 %*	*28.30*	*0.75*
250 mm	*0.37 %*	*36.83*	*0.75*
300 mm	*0.28 %*	*53.04*	*0.75*
350 mm	*0.23 %*	*72.19*	*0.75*
400mm	*0.20 %*	*94.29*	*0.75*
450 mm	*0.17 %*	*119.33*	*0.75*
500,mm	*0.15 %*	*147.32*	*0.75*

Pipe Diameter [nominal diameter]	Minimum slope for gravity	Flow l/s	Velocity m/s
600 mm	0.12 %	212.14	0.75
700 mm	0.10 %	288.75	0.75
800mm	0.08 %	377.14	0.75
900mm	0.07 %	477.32	0.75

If in the initial pipe sections the desired velocity (self cleansing 0.6m/sec) is difficult to obtain, in this case flushing by water tanker shall be required at specified period (Refer in the O&M section)

Minimum Size of Sewer

The minimum pipe diameter of sewer is ND 200 mm and ND 100 mm for House connection. For commercial connections such as Hotel the pipe diameter for the connection is ND 150 mm. The connection from the service pit to the sewer manhole is ND 150 mm.

Design Formula

The sewer network design shall be carried with the ***Manning's Formulae*** i.e.

$$\textbf{Velocity } V = [(1/n) \times (R^{2/3}S^{1/2})] \text{ (in m/s)}$$

Because the hydraulic radius for a circular pipe flowing full is simply D/4 (D = pipe diameter in mm) the formula is as follows:

$$\textbf{Velocity } V \text{ (m/s)} = (1/n)\,(3.968 \times 10^{-3} D^{2/3} S^{1/2})$$
$$\textbf{Flow } Q \text{ (l/s)} = (1/n)\,(3.118 \times 10^{-6} D^{8/3} S^{1/2})$$

Where

Q= Discharge in l/s

S= Slope of hydraulic gradient

D= Internal dia of pipe line in mm

R= Hydraulic radius in m

n= Manning's Coefficient of roughness/coefficient of Roughness (n):

i. RCC pipe is 0.013

ii. HDPE, uPVC pipe n value 0.011

In general calculations are not made full flow, and the use of the formula is indicative as for a circular conduit the peak flow occurs at 93 percent of the height of the pipe, and the average

velocity flowing one-half full is the same as gravity full flow. Gravity full flow condition is usually assumed for purposes of storm drain design.

Software calculations are made for partially full-flow. Note that the computed diameter by the Software for sewerage scheme must be increased in size to a larger nominal dimension in order to carry the design discharge without creating pressure flow with a ratio of depth of flow to diameter d/D of 80% maximum.

Design Period/Life time (excluding construction phase)

For each component of the project the equipments will comply with the following design period:

Table 4- 3: Life Time – Design period

Component	*Years*
Land Acquisition for SPS & STP	*30 years*
Trunk, Main, Branch Sewer & Appurtenances	*20years*
Pumping Stations- Civil Structures	*20years*
Pumping Installations - M&E works (Replacement of E & M Equipment @15 years	*15 years*
Sewage Treatment Plant	*10-20 years*

4.1.4. Pipe Main Features

Most of the arrangements for pipes installation are shown on the set of typical drawings presented in Volume II of the present report. Suitability of different pipe materials against the various factors has been presented in the Concept report and already discussed with the Client.

Pipe Material

RCC pipes: In principle all pipes to be used in the main sewer network are proposed to be reinforced concrete cement RCC pipes with spigot and socket ends, jointed through rubber gaskets.

RCC pipes shall be manufactured as per NS80/2042 and IS 458:2003 medium duty, non pressure pipes. The cement to be used for RCC pipes shall be ordinary Portland cement as per standard: The jointing shall be Rubber Ring Joint (RRJ) type and the rubber gasket to be provided shall be as per NS, NP3 or exceptionally NP4 RCC (Hume) pipes for sewer lines as applicable.

HDPE: Alternatively High Density Poly-ethylene (HDPE) pipe shall also be use for lateral of branches sewers lines ND 200, 250 mm HDPE pipes have the advantage of not been attacked by sewerage, provides less jointing of better quality reducing infiltration, and can have lower minimum gradient with a smoother internal surface. HDPE provides durability, performance, easy handling, and toughness during installation and simplified field fabrication. HDPE pipes shall be manufactured according to the provision of IS 4984 Specification for HDPE Pipes Grade 63 PN6 or equivalent

The lifetime of this HDPE pipeline is better but certainly appropriate bedding such as concrete surrounding shall be required due to road loading increasing the cost. Jointing shall be made by butt welding employing fusion.

uPVC pipes are proposed for property connections ND 100, 150 mm and drop in manhole as well as for inlet sewerage chamber and/or gully connections for the drainage scheme.

uPVC pipes shall be manufactured according to the provision of IS 4985 : Specification for uPVC Pipes or equivalent Class 3 PN 6. Jointing shall be socket type with rubber ring joint gasket.

Pipe Cover

The minimum cover above the crests of the sewer pipe is to be 1.0 m, but to enable house connections the pipe may be constructed deeper. In general the sewers lines need to be at sufficient depth to pass under storm water drains or others services. At the start of a line, the exact depth of the sewer may be reduced depending of the local conditions.

Deep sewers are the inevitable result of relatively flat catchment/gradient. The common preferred depth should be 4 to 5 m, the reasonable practicability and affordability maximum depth been 7.0 meters. The average depth for house connection is 1.50 m [invert level].

In case of pipe cover below 1.0 m the pipes shall be embedded in concrete PCC M15.

Width of Trench

The width of trench for sewer shall be adequate for laying and jointing operations. The trench width at the bottom of the pipe shall not be less than 450mm or more than 600mm greater than the outside diameter of the pipe. Trenches shall be of sufficient width where joints are made to provide a free working space on each side and below the pipe and in any case not less than 750mm for sewers pipe. For the diameter of the pipe in the bottom of the trench it should be taken as follows:

- For diameter up to 450mm, the bottom pipe width of trench shall be OD[3]+45cm
- For diameter above 450 mm, the bottom width of trench shall be OD+60cm

At the same time, the width of the trench needs to be restricted for the following reasons:

- To minimize disturbance to adjoining facilities/utilities, especially in densely developed areas of the old city.
- To reduce cost of excavation and restoration of road surface.

For house connections and pipe uPVC 110, 160 and 200 mm the trench width shall be in all cases not less than OD+300 mm.

Bedding

Generally bedding shall be provided to withstand and provide a good sitting to the pipe and shall be to extent possible from locally available materials. Pipe bedding shall consist of placing the specified bedding material under, around, and to 150 mm above the top of the pipe in the locations and to the details shown on the Drawings and specified herein for type 1 to 4 bedding.

The bedding material and size shall be as per relevant classes as specified in the standard and five categories of bedding will be applied in relation to pipe material and depth of the trench. In case the pipe cover is insufficient and/or heavy load are monitored especially for roads crossing the pipe shall be embedded in concrete [Type 4] as well as uPVC for house connection and HDPE pipes if required for depth less than 1.0m as indicated above (pipe cover).

The main bedding categories are shown in Table 4-4:

Table 4- 4: Categories of Bedding

Category	Description	Abbreviation
Type1	Granular bedding	GRB
Type 2	Plain Cement Concrete M20	PCC
Type 3	Reinforced Cement Concrete 0.4% reinforcement M20	RCC .0.4%
Type 4	Reinforced Cement Concrete 1.0% reinforcement M20	RCC 1.0%
Type 5	"Arch" bedding for PE pipes including the combination of anti-flotation precast RCC blocks every 3m m and type 1 bedding in current sections	ARCH / Type 1

The standards arrangements for pipe bedding in relation to pipe material and depth are presents in the following table.

[3] OD: outside pipe diameter

Table 4- 5: Proposed bedding type v/s pipe material & depth (extract from IS 783-1998) (RCC)

		NP3 - RRJ				
Pipe		Type 1	Type 2	Type 3	Typ 4	Type 5
ND	OD	GRB	PCC	RCC0.4	RCC1.0	ARCH
200	0.26	0-4m	4-5m	>5m	If required	Not Applicable
250	0.31	0-4m	4-5m	>5m		
300	0.38	0-4m	4-5m	>5m		
350	0.50	0-4m	4-5m	>5m		
400	0.55	0-4m	4-5m	>5m		
450	0.60	0-4m	4-5m	>5m		
500	0.65	0-5m	5-6m	>6m		
600	0.77	0-5m	5-6m	>6m		
700	0.87	0-5m	5-6m	>6m		
800	0.99	0-5m	5-6m	>6m		
900	1.10	0-5m	5-6m	>6m		
1000	1.23	Not Applicable	0-7m	>7m		
1200	1.40		0-7m	>7m		
1400	1.65		0-7m	>7m		

Table 4- 6: Proposed bedding type v/s pipe material & depth (extract from IS 783-1998) (HDPE)

		PE class 6				
Pipe		Type 1	Type 2	Type 3	Typ 4	Type 5
ND	OD	GRB	PCC	RCC0.4	RCC1.0	ARCH
150	0.160	Not Applicable	2-4m	Not Applicable	If required	2-4m
200	0.225		2-4m			2-4m
250	0.310		2-4m			2-4m
300	0.315		2-4m			2-4m

In principle PE pipes shall not be use for depth greater than 4 m and replaced the RCCP NP3 pipes. In case the pipe cover is insufficient and/or heavy load are monitored i.e. road crossing PE pipe shall be embedded in concrete [Type 4 bedding]

Table 4- 7: Proposed bedding type v/s pipe material & depth (extract from IS 783-1998) (UPVC)

		uPVC class 6				
Pipe		Type 1	Type 2	Type 3	Typ 4	Type 5
ND	OD	GRB	PCC	RCC0.4	RCC1.0	ARCH
150	0.160	0-4m	Not Applicable		If required	Not Applicable
200	0.225	0-4m				
250	0.310	0-4m				
300	0.315	0-4m				

Depth of Trench

The trench shall be excavated to a sufficient depth below the underside of the pipe as shown on the Drawings to provide for installation of the cradle of properly compacted granular bedding or concrete, as required type of bedding. The bottom of trenches shall be hand cleaned to the desired grade.

The depth of the bedding bellow the pipe (H1) for all type of bedding shall not be less than 100 mm for pipe smaller than 450 mm and shall be at least of 150 mm for pipes greater than 450mm. In general the depth shall be:

Trench Depth = Ground Level - Invert level + e^4 + H1

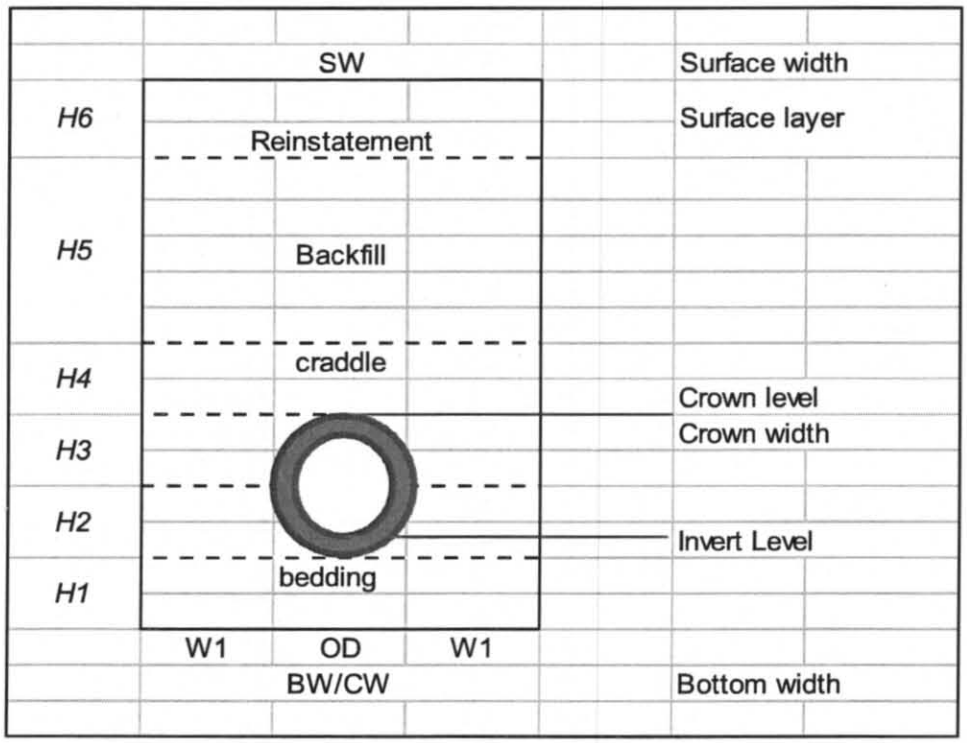


Figure 4- 1: Trench schematic dimension

Where,

H1 is related to the pipe diameter.

H2 and H3 are related to the type of bedding

[4] Pipe thickness

H4 is related the pipe diameter

H5 depend of the bedding arrangements and the surface reinstatement

H6 is defined by the characteristics of the surface finishing.

H2 + H3 is equal to the outside diameter of the pipe

The dimension on the top of the crown of the pipe (H4) for all type of bedding shall not be less than 150 mm for pipe smaller than 450 mm and shall be at least of 150 mm for pipes greater than 450mm.

The dimensions of the trench i.e. width, pipe bedding and pipe cradle are summarized in the following table

Table 4- 8: Trench dimensions

Position of pipe	Width	H1	H4	Material
uPVC House connection and service pipe 110/160 mm	OD+ 300 mm	15 cm	15 cm	Granular bedding and carefully compacted backfill (B)
HDPE sewer 200/250 mm	OD + 450 mm	10 cm	15 cm	Anti-flotation block, granular bedding and carefully compacted backfill (B)
RCCP sewer <= 450mm	OD + 450 mm	10 cm	15 cm	According to depth [refer table 5-5]
RCCP sewer >450 mm	OD+600 mm	15 cm	15 cm	According to depth [refer table 5-5]

Sheeting and bracing

Where required and where otherwise necessary to prevent caving of the trench walls or to protect adjacent utility services, excavation shall be adequately sheeted and braced. Sheeting shall be carried out by the Contractor The Contractor shall provide and set all shoring, bracing, sheet piling, etc. required to adequately protect the excavation from damage by caving in, heavy rainfalls or other causes.

The quality of material and methods used for sheeting or sheet piling and shoring or bracing shall be subject to the approval of the Engineer, who shall reserve the right to order any unsatisfactory material replaced at the expense of the Contractor.

In the absence of detailed soil investigation a provision of trench shoring shall be taken in the

cots calculations. The provision shall be taken in relation to the depth of the trench the planned ratio is as follows:

Table 4- 9: Proposed shoring ratio v/s trench depth

Trench Depth	Below 4m	Between 4 to 6 m	Above 6 m
Shoring Ratio	30%	60%	80%

Dewatering excavations

The Contractor shall provide, and keep in operation on each section of the work, when necessary, pumps of sufficient capacity to keep the bottom of the excavation or trench dry and free from water at all times or other means of dewatering satisfactory to the Engineer until the pipe or structure has been installed and inspected. Further, he shall, at his own expense, take all measures necessary to lower the piezometric surface so that the bottom of the excavation is maintained in a dry and stable condition to the satisfaction of the Engineer.

The Contractor shall take all necessary precautions to prevent uplift of any structure during and after construction.

4.1.5. Manholes

A manhole is an opening constructed on the alignment of a sewer at frequent intervals to provide access for maintenance purposes like inspection, testing, cleaning and removal of obstructions from the sewer line etc. Manholes are located at each sewer junction or change of sewer direction, diameter or gradient. No connection pipe should enter the manhole at an angle greater than 90° to the direction of the flow.

General

Manholes are generally constructed in circular shape. The manholes are in brick masonry walls with plastered inside, RC concrete bottom and top slab with cover and finished with a benching. Alternatively small size masonry manholes can be rectangular for easy construction

Where the water table is high and the pipe sewer is laid in open field or along the side of the drain, the RCC circular manholes would be constructed to avoid any leakages into or out the manholes. If possible brick masonry manholes are planned for narrow streets and RCC cast in situ manholes are proposed for main roads or for heavy traffic roads. Masonry manholes are limited to 2 m depth for pipes 200-450 mm.

Manhole cover levels

The final level of manholes would be depending on site condition, and therefore the final levels will be finalised during the execution time. However, generally the following values may be considered;

- Paved areas cover level = final paved level.
- Landscaped areas cover level = final ground level +0.1m.
- Open, unpaved areas cover level = final ground level +0.25m. or as instructed by the Engineer during construction.
- Manhole covers with frame with a minimum clear opening of 600 mm

Cast Iron (CI) manhole cover and frame should be used for covering manhole, heavy or medium duty CI covers shall be used in relation to the location of the manhole (road or sidewalk)

Manhole Spacing

It has been proposed to provide the manholes at every junction, change of alignment/grade or 30m whichever is less in order to construct the house connections. In large street larger than 4 meter lateral sewerage pipes lines may be laid and the sewerage collection made from service pits, in this case the distance with manhole may be increase from 30 to 60m case by case.

Procurement of mobile sewer cleaning equipment and sewer flushing machines would be required for operation and maintenance of the sewer system. The flushing machine would be required to generate self cleansing velocity at the starting manholes, if the self cleansing velocity not achieved in the system.

The spacing between manholes is adopted as per standard engineering practice and recommendation of SAARC Country's manual. Mechanical cleaning has been considered for which manhole spacing has been kept as follows:

- For lateral & branch sewer until ND 450 mm manhole dia 900/1200 and 1500 mm at a spacing of 30 m; when lateral services pits are installed longer space between manholes is acceptable.
- For main sewer ND 500/900 mm. with manhole dia 1500 mm a spacing maximum of maximum 45 m;
- For trunk/outfall main collector dia>900 mm manhole dia 1800 mm a spacing of maximum 60 m.

Size and Shape

Rectangular or circular size manhole, bricks or RC manhole are defined in relation to the pipe diameter and depth. The size (internal dimension) of the manhole will increase with increasing depth and the increase of the pipe diameter. The table here after summarized the different size and material for manhole in relation to depth and pipe size:

Table 4- 10: Manhole Size, Shape and Material

Internal Diameter of Manhole

Pipe	≤ 1m	≤ 2m	≤ 3m	≤ 4m	≤ 5m	≤ 6m	≤ 7m	>7m
200-450	0.9 x 1.2	0.9	0.9	1.2	1.2	1.2		
500-900		1.5	1.5	1.5	1.5	1.5	1.5	
Wall Thickness of manhole								
200-450	0.25	0.345	0.20	0.20	0.25	0.25		
500-900		0.20	0.20	.0.25	0.25	0.30	0.30	
	Bricks Masonry structures							

Manhole sizes and material, sewer depths shall be kept as per prudent practice in Nepal. GI or CI footrest should be provided for entry into manholes as well as steps inside.

The others characteristics such as thickness of the bottom and upper slab are show on the standards drawings presented with the final Engineering Design

Drop Manhole

Drop Manhole shall be provided when the difference between incoming and outgoing invert exceeds 900mm. The drop pipe is encased in concrete or supported on brackets inside or outside the shaft and the incoming RCC sewer pipe at higher level will be connected through a PVC drop pipe of the same size and encased in PCC concrete.

Scraper Manhole/Service Manhole

Scrapper manhole may be provided at a spacing of 110-120m for sewer diameters greater than 450mm. Scrapper or service manhole shall have clear opening of 1500 mm x 1000 mm to facilitate lowering of the bucket. The manholes shall be constructed in RCC. The covers shall

be removable rectangular Pre-cast / SFRC RC slabs with hooks or handle and suitable to withstand heavy traffic loads. The location of service manhole shall be decided during the construction of the works at appropriate location with the Engineer.

4.1.6. House Connections (HSC) – Property connection

General

Public house connections shall be uPVC of an outside diameter(OD) 160/110 mm diameter sewer with a slope minimum slope 1 in 50 to be provided to the connection as follows:

- Property connection (OD 110 mm dia uPVC) shall be direct to the street manhole subject to maximum 6 nos. connection to particular Manhole when road width is less than 4.00-4.50 m depending of the site conditions. Connection with pipe 160mm is made for hotel or large customer.
- Property connection (OD 160 mm dia uPVC) shall be through road side chamber/service pit to the street Manhole when road width is more than 4.0-4.5 m. Several service pits may be installed in the pavement to collect house connections,

Pipe installation

The pipe installation for house connection [uPVC OD 110 mm] shall be conforming to the specifications for trench width/depth and for bedding as defined in the previous paragraph. For uPVC the type 1 of bedding shall be apply and case by case in relation to the site conditions pipe embedding type 4 bedding type shall be carried out. It is planned to provide a length of 3 m by connection. The pipe will be plugged at its end until the complete system is constructed.

Connection chamber/service pit

A connection chamber or service pit is to be constructed adjacent to the boundary of property so that house connection can be made at any time in the future. Also, stub pipes shall be to be incorporated in selected manholes to facilitate system extension and property connection of possible future development and also at space constraint for construction of chambers.

Spacing of collection chambers shall be between 20m or 30m or as per site condition where it is possible to construct the chambers.

Non-standard chambers may be required to accommodate the arrangement and number of outlets from property internal drainage layout, and in restricted areas where plan area/depth requirements are not available. Generally chamber cover levels are:

- Paved areas cover level = final paved level.
- Landscaped areas cover level = final ground level +0.1m.
- Open and unpaved areas cover level = final ground level +0.25m. Or as per instructed by Engineer.

The pipe connection between service pit is uPVC OD 160 mm conforming to the specifications for trench width/depth and for bedding as defined in the previous paragraph.

4.1.7. Summary Table of Design Criteria

The following table summarises the design criteria and assumptions to be used for the design of the sewerage components, BIRGUNJ

Table 4- 11: Summaries of General Design Criteria

Parameter	:	Criteria	PPTA
Design population			
Project Horizon and projected population	:	20 Years Base Year : 2015 Design Year : 2035	Main collector design for ultimate population
Population Projection Method Adopted	:	Geometric Increase Method or as applicable for Birgunj City	
Design Flow			
Water Supply Rate	:	Domestic : 80 lpcd	80 lpcd
Sewage Generation Rate	:	80% of Consumer-end water supply Institutional flow 10% domestic sewage	80%of water supply to HH
Peak Factors	:	Pop. > 20,000 - 50,000 : 2.5 Peak Factor (PF) as per cumulative population taken at 2.5	Peak factor 2.5-3.0 depending of population served
Ground water infiltration	:	10.000 l/h/day (GWI)	
Sewerage Generation	:	**Average flow:** 80% of water supply +10% Institutional **Design flow:** Average Flow x P.F. + Ground Water Infiltration	
Pipe Design Formula	:	**Manning's Formula**	Pipe sized for flow

Parameter	:	Criteria	PPTA
		For ventilation consideration sewers should not be designed to run full, max depth of sewer is 0.80 of peak flow.	at end design period
Manning's Coefficient of roughness (n):	:	RCC S&S pipe is 0.013 HDPE, uPVC pipe n value 0.011	Mini 0.60m/s at peak flow
Min. & Max. Velocity in Sewers	:	Min.: 0.6m/s at design flow Max.: 3.0m/s better max 2.5m/s, earth drain 1.5m/s	Mini 0.60m/s at peak flow
Max. d/D ratio (h/H)	:	80%	
Pipe main characteristics			
Min. & Max. Pipe Size	:	Min. ND: 200 mm HS Connection 110mm [OD uPVC] Max.: as per design	200 mm Concrete pipes, 150 mm for hotels
Pipe material	:	RCC (Hume pipe) NP3 RRJ 200 mm to 1400mm for main collector HDPE 200 to 250 mm lateral and branch uPVC for HS Connection OD 110mm and OD 160 mm for side connections	200 mm Concrete pipes NP2, 150 mm for hotels
Clear Cover over Pipe Crest	:	Min. 1.00 m, In case min. cover is not available, pipe shall be encased in concrete [type 4 bedding].	900mm for pipes laid under street
Manholes			
Manhole Spacing	:	Lateral & Branch : 30 to 40 m Collector Trunk : 60 m Main trunk /Outfall : 60 to 80 m	45 m 100 m main collector
Manhole diameters	:	Bricks or RCC, 200-450 1200 mm, 500-900 1.500mm above 900mm 1.800 mm	No info

Parameter	:	Criteria	PPTA
Vent Shaft Provision	:	1 Vent Shaft per km at least in Trunk/Outfall Sewers (not mandatory)	

4.2. SEWERAGE DESIGN

4.2.1 Design Concepts

Natural Catchment Area

As it has been outlined in the earlier studies, including the 1988 Combined Sewerage and Drainage Study by PADCO Inc, the 2007 Master Plan by Integrated Consultants, and the PPTA study by Padeco Birgunj represents a considerable challenge in the design of drainage systems.

The Area extends over an area which is approximately 8 km in the north-south direction and 4 km in the east-west direction. The municipality is bounded on the east and west by two important rivers, namely the Sirsiya River in the west and the Singha River in the east. Both these rivers meander, but flow generally from north to south. A further important water course, called as Drain MD1 flows in the central part (west of the main road) of Birgunj, and plays an important role in the drainage of the area it drains.

Thus the municipality is founded on the relatively higher ground between the two principal water courses. The situation is however complicated by other features. There exists a little higher level ridge (in east side of the Main City Road) between the two rivers running mostly from north to south. In addition there exist many localised shallow depressions, forming natural flood retention prone areas.

These shallow depressions are located on both side of the ridge. The catchment areas of the future sewerage network are defined according to the natural inclination and possibility to collect and transfer wastewater towards the new collection system each side of the ridge through a main collectors. The main collectors will convey wastewater to the sewage treatment plant (STP) in the southern area of the catchment.

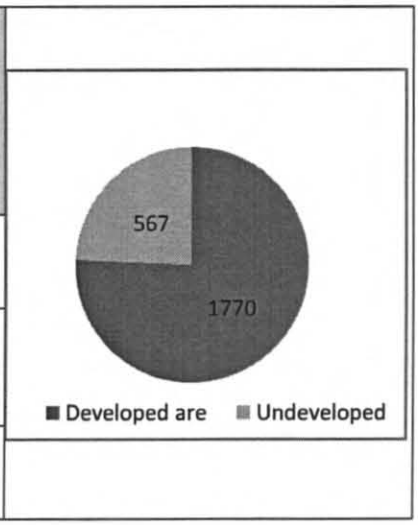
Planning of Sewerage System:

As per Concept Master Plan prepared by DSC and topographical survey, there is two major sewerage catchments divided by the TRP Highway, one is whole western part of whole Birgunj city under Sirsiya catchment and other one is eastern part of whole Birgunj city under Singha River catchment. Major core area falls under western part (Sirsiya) catchment.

The estimated catchment area for Sirsiya is about 1151 hectare and for Singha it is 1186 ha. Today the developed area is about 947 ha in Sirsiya side and 823 ha towards Singha side. The undeveloped area is about 204 ha towards Sirsiya and 363 ha under Singha side catchment as presented in the following table.

Table 4- 12: Main Catchments West and East

Designation	Total area	Western Area Sirsiya River	Eastern area Singha River
Total Catchment	2337.02 ha	1106.50 ha	1230.52 ha
Developed are	1,771.02 ha	903.50 ha	867.52 ha
Undeveloped area	566.00 ha	204.00 ha	363.00 ha



With an estimated total of 280 km of roadways, there are 115 Km black toped road, 83 Km gravelled road and 82 Km earthen road within the municipality. There is no centralized separate sewerage system within municipality except existing surface storm water scheme. House hold septic tank effluent is directly discharged to open surface drains made for storm water flow.

The basic concept of separate sewerage system is to cater the wastewater flow only and for separate drainage system is to carry only storm water. But certainly in narrow road where many infrastructure facilities/utilities the separate system is difficult to construct within this confined and limited space. The use of HDPE easier to lay with a reduced number of joint will facilitate the installation of both system, as well as the use of the existing drainage surface drains.

Other areas where Road width is more, separate sewerage and separate storm water drainage are proposed. In this principle, major area of Sirsiya catchment will be served by separate system.

Concept Planning for Sanitary Sewerage System

The Consultant has prepared concept planning for sanitary sewerage system. It mainly consist of network of main trunk sewer with main, branch and lateral sewers and serves the area west of TRP highway and half of the area in east/south from TRP highway. The international norms and practice differentiate between the various parts of sewerage system by definitions such as

house connections, branch sewers, lateral sewers and main collectors. The following figure illustrates these definitions.

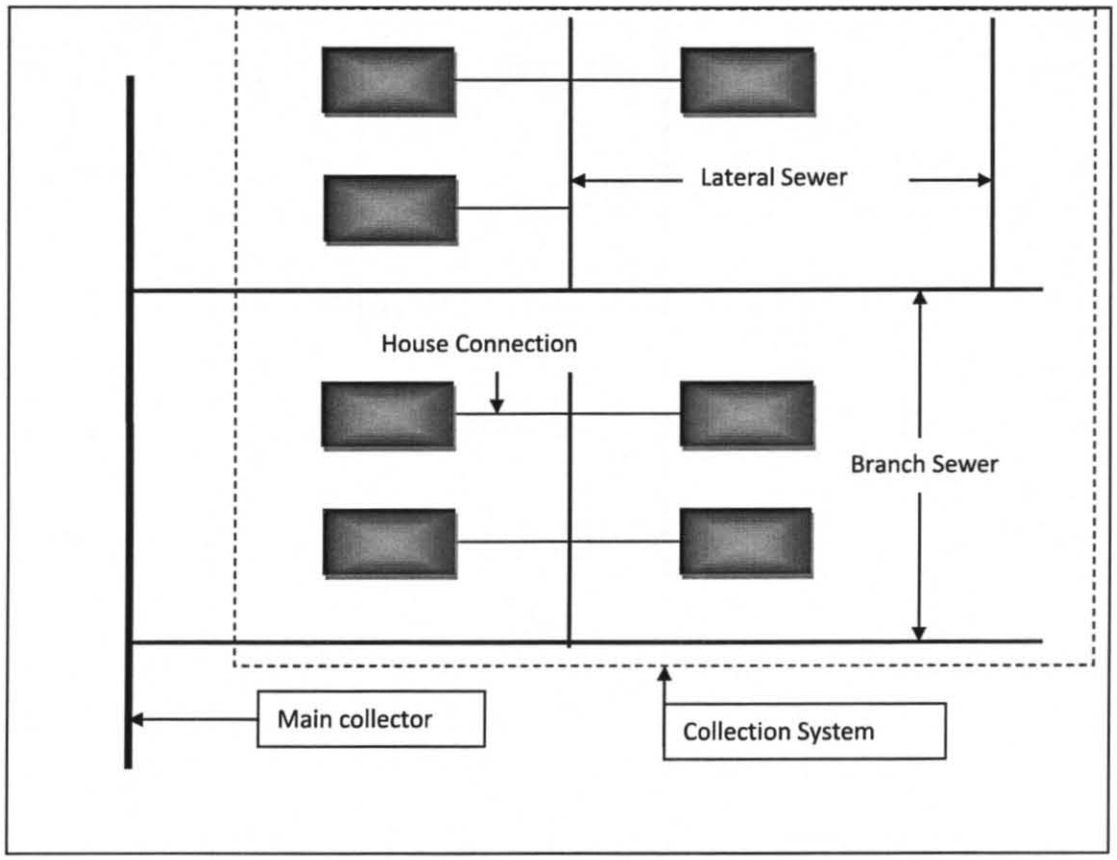


Figure 4- 2: Sewerage – Collection System

- House connection – is small diameter sewer that connects building or residence to the lateral sewer. [ND 100/150 mm]
- Lateral sewer – is the one that discharges into a branch or main sewer and receives wastewater from individual sources.
- Branch sewer – is the one that serves small area and receives wastewater directly from sources or from lateral sewers and discharges to the main sewer
- Main sewer (main collector) – receives water from many tributary branches and serves a large area. The systems of main collectors serve the STP.

The project area is being delineated based on limitation in the survey work agreed with the client, PPTA report and the area available for STP. It is expected that remaining part of the area (Catchment which falls towards Singha River side) will be served by another separate sewerage catchment with a separate Sewerage Treatment Plant based on availability of land. The areas form both side of the existing natural drain MD-1 are planned with main collectors, branch and

lateral sewers with junction in the south of the catchments and outfall to the sewerage treatment plant site at Chhapkaiya area.

The boundary line in the east is the TRP highway from Power House Chowk to Ghantaghar Chowk. On the south of Ghantaghar Chowk the delineated area for sanitary sewerage coverage is the Railway Road in the east of TRP road. On the west side of the road the terrain is usually flat till it reaches Sirsiya River. Hence, most of the Birgunj areas on the west side of the trunk sewer are also served by the proposed trunk sewer.

Sewage generation

The quantity of sewerage is related to the defined project area and the corresponding population served within the area. The population projection is based on the ward wise population figures obtained from Birgunj Municipality, census of Nepal and the forecast calculation approved by the Client and presented in Appendix 1of the present report.

The Sewage generation for two Catchments (one is for Sirsiya and other for Singha Catchment) is presented in the following table. Sewage for Sirsiya catchment will be diverted to centralized STP at Chhapkaiya (location identified and area is acquired already) and sewage generated from Singha catchment will be diverted towards ward no.19 under Singha side catchment and centralized STP location will be identified by department in due course.

Table 4- 13: Sewage Quantity for Each Catchment of BIRGUNJ City

Description	Unit	Sirsiya Sewerage Catchment	Singha – Sewerage Catchment
Total Area	ha	1,106.50	1,230.52
Undeveloped area Area	ha	202.93	364.00
Effective/developed Area	ha	903.57	866.52
Population	inhbts	140,219	128,935.39
Description	**Unit**	**Sirsiya Sewerage Catchment**	**Singha – Sewerage Catchment**
Water Supply rate	l/s	80	80
Sewage conversion rate	%	0.80	0.80

Domestic sewage qty	l/s	103.87	95.51
Non domestic sewage rate	%	10%	10%
Non domestic sewage qty	l/s	10.39	9.55
Average Sewerage qty	**l/s**	**114.25**	**105.06**
	MLD	**9.87**	**9.08**
Peak Factor	%	2.50	2.50
Sewerage infiltration rate	l/ha/d	10,000.00	10,000.00
Sewerage infiltration qty	l/s	104.58	100.29
Design sewerage qty	**l/s**	**390.21**	**362.94**
	MLD	**33,71**	**31,357.87**

The site location for Singha site catchment and collectors are shown Figure 4-3. The planned actions in the Core area have been reduced and the Area east of the main road has been included in the next phase of the project in next phase.

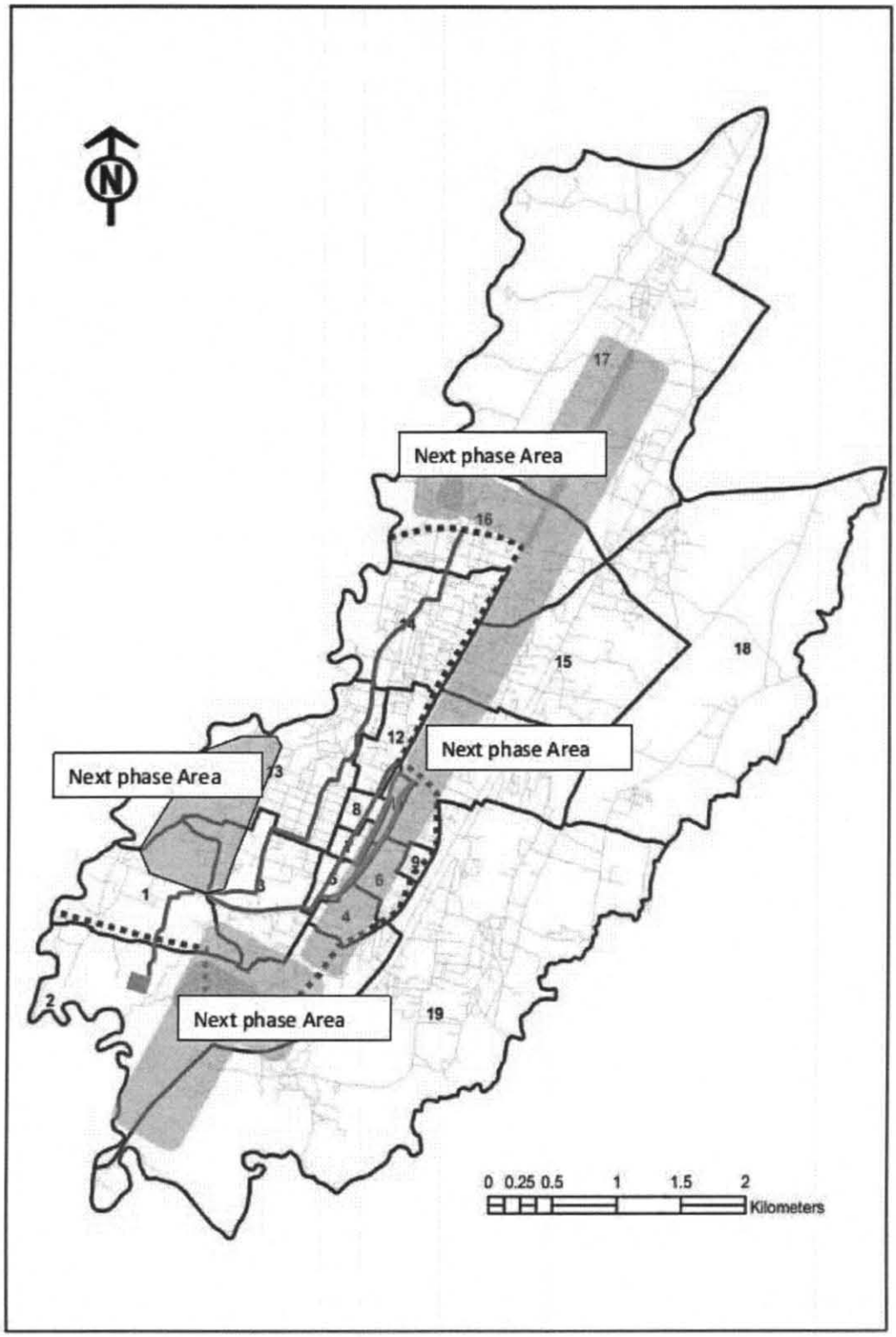


Figure 4- 3: Singha Catchment Including Next Phase Area

Apart from these two STP at Birgunj there will be onsite sanitation system for Slum & Squatter area and low pocket area where use of septic tank will be in practice.

The sewerage quantity includes the fringe area on the northern, western and eastern part of the service area noted next phase area. The sewerage generation for each five years from 2015 until the design horizon in 2035 in presented in the table hereafter for each respective catchment.

Table 4- 14: Five Years Sewage Generation for the Whole BIRGUNJ City

Year-Phase	Sirsiya- Sewerage Catchment		Singha -Sewerage Catchment		Total -Sewerage Catchment	
Wise	(Effective area 904 ha)		(Effective area 867 ha)		(Effective area 1,771 ha)	
	Population	Sewage Generation	Population	Sewage Generation	Population	Sewage Generation
Year	inhbts	l/s	inhbts	l/s	Inhbts	l/s
Year 2015	95,097	77.49	54,911	44.74	150,008	122.23
Year 2020	103,813	84.59	67,267	54.81	171,080	139.40
Year 2025	113,863	92.78	83,028	67.65	196,891	160.43
Year 2030	125,499	102.26	103,167	84.06	228,666	186.32
Year 2035	140,219	114.25	128,936	105.06	269,154	219.31

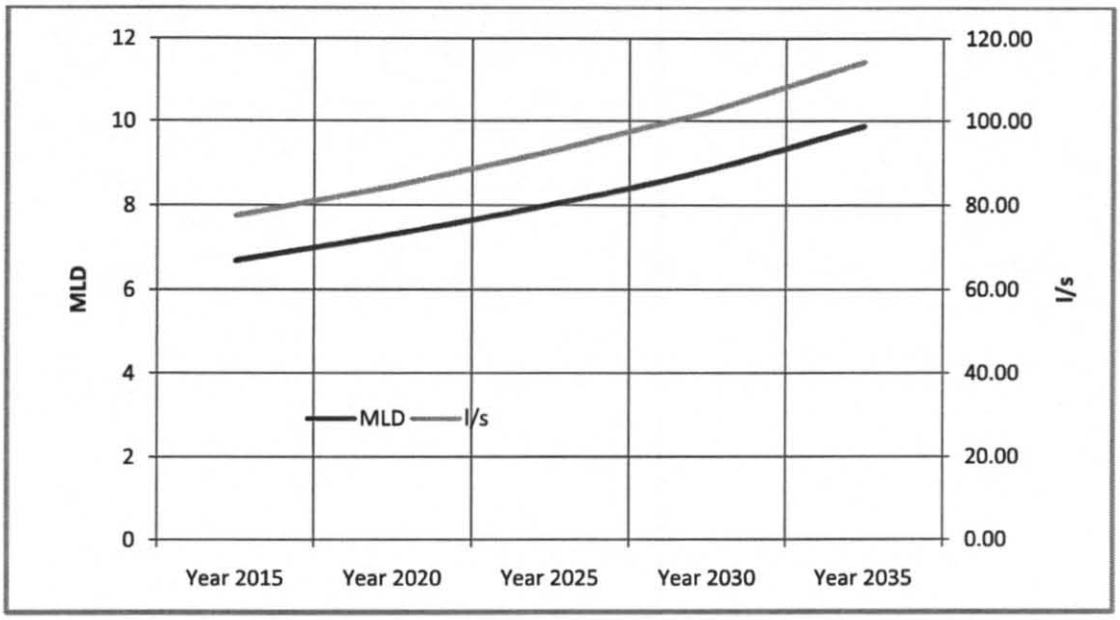


Figure 4- 4: Five Years Sewerage Generation Sirsiya Catchment

4.2.2 Catchments

Nodal Flow

As described in the Concept Report the catchment areas were studied and defined on the basis of topographical maps 1:5 000 with contour lines of the natural ground elevation and the latest GIS map of the design area. Data obtained from the detailed surveying were also used for preparation of final layouts of the collection systems.

In one side areas of the Main drain MD1, a main collectors sewer SW1 is planned with branch and sub-branch sewers. The boundary line in the east is the TRP highway from Power House Chowk to Ghantaghar Chowk. On the south of Ghantaghar Chowk the delineated area for sanitary sewerage coverage is the Railway Road in the east of TRP road and included the Collectors SW4 and SW5 which are planned to be constructed in Phase.2.

On the west side of the road the terrain is usually flat till it reaches Sirsiya River and most of the Birgunj area on the west side of collector is also served by the proposed collector. All collectors will be connected in the south at proximity of the MD1 until the STP site in Chhapkaiya area. The collector SW2 will collect the southern area of the catchment but shall be constructed in Next phase.

Flow in 2035

Following the ground elevation and slope, the ward is sub-divided and the generated flow of the corresponding population [Catchment] is allocated to the nearest node of the sewers lines. The population is calculated with the density of the ward or the adjusted density made after the consideration of the effective populated area[5].

The table hereafter summarized the population of each 19 wards showing the total area of the ward, its population and the effective area taken into account for the calculations in the service area. The table in Appendix 2 of the report presents the list of Ward with the detailed subdivisions, density, population and calculated flow.

In 2015, the detail of the population par ward is as per the following table:

Table 4- 15: Total Population in 2035, Effective Area and Flows

Ward No	Area (ha)				Population(inhbts)			Flow (l/s)	
	Total	Sirsiya Service Area		Singaha	Total	Sirsiya	Singaha	Sirsiya	
		Effective	Cultivated					Average	Design
1	146.46	70.61	75.85	0.00	14,013	14,013	0	11.418	36.717
2	149.30	68.03	81.27	0.00	18,404	18,404	0	14.996	45.364
3	57.15	57.15	0.00	0.00	12,932	12,932	0	10.537	32.958
4	18.92	18.92	0.00	0.00	2,527	2,527	0	2.059	7.337
5	9.48	9.48	0.00	0.00	1,988	1,988	0	1.620	5.146
6	15.63	15.63	0.00	0.00	3,685	3,685	0	3.003	9.316
7	9.92	9.92	0.00	0.00	1,813	1,813	0	1.477	4.841
8	5.61	5.61	0.00	0.00	1,227	1,227	0	1.000	3.149
9	13.43	13.43	0.00	0.00	4,869	4,869	0	3.967	11.473
10	42.91	14.28	0.00	28.63	7,527	2,505	5,022	2.041	6.756
11	6.63	6.63	0.00	0.00	1,822	1,822	0	1.485	4.479
12	26.41	20.51	5.90	0.00	3,632	3,632	0	2.959	9.772
13	109.26	103.61	5.65	0.00	19,739	19,739	0	16.084	52.201
14	95.60	73.44	22.16	0.00	17,727	17,727	0	14.444	44.611
15	56.77	11.67	0.00	45.10	10,631	2,185	8,446	1.780	5.801
16	129.22	77.57	12.10	39.55	33,438	23,204	10,234	18.907	56.245
17	454.33	327.08	0.00	127.25	11,038	7,946	3,092	6.475	54.044
18	482.20	0.00	0.00	482.20	31,051	0	31,051	0.000	0.000
19	507.79	0.00	0.00	507.79	71,091	0	71,091	0.000	0.000
Total	**2,337.02**	**903.57**	**202.93**	**1,230.52**	**269,154.00**	**140,219**	**128,935**	**114.25**	**390.21**
		1,106.50						**9.87**	**33.71**

[5] The effective populated area of the ward is the area less the cultivated and/or non built area of the ward.

In 2035 the total flow generation toward the Chhapkaiya STP is 9.87MLD for a total population of 140.219 in the area served.

The flow generation is based on the total population including the core areas and the peripheral population of areas to be developed later (next phase).In 2035 the corresponding population and flow related to the next phase area are as per table hereafter:

Table 4- 16: Population 2035 in Peripheral Area and Flow

Ward	Ha	Inhabitants	Area	Phase	Avg Flow	Design Flow
Ward 1	51.68	10,257	Core Area	Next phase	8.36	26.88
Ward 10	8.69	1,524	Peripheral	Next phase	1.24	4.11
Ward 15	11.67	2,185	Peripheral	Next phase	1.78	5.80
Ward 16	62.05	18,562	Peripheral	Next phase	15.12	44.99
Ward 17	327.08	7,946	Peripheral	Next phase	6.47	54.04
Total	**461.17**	**40,475**			**32.98**	**135.83**

With a population in the peripheral area of 40.475 inhabitants in 2035, the potential population covered by the present project is a maximum of 140.219 less 40,475 or 99,740 say 100,000 inhabitants with a total length scheme of 49km. of collector, branches and lateral sewers.

Flow in 2015 – House connections

At the time of construction say 2015, the maximum corresponding potential population to be served and connected, is estimated to be 67.650 inhabitants or approximately 13.530 house connections [5 inhabitants/connection] for a total length of scheme of 33km.(rate of connection of 100%).

Table 4- 17: Potential Population in 2015 to be connected in Phase 1

Year	Total population	Population next phase	Population phase 1	Ratio Ph1/Ph2	Length scheme	Ratio Inhbts/m	Avg l/s	HC
2035	140,219	40,475	99,740	0.71	49,301	2.0	114.25	19,950
2015	95,097	27,450	67,650	0.71	33,439	2.0	77.49	13,530

Due to budget constraint, it is planned to construct a reduced sewerage scheme. The table hereafter proposes for different length of scheme the corresponding total of number of connection in relation to the corresponding population in the area.

Table 4- 18: Potential Population and connection in 2015 v/s length of sewerage sewers

Parameters		Year							
Sheme	m	16,000	18,000	20,000	22,000	24,000	26,000	28,000	30,000
% scheme	%	0.48	0.54	0.60	0.66	0.72	0.78	0.84	0.90
Population	inhbts	32,370	36,420	40,460	44,510	48,550	52,600	56,650	60,690
HC	NB	6,470	7,280	8,090	8,900	9,710	10,520	11,330	12,140
Avg flow	l/s	37.08	41.72	46.35	50.99	55.61	60.25	64.89	69.52
Avg flow	MLD	3.20	3.60	4.00	4.41	4.81	5.21	5.61	6.01

For a planned length of the scheme of 16 km, the potential population to be connected is approximately 33.000 inhabitants with approximately 6,500 connections. The average flow at the inlet pumping station of the STP will be 4.41 MLD or 51 l/s

4.3. HYDRAULIC CALCULATIONS

4.3.1. Network Model

The principal objective of model built is to understand the system performance and hydraulic capacity of the proposed system within the catchment. The constructed model can replicate the true picture of the proposed system and can be used as a tool for future Capital Investment Programmes which would enhance the cost effectiveness of the investment. The hydraulic model provides the following benefits to Birgunj Municipality:

- Better understanding of the catchment including bottlenecks, system capacity issues etc.;
- Helps in better asset management planning and implementation of engineering solutions;
- Helps in efficient operation and maintenance principles;
- Helps in maximizing the benefits in hydraulic performance and system reliability.

4.3.2. Applied Modelling Software

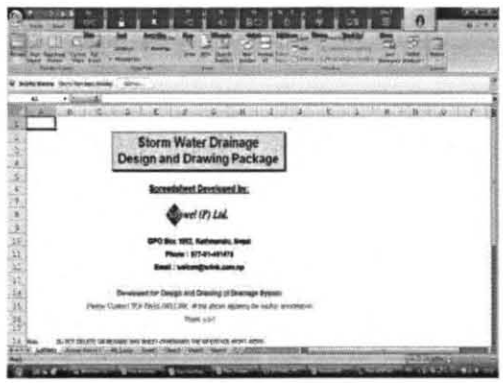
The model has been prepared and verified using EPA Storm Water Management Model (SWMM), as supplied by EPA, USA. This software is considered suitable for modeling sewerage networks and complex ancillaries. SWMM is a dynamic simulation model used for single event or long-term (continuous) simulation of quantity and quality from primarily urban

areas. The wastewater flow component of SWMM operates on a collection of sub-catchment population, daily consumption rate and the agreed peak factor.

The EPA SWMM (Version 5.5.1) software package was used to build the sewerage network model of the Birgunj sewerage system. SWMM is a hydraulic modelling and data handling software package. This software is considered suitable for modelling of sewerage networks and complex ancillaries. It allows the modelling of sewerage systems and the analysis of the results permitting identification of potential problem areas in the sewerage system and the testing of solutions.

The use of the software "EPA SWMM" for hydraulic modeling is good, but the DSC has also carried out the calculations using SoftWel Software [main collectors and branches] in order to cross check the output of SWMM and to prepare the files for the generation of long sections. The cross check of output has been made in the following calculations results: pipe size, gradient, velocity, water depth etc.

The SOFWELL[6] software is used for storm water design and design sewerage. It's calculating the hydraulics characteristics of each section and with the user-friendly interface, as an AutoCAD add-on, makes it relatively simple to access data tables and produce the long section including site information such as ground elevations, length of sewer pipes and diameters, slope, flow and even more importantly can present the result in a clear and professional manner.



4.3.3. Calculations

The Hydraulics calculations are presented in a separate Volume 1B including the data input tables and results of the calculations for each sewerage line of the Scheme.

[6] *SOFTWEL (P) Ltd. is a company dedicated in the development of Engineering Software and formally registered in the Department of Industry HMG/Nepal.*

4.3.4. Detailed Network Model

Main Collectors and Branches

The proposed sewerage scheme includes 2 main collectors for which the respective length is summarized in the table hereafter: The sewerage line SW2 **(1,174.88 m)** in the southern village of Chhapkaiya and the Line SW4 and SW5 in road 2 and road3 shall not be constructed but the calculations/sizing of the line have been made in the Model.

Table 4- 19: Main proposed Sewerage Collectors

Main collector	Area/Catchment	Length (m) Interim Report	Length (m) Draft Design	Length (m) Final Design	Comment
SW1	West area	4,963.13	4,856.58	4,856.00	Main collector to STP
SW3	Central area	2,154.70	2,162.30	2,162.00	Toll road, core area
	Total length	**(10,370.00)**	**(9,083.44)**	**7,018.00**	-

An A4 size schematic of the network model is presented in Volume 1B Part 1 Sewerage as Appendix of this report as well as a model schematic with its main characteristics [velocity, flow, etc .]. The length s interim stage include the main lines SW1, 2, 3, 4 and 5, the length at draft stage include all line except the collector SW2.

Table 4- 20: Branches Connected to the Main Collectors

Branches	Main Collector	Nb of line	Area/Catchment	Length (m)	Comment
SW9-SW32	SW1	28	Western Area from north to south	**7,528**	Branches of SW1, future connection of SW50 and SW2
SW33 and new lines 33A, B C	SW3	4	Core area main road	**669**	Connections to SW3, future connection of SW51
	-	**32**	**Total**	**8,197**	**At present Final design**

In addition to the main collectors of the present model (SW1 and SW3), the future scheme includes 32 branches connected to the main collector as shown in Table 4-20 and Table 4- 21

Table 4- 21: Next phase Main Branches Connected to the Main Collectors

Branches	Area/Catchment	Comment
SW2	South area	Southern area, connection to main collector SW3
SW4	East area	Southern area, connection to main collector SW3
SW5	East area	Southern area, connection to main collector SW3
SW50	Western area	Southern East, connection to main collector SW1
SW51	Northern area	Toll road, connection to SW4 & SW3

Lateral section

In order to minimize the investment cost of the project, it has been proposed to postpone the execution of the lateral collection sewers connected to the branches. The network will develop later stage by stage from the branches and main collector.

No lateral shall be design at this stage, but the design of the branches has been increase especially in the Aadarsh Nagar Area where house connection can be largely developed.

4.3.5. Results of Hydraulics Calculations – the Sewerage Collection system

The sewerage network design and the results that demonstrate the diameter of the pipe, the length, flow in each pipe and the velocity is shown in the model result file which is attached in Appendix to the report for the sections of the main collectors and branches sewers. The results of the sewerage scheme are presented and summarized hereafter.

The following section gives a brief description of the characteristics of the main collection networks designed under the present project. It is presented the total length of the designed system and its general characteristics such as pipe diameter, depth and road where the future main sewer of the collection system shall be constructed.

Main collector SW1 and related SW1 branches

The collector SW1 is the artery of the system from the northern part of the project area an conveys the sewerage to the STP in the southern area of Chhapkaiya. The total length of SW1 is 4.9 km from a starting diameter of 200 mm until 800mm at its connection point to the STP. The following table present the pipe repartition per diameter (mm), length (m) and depth (m):

The average depth of the pipe sections is between 3 to 5 m. A short section of 500 mm pipe is deeper than 5 m.

The SW1 collection system can be divided into four main areas:

- The first catchment area in the north of the catchment receives waste water from a small part of residential area of Dhangad To Shripur. These flows are collected from the start of the drain from node 35 to the Shreepure road to node SW1/6 in Naya Basti area
- The second catchment is collecting the remote area of Ranighat from node SW1/6 to node SW1/14 located in Ghadiharwa road close to the Ghadiharwa Pokhari.
- The third area will collect the residential/commercial area of Aadarsh Nagar from the node SW1/14 to the node SW1/18 in Hajid Ali Raod.
- The forth is mainly the main trunk to the STP and collecting the Pulchowk village. In this last section the pipe has its biggest diameter Dia 800mm and will be laid after node SW1/20 long the MD1 natural drain.

The total length of SW1 is 4.9 km of diameter 200mm until 800 from a depth of 2 m to 6 m maximum.

Table 4- 22: Length of Main Collector SW1

SW 1 - Main Collectors Length v/s depth (in m)							
Depth m	0 - 2	2 to 3	3 to 4	4 to 5	5 to 6	above 6	Total
200	249.63						249.63
250		310.47					310.47
300			120.51				120.51
400		339.20	550.77				889.97
450			828.54	930.51			1,759.05
500				509.74	193.08		702.82
800			275.32	548.81			824.13
	249.63	**649.68**	**1,775.14**	**1,989.06**	**193.08**		**4,856.58**

In each respective catchment several branches have been developed to receive waste water. The following table presents the pipe repartition per diameter (mm), length (m) and depth (m) for the 28 branches connected to SW1. The total length of branches lines of SW! is 7.6 km of diameter 200mm from a depth of 2m to 4m maximum.

Table 4- 23: Length of main branches from SW1

Main Branches to SW1 Collectors Length v/s depth (in m)							
Depth(m	**0 - 2**	**2 to 3**	**3 to 4**	**4 to 5**	**5 to 6**	**above 6**	**Total**
200	4,339.91	3,037.23	150.90	0.00	0.00	0.00	7,528.05
250	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4,339.91	**3,037.23**	**150.90**	**0.00**	**0.00**	**0.00**	**7,528.05**

Main collector SW3 and related SW3 branches

The collector SW3 is one of the main branch of SW1 collecting the sewer from the centre of the Municipality in Tribhuvan Rajpath road from at Ghantaghar Chowk at node SW3/1. The total length of SW3 is 2.16 km with a starting diameter of 300 mm until a diameter of 600mm at its connection point with SW1 in node SW1/23 in Pulchowk village

The section SW3 is relatively deep and almost all the sections have a depth between 4 to 6 m. The figure hereafter presents the water elevation profile in SW3 from the starting Node SW3/1 to node SW1/23.

The SW3 collection line can be divided into two main catchments:

- The first catchment area in the core area from the Ghantaghar Chowk along the commercial road Tribhuvan Rajpath road where connection shall be done each site of the street through services pits installed in the lateral pavement. The line will collect the sewerage from the node SW3/1 until the node SW3/9 where the line is turning at the Tax Office Chowk. The line SW3 is collecting the line SW5 at the node SW3/8.

- The second catchment is collecting the remote area of Chhapkayia from the node SW3/9 until the node SW1/23 at the connection of the SW1 in the village. The road is narrow and connections shall be made through manhole along the SW3 sewer.

The total length of SW3 is 2.1 km of diameter 300mm until 600 from a depth of 3 m to 6 m maximum (Table 4-24). In each respective catchment several branches have been developed to receive waste water. The following table presents the pipe repartition per diameter (mm), length (m) and depth (m) for the 4 branches connected to SW3. The total length is 0.70 km of diameter 200 mm from a depth of 2m to 3 m maximum (Table 4-25).

Table 4- 24: Length of Main Collector SW3

SW 3 - Main Collectors Length v/s depth (in m)							
Depth m	**0 - 2**	**2 to 3**	**3 to 4**	**4 to 5**	**5 to 6**	**above 6**	**Total**
200							
250							
300			100.51	188.90			289.41
350							
400				682.57	200.82		883.38
500					138.92		138.92
600					850.59		850.59
			100.51	**871.47**	**1,190.33**		**2,162.30**

Table 4- 25: Length of main branches from SW3

Main Branches to SW3 Collectors Length v/s depth (in m)							
Depth m	**0 - 2**	**2 to 3**	**3 to 4**	**4 to 5**	**5 to 6**	**above 6**	**Total**
200	489.44	179.79	0.00	0.00	0.00	0.00	669.24
250	0.00	0.00	0.00	0.00	0.00	0.00	0.00
300	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	489.44	**179.79**	**0.00**	**0.00**	**0.00**	**0.00**	**669.24**

4.3.6. Drawings - Long sections/Plan view

The preparation of the long section has been made using SOFTWEL software. From the topographical survey the ground level, the distance and design characteristics are entered into the software. The detailed results of the hydraulic computation for the gravity networks are

presented in forms of tables and are given in the appendices 3 of this report. An extract of the excel sheet is presented hereafter.

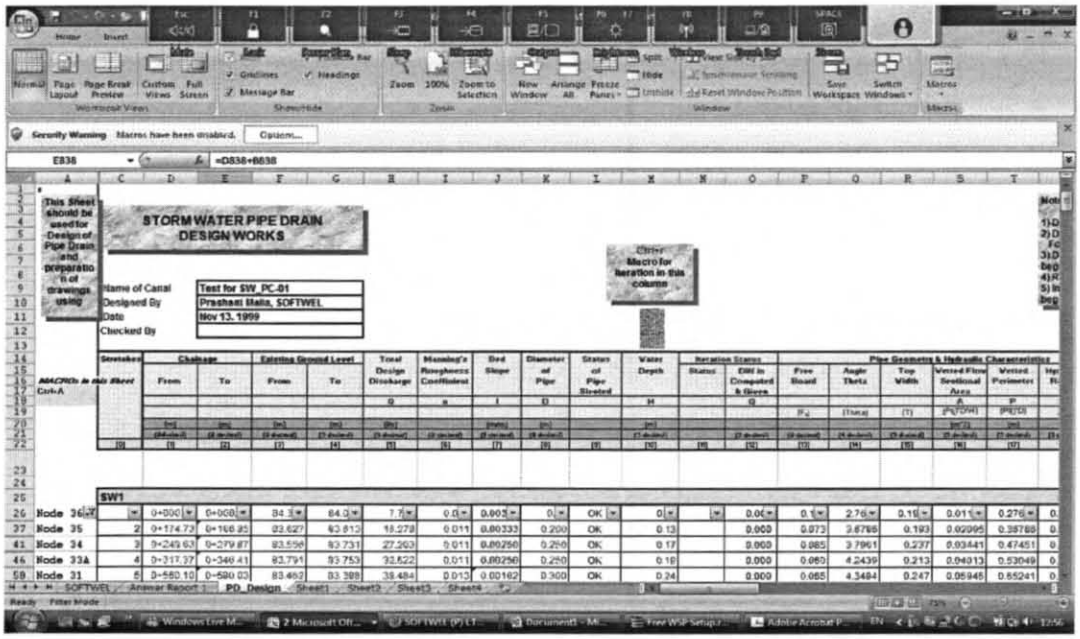


Figure 4- 5: Extract of the Excel sheet for the preparation of long sections

The corresponding long section with the design results such as finish sewerage top level, water level and design invert level are presented in an automatic long section generated by the software. The long section will show the pipe characteristics i.e. diameter, material, bedding, slope and length of each section. The related plan view and cross section will complete the design of the sewerage line. The corresponding drawings are included in the Volume 1E Part 1 Sewerage Drawings.

4.3.7. Summary of length

The Consultant has now carried out the final design of the collection system of the areas covered in the core area using the mathematical model described previously. From these calculations it is possible to summarize the pipe diameter and pipe depth within the collection network. For reference purposes, the total length of the gravity collection network in the present scheme has been determined to be around **15,3 km** (initial proposed network at draft Engineering Design 19,2 km and 49.3 km at interim stage report). The Table4-26 presents the corresponding length at different stages of the study.

Table 4- 26: Summary of length of collection scheme:

Line	Designation			Length Final	Length Draft	Length Interim
Main collectors	**Main lines**	**m**	**length**	7,019m Only SW1 & 3	9,083 m (All less SW2)	10,359 m (All mains)
	Main SW1	m	4,857			
	Main SW2	m	0			
	Main SW3	m	2,162			
	Main SW4	m	827			
	Main SW5	m	1,238			
Line	**Designation**			**Length Final**	**Length Draft**	**Length Interim**
Branches	**Branches**	**m**	**length**	8,197 m Only SW1 & 3 branches	10,295 m (less SW2 branches)	7,537 m
	Branches SW1	m	7,528			
	Branches SW2	m	0			
	Branches SW3	m	669			
	Branches SW4	m	1,242			
	Branches SW5	m	783			
Lateral s	No line at draft and final design			0 m	0 m	31.405 m
	Total Length			**15,216 m**	**19,192 m**	**49,301 m**

The excavation depth is a parameter which greatly determines the rate of sewerage piping laid by the contractor. Larger equipment is required, more time is required to excavate the trench, and more safety precautions such as support beams which need to be placed are some of the elements burdening the contractor with time and monetary costs. Hence, since the excavation depth is a parameter which greatly influences the cost of the network, this parameter was also investigated and presented in the following figures.

The following table show the pipe diameter with the depth's distribution for the main collector and branches at this stage of the project.

Table 4- 27: Summary of length of collection system:

Sewerage Collectors Length v/s depth (in m)							
Depth in m	**0 – 2**	**2 to 3**	**3 to 4**	**4 to 5**	**5 to 6**	**above 6**	**Total**
200				0.00	0.00	0.00	0.00
200 PE	5,078.98	3,217.03	150.90				8,446.91
250	0.00		0.00	0.00	0.00	0.00	0.00
250PE		310.47					310.47
300	0.00	0.00	221.02	188.90	0.00	0.00	409.92
350	0.00	0.00	0.00	0.00	0.00	0.00	0.00
400	0.00	339.20	550.77	682.57	200.82	0.00	1,773.35
450	0.00	0.00	828.54	930.51	0.00	0.00	1,759.05
500	0.00	0.00	0.00	509.74	332.00	0.00	841.74
600	0.00	0.00	0.00	0.00	850.59	0.00	850.59
700	0.00	0.00	0.00	0.00	0.00	0.00	0.00
800	0.00	0.00	275.32	548.81	0.00	0.00	824.13
	5,078.98	**3,866.70**	**2,026.55**	**2,860.53**	**1,383.41**	**0.00**	**15,216.16**

The Figure 4-6 illustrates (1) the pipe diameter v/s length and (2) the length v/s length of the sewerage collection system at this stage of the project.

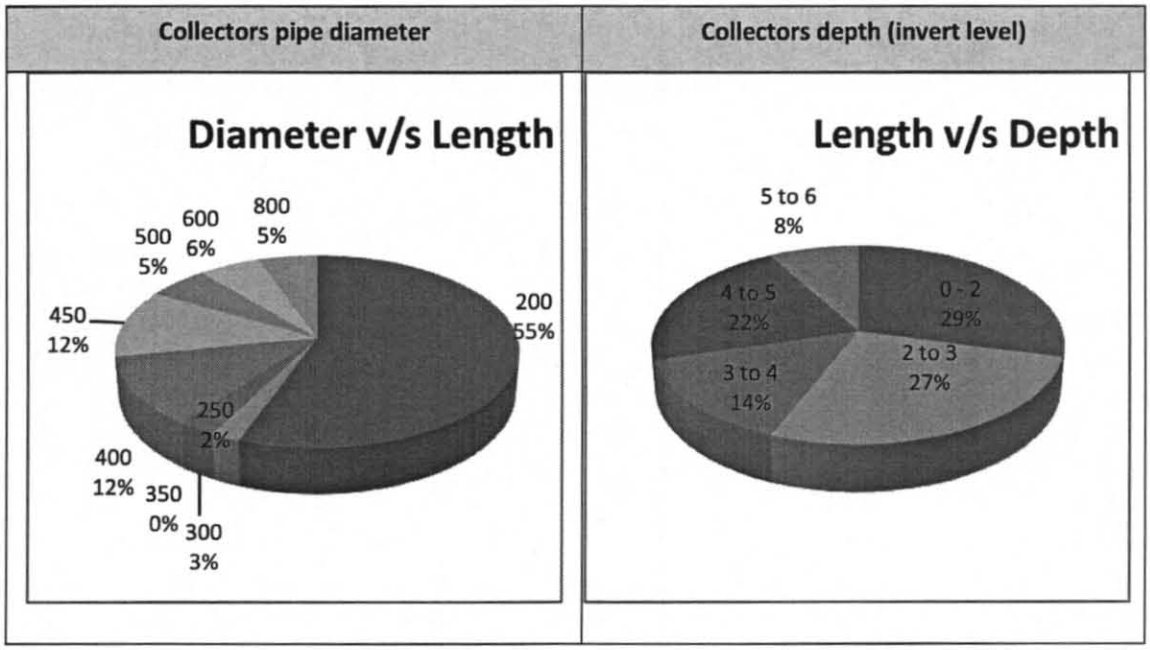


Figure 4- 6: Summary Sewerage pipe Distributions 1

It is noted that 55% of the length of pipes are small diameter 200 (HDPE) and 28% are large diameter 450mm and above. In average 56% of the pipe length has a depth below 3 m and only 8% of the pipe length has a depth between 5 to 6 m.

4.3.8. Connection points – Main collector / branches lines

In order to analyse the characteristics of the connection points and detect any drop between sewers lines such as branches and collectors, the DSC prepared a table showing for each node its ground level and invert level. The table highlight the drop and for any drop more than 090 m the connection point shall be made throughout a drop manhole. The corresponding construction details are presented in the standard drawings.

Table 4- 28 Check list of pipe junctions:

Main Line	Node No	Dia mm	GL m	IL m	Branch Line	Dia mm	GL m	IL m	Drop m	Drop >0.9
SW1	35	200	83.627	81.759	SW22	200	83.627	81.759	0.00	0.00
	34	250	83.556	81.460	SW24	200	83.556	81.460	0.00	0.00
	33A	250	83.791	81.290	SW21	200	83.791	81.290	0.00	0.00
	31	300	83.462	80.634	SW20	200	83.462	81.334	0.70	0.00
	4	400	84.035	80.315	SW23	200	84.035	81.315	1.00	1.00
	5	400	82.841							
	6	400	82.553	79.539	SW19	200	82.553	79.539	0.00	0.00
	7A	400	82.764	79.221	SW18	200	82.764	79.221	0.00	0.00
	7	400	83.164							
	8	450	82.871	78.993	SW17	200	82.871	79.093	0.10	0.00
	9	450	82.688	78.723	SW16	200	82.688	79.806	1.08	1.08
	9A	450	82.784	78.680	SW15	200	82.784	79.980	1.30	1.30
	10	450	82.769							
	11	450	82.596							
	12	450	82.328							
	13	450	82.179	78.166	SW14	200	82.179	78.866	0.70	0.00
	14	450	81.985	78.013	SW13	200	81.985	79.513	1.50	1.50
	14A	450	81.77	77.940	SW12A	200	81.77	78.34	0.40	0.00
		450	81.77	77.940	SW12A1	200	81.77	78.29	0.35	0.00
	15	450	81.737							
	15A	450	81.287	77.855	SW12B	200	81.287	77.855	0.00	0.00
		450	81.287	77.855	SW12B1	200	81.287	78.455	0.60	0.00
	15B	450	81.301	77.770	SW12C	200	81.301	78.07	0.30	0.00
		450	81.301	77.770	SW12C1	200	81.301	77.97	0.20	0.00
	15C	450	81.185	77.679	SW12D	200	81.185	77.929	0.25	0.00
		450	81.185	77.679	SW12D1	200	81.185	77.879	0.20	0.00
	16	450	81.01							
	16A	450	81.241	77.555	SW11A	200	81.241	77.65	0.09	0.00
		450	81.241	77.555	SW11A1	200	81.241	77.65	0.09	0.00
	16B	450	81.357	77.446	SW11B	200	81.357	77.546	0.10	0.00
		450	81.357	77.446	SW11B1	200	81.357	78.096	0.65	0.00
	16C	450	80.685	77.355	SW11C	200	80.685	77.955	0.60	0.00
		450	80.685	77.355	SW11C1	200	80.685	78.005	0.65	0.00
	17	450	81.416	77.301	SW10	200	81.416	79.001	1.70	1.70
	18	450	81.853							
	19	500	80.753	76.396	SW9	200	80.753	77.896	1.50	1.50
	20	500	80.495							
	21	500	80.969							
	22	500	81.109							
	23	800	80.139	75.315	SW3	600	80.139	75.611	0.30	0.00
	23B	800	80.139							
	24	800	79.693							
	25	800	79.693							

Main Line	Node No	Dia mm	GL m	IL m	Branch Line	Dia mm	GL m	IL m	Drop m	Drop >0.9
SW3	1	300	83.006							
	2	300	83.037							
	3	400	82.921							
	4A	400	82.396	77.844	SW3A	200	82.396	80.339	2.50	2.50
	4	400	82.342							
	5	400	82.076	77.624	SW3B	200	82.076	79.624	2.00	2.00
	6A	400	81.973	77.272	SW3C	200	81.973	79.475	2.20	2.20
	6	400	82.082							
	7	400	82.107							
	7A	400	82.038							
	8	500	81.934	76.586	SW5	450	81.934	77.3	0.71	0.00
	9	600	81.697							
	10	600	81.893							
	11	600	81.934							
	12	600	80.333							
SW4	1	200	83.417							
	2	200	83.206							
	3	200	83.575	79.778	SW32	200	83.575	79.778	0.00	0.00
	4	200	83.327	83.327						
	4A	200	83.267	79.059	SW31	200	83.267	79.059	0.00	0.00
	5	200	83.089	78.863	SW30	200	83.089	78.863	0.00	0.00
	6	250	82.567	78.522	SW29	200	82.567	78.522	0.00	0.00
	7	250	82.415							
SW5	1	300	83.398							
	2	400	82.795							
	3	400	82.898							
	4	400	82.795							
	5	400	82.197							
	6	400	81.791							
	8	400	82.664	77.738	SW4	250	82.664	78	0.26	0.00
	8A	450	82.652	77.701	SW28	200	82.652	79.701	2.00	2.00
	9	450	82.679							
	10	450	82.637	77.450	SW27	200	82.637	78.45	1.00	1.00

4.3.9. Entry to the STP

Following the results of the hydraulic calculations the average flow at the entry of the STP in the main line SW1 is 114.25 l/s for an average daily of 9.871 MLD. The pipe diameter is Dia 800 mm with an invert level of 74.33 m at the inlet chamber of the Pump House with a cover of 3.527 m above crown.

The X, Y and Z of the connection point is: X=585435.782, Y= 2987630.149, Z=78.957m.

4.4. COST ESTIMATE

4.4.1 Quantities and rates

Quantities

The quantities of works for the calculation of the cost estimates (CE) and the preparation of the Bill of Quantities (BOQ) are based on the technical assumptions and requirements defines to maintain the quality, live time and stability of the system. The standard drawings give the dimension of the structures and the long section the conditions for installation including location depth, length required for the calculations. The others assumptions for calculations are presented in the draft report and have been slightly modified to take into account the improvements and comments on the draft Report. In addition to the reduction of the sewerage line to be constructed, the main modifications are the following:

- Optimization of reinforcement in manhole bottom slab
- Use of M20 Concrete in general of reinforced concrete
- Execution of the soling in granular materials
- Reduction of the pipe surrounding and crown cover with selected materials
- Inlet chamber/service chambers in Masonry
- Increase the spacing of the Arch concrete blocks for HDPE to 3 m instead of 2m.

The quantities have been recalculated using the previous tailored model for each the work items such as excavation, backfill, pipe, concrete, surface removal and reinstatement, service pit, service pipe, house connections, etc...

The Cost Estimate is divided in four categories for which the quantities of works shall be multiplied by the unit rates to calculate the cost of the works. The four main sections/parts of the BOQ are the following:

- Sewer pipes works
- Manhole works
- Surface reinstatement works
- House connection works

The respective quantities of the main items of works are presented in the following table:

Table 4- 29: List of main works (Main sewers and Branches)

Works	Comments	Unit	Qty
Sewers Pipe	RCC/HDPE	m	15,216
RCC NP3 pipes	Main pipes 200-800 mm	m	6,459
HDPE pipes	Sewers pipe 200-250 mm	m	8,757
Manhole	Masonry an RCC	No	447
Surface Reinstatement	Gravel/Concrete/Asphalt	m	14,500
House connections	Connections	No	6,088
Service & HC pipes	uPVC 110/160 mm	m	26,379
Service pits	Masonry chambers	No	614

Rates and unit Prices

Based on the DSC experience of similar works and the market prices the list of the basic prices to be use for the calculations has been prepared. The unit prices are based on recent prices from manpower, machinery and materials. As per the quantities in the Cost estimates the unit prices are made for the four main sections/parts as presented hereafter

4.4.2. Cost Estimate of Main sewers

The Cost estimates for the main collectors and associated branches are calculated for pipe works, manhole surface removal and reinstatement and house connections works of the sewerage scheme. The cost estimate is the result of the multiplication of the quantities by the unit price i.e. basic rates. The table hereafter gives the results of the calculations:

Table 4- 30: Sewerage Costs Estimate (NRs)

Summary of costs - Sewerage Scheme				**NRs**
Collectors, branches and laterals		**unit**	**Qty**	**Total Cost**
Part 1	Pipe works	m	15,216.16	205,684,774
Part 2	Manhole works	no	447.00	51,105,053
Part 3	Surface Reinstatement works	m2	14,500.89	31,705,113
Part 4	House connections works	no	6,088.00	76,723,491
			Total	**365,218,431**

The detailed calculations and the cost estimates of the main component are presented in Volume 1D Cost Estimate and BOQ as Appendix to the final report. The Volume includes the

assumptions, the calculations tables for main collectors and branches, the summary tables of quantifies and costs of the proposed work items.

4.4.3. Total Costs estimates

Based on proposed design criteria and assumptions, the catchments and the related population, the modeling and pipe sizing, with the quantities of works calculated by the DSC, the total price of the proposed system is presented hereafter.

The total cost estimates for the sewerage scheme as designed at Final Design stage is given in the following table for the main collectors and associated branches of the sewerage scheme.

Table 4- 31: Sewerage Costs Estimate (NRs)

Summary of costs - Sewerage Scheme				**NRs**	**Cost/m**
Collectors, branches and laterals		**unit**	**Qty**	**Total Cost**	**Avg**
SW1	All works	m	4,857	152,466,110	31,394
SW3	All works	m	2,162	86,131,544	39,833
Branches of SW1	All works	m	7,528	115,649,837	15,363
Branches of SW3	All works	m	669	10,970,939	16,393
	Total		**15,216**	**365,218,431**	24,002

The total cost of the sewerage system as proposed by the DSC at Final Design stage has been estimated to the total amount of **NRs 365,218,431.00**

The detailed calculations and the cost estimates of the main sewerage line and associated branches are presented in Volume 1D as Appendix of the final report. The calculations include the assumptions, the tables for calculations, summary tables of the scheme for the proposed work items.

4.4.4. Bill of Quantities

Bill 2 – Civil Works total amount

The format of the bill of Quantities (BOQ) for the tender documents is prepared from the works items of the Cost Estimates. According to the Nepalese standards the BOQ will include all basic quantities and therefore some of the items included in the Cost Estimate will be break up in

individual basic work items such as concrete, formwork reinforcement, plastering. Other item expressed in m2 shall be transformed in m3 as per standard practice. In addition an identical description will apply in the description of the items as they unit rates will apply uniformly to the four components of the Tender i.e. STP, Sewerage, Drainage and Road.

The Final BOQ for the tender document is presented in Volume 1D Cost Estimate and BOQ as annex to the report. The table hereafter presents the Bill 2 "Civil Works" of the final cost the BOQ including the four component of the Tender document and the Bill No 2B related to the Sewerage Scheme as described in the present Final Report.

Table 4- 32: Bill 2 Civil Works (NRs)

No	Component	Spec's	Total Cost
2A	Sewerage Treatment Plant	-	83.383 MNRs
2B	Sewerage	15,216 m	365.218 MNRs
2C	Drainage	53,461 m	1,617.949 MNRs
2D	Road	11,306 m	429.144 MNRs
-	**Total Bill 2 – Civil Works**		**2,495.695 MNRs**

Bill 2 – Sewerage and drainage Cost

The table hereafter presents the Bill 2 "Civil Works" of the final Cost Estimate for Sewerage and Drainage as included in the BOQ of the Tender document. This refers to the Bills No 2B and 2C respectively for the Sewerage and the Drainage Scheme as described in the present Final Report.

Table 4- 33: Sewerage and drainage Cost

No	Component	unit	Length	Total Cost mNRs
2B	Sewerage	m	15,216	365.218
2C	Drainage	m	53,461	1,617.95
-	**Total Bill 2B & C**	**m**	**68,677**	**1,983.17**

4.5. SEWERAGE DESIGN DRAWINGS (IN SEPARATE VOLUME)

The design drawings related to the proposed sewerage collection scheme are included in a separate Volume 1E-A. The volume includes the following drawings related to the present sewerage scheme:

- 1-General drawing
- 2-Layout drawings
- 3-Long sections, plan view and cross sections drawing
- 4-Standards drawings

5. STORM DRAINAGE SYSTEM

5.1 INTRODUCTION

5.1.1 General

Each town has a natural system of drainage which is governed by the physiographic profile of the region. Over the years, this town has not only expanded spatially but has also used the available urban space more intensely. In the process, the natural system of drainage has changed substantially. This often results in flooding and water-logging causing considerable inconvenience and economic losses. Due to these recurring problems, a suitable integrated surface drainage system needs to be developed.

Objectives:

The basic objectives of surface drainage project are to develop and maintain an effective network of surfaces inlet structures connected to an underground primary, secondary and tertiary drains system. The primary aim of storm drain design is to limit the amount of water flowing along the gutters, or pounding at the sags, to quantities which will not interfere with the passage of traffic for a common design storm. The inlets are located at points and at such intervals to intercept flows and control the water's spread width into the travelled lane. Storm drain facilities should provide enough combined capacity in the storm drain and the street typical to convey the major storm runoff through the roadway right-of-way in a manner which adequately drains the roadway and minimizes the potential for flooding and erosion to properties adjacent to the right-of-way.

To ensure natural drainage, it is essential that the bed levels of the primary, secondary and tertiary drains be inter related. To develop, operate and maintain the drainage system is a pre-requisite for developing the primary, secondary and tertiary drain network where tertiary drain to be given and maintained by Urban Local Bodies i.e. Municipality etc.

Selected Option:

The selected option and proposed system includes a complete new separate sewerage and drainage system using partially the existing drain where appropriate. This option was presented in the Concept Plan report dated august 2012.

The advantage of the separate system is as follows:

- It is cost effective as small size pipes are used but additional cost of pipe laying; pavement works etc. are required for the sewerage network.

- The MD1 main drain will become a friendly environmental natural open drain and cover required.
- Does not require any overflow structures
- The sewerage treatment plant will also be optimized as no storm water flows will enter into the plant.

Constraints:

The house plumbing will need to be changed for those properties having a common outlet to the combined sewerage system. No storm and/or drain water may be permitted to enter the sewerage system and overload the system. Provision should be made for a separate and independent storm/rain water disposal system leading to the public storm-water drain or natural watercourse for individual buildings.

Due to flat terrain, the sewer line also need to be laid at less slope resulting in velocities less than self cleaning velocity thus requiring regular flushing and cleaning.

The Consultant presents in the following sections the philosophy of the design and outlines the main criteria followed during the design. This section should also be read together with the relevant Hydrological and Hydraulic reports of the design part of the present report. The hydrological and hydraulic sections shall be followed by the description of the proposed system and corresponding estimates.

5.1.2. Current Situation and Poor Drainage System

Introduction

As discussed in the previous report on the subject, in Birgunj, there is an acute lack of drainage system. The existing drainage system in several locations in place does not function well as these have. Natural surface drainage patterns in Birgunj have altered due to differential filling of allotments and roads as well as the conversion of natural wetlands into urban settlements and associated back fillings.

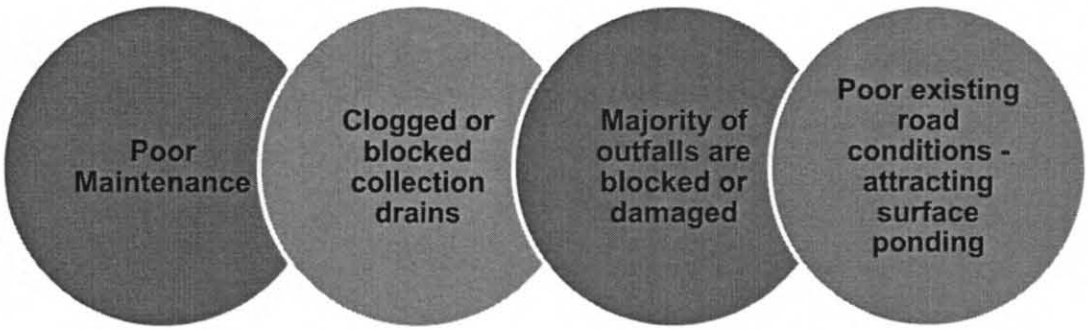


Figure 5- 1: Keys Projects Drivers

The key driver for an immediate solution for the drainage system is the public health and safety. The fundamental ideology is to protect the public health, safety, welfare, property damage and extreme inconvenience to the public movement.

Considering the level and quality of wastewater management in Birgunj, flooding exposes the residents of Birgunj and water wells are subjected to risk of contamination with raw sewage and associated diseases. In view of this, an attempt was made to address the majority of these concerns and provide techno-economical solutions which would enhance the living conditions for citizens of Birgunj.

Birgunj is undergoing rapid urban development resulting increase in population for which the existing drainage infrastructure requires immediate attention towards upgrading the system. Due to the recent urbanization, the percentage of impermeable areas such as roads and high density town centers with paved areas has been significantly increased.

The topography of Birgunj is such that it cannot drain to any nearest outfall points and the current ground level in many areas is very close to the groundwater level. The proposed drainage system design shall take these factors into account.

Keys Project Issues

As part of this current study, evaluation of possible solutions to mitigate the current under-capacity problems within the network will be carried together with the proposal for new drainage system within Birgunj. Identification of bottle-necks and provision of new drainage system can be achieved either through numerical modeling or physical observation during severe storm conditions.

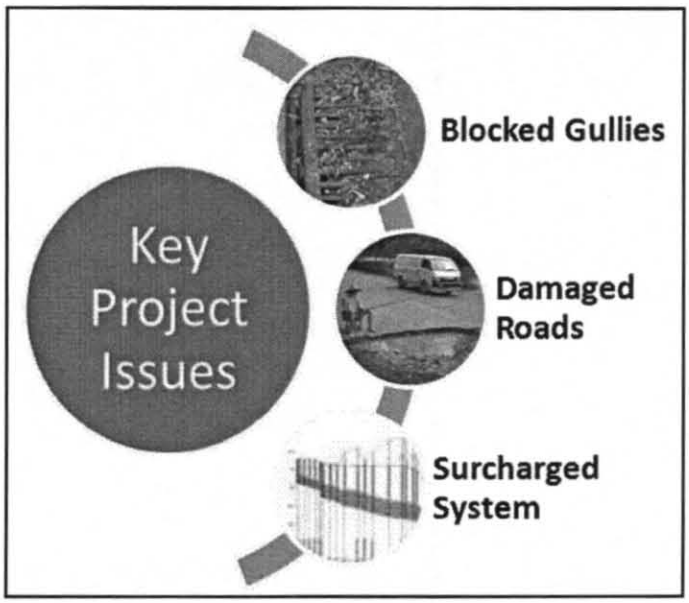


Figure 5- 2: Key project issues

Significant Man Made Features

A number of significant man made features impact on the natural drainage characteristics of the catchment.

There are two irrigation canals running north to south in the catchment area. The origin of both these canals is the Main Gandak Canal located on the north of Birgunj municipal area. One of the canals is located in the west of the city whereas the other is located on the east side of the city. The eastern side canal is intercepting almost the whole catchment from north to south whereas the western side canal is intercepting about two third of the catchment starting from Main Gandak Canal in north to Ranighat Bridge on Sirsiya River in the south.

This canal is embanked above natural ground level, on both sides, and the embankments have the effect of forming an earth dam across any low areas which the canal traverses, preventing natural drainage of such areas in the easterly and westerly direction towards the Singha and Sirsiya River respectively.

Two large roads have been constructed through Birgunj municipal area, namely the Main Bypass road and the City Main Road. The main Bypass Road is located in east of the city core area whereas the Main Road passes through the centre of the city. These roads are generally built above the prevailing ground levels hence act as physical barriers to the natural drainage of storm water across their alignment.

Other features which impact the catchment are local natural small size drain (Nala) which starts from Shreepur area and finally discharge at Sirsiya River at upstream of the Ranighat bridge. It has an appreciable draining capacity and it flows from northeast to south west direction. This natural drain can be well used for discharging storm water falling under its catchment area and improvement of this natural drain should be considered.

After a careful consideration of the constraints mentioned above, due to the low gradients, natural and man-made barriers, and the tendency to encounter shallow flood retention prone areas, Birgunj is indeed, a challenging location for the development of drainage and sewerage network systems.

5.1.3. Existing Drainage Network

Details of the existing system

Birgunj municipality has only storm drainage system. A field Inventory Survey was carried by DSC to find out the details of the existing drainage network system in the Birgunj Municipal area. During the Inventory Survey the drainage networks all over the urban municipal area was taken into consideration. During the survey works the type of drains, its physical condition, direction of flow, its size (breadth and width), location of the discharge point and its existence either on one side or on both side of the road was recorded.

The earthen drains on the side of black topped road or along the gravel road within the municipal urban area were not measured during the inventory survey. The length of the drains was measured with the help of available soft drawing. No measurement could be made for the main drain MD1 as it has wider in section, structures over it at few locations and some length spread on surface (downstream of Khetan Campus).

The total length of the drain was found to be about 71.3 km. The length of Brick Masonry (BM) drains, RCC drains and main drain MD1 were found to be 56.5 km, 9.9 km and 4.9 km respectively. The details about these drains are given in tabular for in Appendix to the present report for reference. At the moment, the drainage network system is severely stressed and causes flooding along major streets under severe rainfall events. The detailed size drains is presented in the following table for each catchment as defined later in this section.

Table 5- 1: Length of Existing Storm Drains

Catchment	Small Width <0.40 m	Medium 0.40<width< .0.60	Large Width > 0.60 m	Total length m
3	966	771	390	2,127
4	2,909	1,357	194	4,460
4A	5,752	679	734	7,165
5	3,448	2,476	826	6,749
6	1,139	1,596	160	2,895
8	1,185	845	165	2,195
9	13,002	10,597	2,351	25,949
10	3,760	2,779	8,297	14,835
Total	**32,161**	**21,099**	**13,117**	**66,376**
%	48%	32%	20%	100%
Size	20-40	40-60	>60	All size

The details about the drains with their location are given in tabular form in Volume 1B Appendix A of the Final Report.

In general the existing drain located along the new drain and/or parallel shall be abandoned as too small and/or inadequate to be part of the new drainage scheme. Some existing drain in road where no new system is developed may be cleaned, covered and integrated in the new system. The detail instructions shall be given during the construction of the works.

From the inventory of the existing drains, the tentative summary of the total length of existing drain to be replaced, re-commissioned/renewed or decommissioned is forecast in the BOQ of each respective catchment. Following the local conditions, the final decision and action shall be made during the execution of the works under the instruction of the Engineer.

The existing drains to be reconditioned are in general in road where the new drainage shall not be constructed, the lines to be abandoned refer to some drains in parallel of new drains which therefore become unnecessary. The replaced drains are drains on the route of the new drains.

Issues

The key issues related to the ineffective and malfunctioning of existing drainage system are:

- → Majority of the existing drainage system is deteriorated and needs an immediate attention for repair;
- → In some cases the existing system was disjointed;
- → Clogged drains and blocked outfalls.

Root Causes

The primary root causes for the above issues are:

- → Poor design and not built according to the design specifications;
- → Illegal dumping of debris;
- → No or limited construction supervision;
- → Poor technical review of design and construction;
- → Weak institutional capability and capacity;
- → Design considerations are not in line with the urban development pace;
- → No proper planning to rehabilitate or repair;
- → Piece-meal planning and implementation;
- → Illegal dumping of solid waste in storm drains or open ditches.

Strategies

It is essential to understand the reasons for such flooding and if required to upgrade the drainage system along the surcharged and flooding zones. It is also necessary to jet the drainage pipes on regular basis to flush out the aged sediments, which are responsible for the reduced drain capacity. In order to achieve the highest standards in providing the best urban drainage solution to the Birgunj Town, the following strategies shall be considered during the current investment program:

- → Better understanding on the catchment and existing assets;
- → Regular cleaning and maintenance programs;
- → Capacity building in design, supervision and maintenance areas;
- → Community awareness programs;

- → Understand the hydraulic deficient areas and minimizing the frequency of flooding through advanced technologies such as retention ponds, swales *etc.*
- → Enforce solid waste disposal regulations and provide street garbage bins at key corners of the streets for effective and efficient collection.
- → Allowing maximum usage of the existing assets.

For the sustainability of road surfaces, it is important that there is proper consideration and design for the safe carriage of storm-water to natural drainage courses without causing flooding, erosion or other environmental degradation. Rather than combined sewerage, experience demonstrates that the drainage of storm-water is best handled in surface drains.

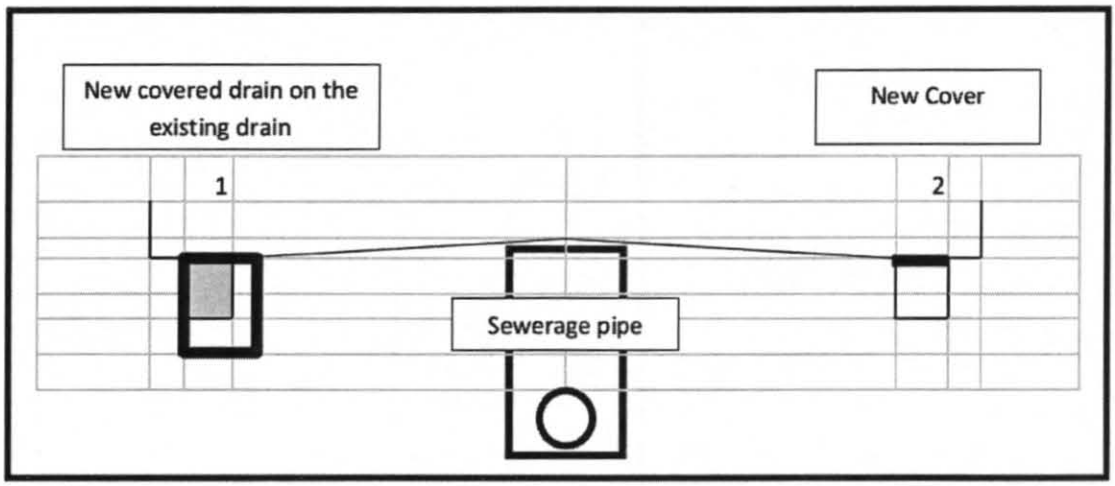


Figure 5- 3: Typical road crossing and drains

The tentative length of existing drain to be replaced, re-commissioned/renewed or decommissioned is included in the Cost Estimates of each respective catchment

In core urban areas, space is at a premium, the planned new drains shall be normally covered with removable cover-slabs at the location of the existing drain which is going to be decommissioned (Refer 1 in figure below). The new drain shall be in one site of the road and the parallel drain in the other side of the road shall be either renewed/connected to the new drain [clean and covered] or decommissioned following the local conditions (Refer 2 in figure below). The existing drain in streets where no new drainage shall be developed shall be renewed i.e. clean and covered.

It is important that these are properly designed and constructed to resist the high loading which may be applied from high axle loads. At the same time such covers should be able to be readily removed for periodic cleaning, particularly in advance of the rainy season or alternatively

access point with covers shall be installed along the drain especially for deep drain a shaft will be construct to access the drain below.

5.1.4. Severe Water Logging

The drains in the core area are in effect open sewers. They present a clear and present threat to public health. The black water flows downstream to discharge directly into India in contravention of the Basel Convention. Moreover, to the east of the built up area, water logging is a common phenomenon.

In extreme cases of torrential rain, the existing open drainage network clears water within an hour, various other parts of the city become completely submerged and inundated for many days; indeed some areas stay flooded for months into the dry season. This situation was aggravated historically by landowners selling off their topsoil, effectively causing unnatural swamp and ponds within the urban area. Indeed the status of drainage in Birgunj Municipality can be described as dire.

The drainage networks are not functioning to capacity due to obstructions from solid waste dumping. Various obstructions to the main drainage causing major problems that must be rectified.

During the monsoon, flooding is becoming more frequent in Birgunj, affecting public buildings as well as private houses and industries. Without drainage, storm water generally flows along roadways, eroding the surface and edges of the roads and damaging buildings. Even in parts of the towns where a drainage system exists, flooding still occurs. The reasons include the following:

(i) The drains are blocked by solid waste disposal and silt coming down from agricultural areas, or from unpaved roads or, more often construction materials deposited on roadsides also wash into drains and contribute to their blockage.

(ii) The base and walls of the drains have been eroded consequently; the earth around the drains accumulates inside the drains and blocks them up.

(iii) There is an excessive growth of vegetation in the drains that is not cleared out.

(iv) Little attempt has been made to repair and maintain the existing drainage channels.

5.1.5. Existing Flooding Issues in Birgunj

Introduction

Draining storm water inundated during wet monsoon period is the environmental issue. The land is very gentle and the infiltration rate is very low as the soils are mixed with silt and clay. Moreover, the construction of infrastructures such as roads without adequate drainage provision has exacerbated the problem of inundation. Since, the present system of the sewage disposal is the on-site sanitation with septic tank and soak pits, black water is rarely discharged into open drains and rivers. However; the grey water is discharged directly to the drain and rivers. The water from those rivers is used for washing utensils, cloths and vegetables and for bathing and animal feeding. So, the discharging of grey water without further treatment has increased the risk of health hazard.

Flooding and river bank cutting is common problem. Bank cutting in different reaches of Sirsiya River in Birgunj has threatened settlements, infrastructures and cultivated land located in near the river bank. In some specific area of Birgunj City, there are some scattered low-lying areas which are subjected to water-logging during and after heavy rainfall. The depth of stagnant water varies between 0.25 m to 0.35m and usually lasts for 4.00 to 6.00 hours. The water — logging situation is likely to further aggravate in the years to come with growing urbanization.

Flooding Areas inside Core Area

a. Rani Ghat Shreepur Area – Catchment 4 /4A

This area includes Shreepur Road, Dhangad Tol, Shreepur Tinphedia Chowk and surrounding areas. These areas are under low elevations having lacks of proper drainage outlets. The topographical gradient of these areas is flat and the existing drain networks are of inadequate capacities. These drains are also not in fully operable condition due to the deposition of garbage, debris, plastic, silt and other wastes.

Storm drains of suitable capacity with proper gradient have been proposed in this area to drain off the storm flow through proposed Outfall No.4 located just downstream of the Ranighat bridge.

b. Vanu Chowk Area. – Catchment 8

Bhanu Chowk is situated on Main Bypass Road connected with Ghantaghar through Ghantghar Link Road. The connecting road to National Medical College starts from Bhanu Chowk and runs towards east. The area east of Bhanu Chowk along this road is highly affected during peak monsoon time. The road section between Bhanu Chowk and Vishwa Chowk (about 200 m) in

length gets highly affected and the area south of the road (Paddy field) gets fully submerged and flooded.

The main reason of this area for getting flooded is the surface runoff coming partially from Ward No.10, 15 and 18 and flowing towards Tallo Naguwa village. After the construction of the storm drains in these wards, the surface runoff will significantly reduce and will be collected through the Diversion Drain 12 to be constructed along this road and to be discharged to Singha River through the Outfall No.6 located at south east corner of the National Medical College.

c. Aadarsh Nagar (AN) – Catchment 9

This area is supposed to be the main business center and the heart of the city. Though this area was planned many years ago but proper provision was not made to collect the storm water from the streets. The existing east –west direction drains located in this area between the two rows of building are being used as combined sewer. In one hand, these drains are itself inadequate in size and capacity and on other hand these are full of garbage, plastics, silt and other wastes. During the heavy rainfall these drain are not capable to drain off the storm water and there is accumulation of water on the street. The maximum accumulation of storm water takes place in the main Chowk (Junction) area around the Kailash Hotel which is situated comparatively at lower elevation.

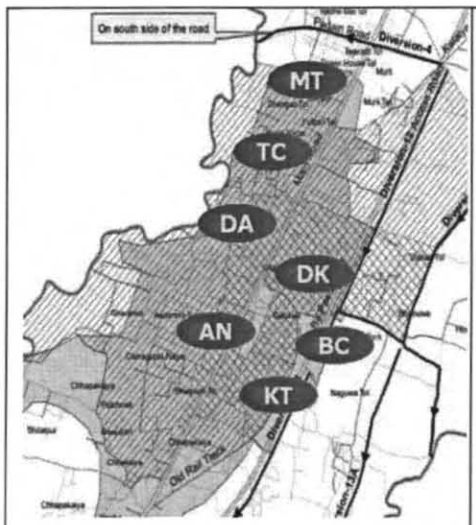
Provision of storm drain in the centre of the road with side drain and catch pits on both side of the road has been proposed on all the streets in Aadarsh Nagar area. It has been estimated that this provision will provide the facility of full evacuation of the streets during the monsoon season.

d. Panitanki Hulaki Road Area (Daak Road - DK) – Catchment 9

This area covers the southern part of Ward No. 15 and the northern part of Ward No. 10. This area has been bordered by TRP in west and National Treading Road in north. This area has been changed into chronic flooding area of the city from last few years. The main street Daak Road gets inundated even more than one meter at some locations. Almost the ground floor of most of the buildings situated on both sides of the road in southern part are submerged for days every year during the peak wet seasons and the people have no access outside. The existing brick masonry drain on the east side of the Daak Road receives storm flows from its branch road and also flow from southern part of Murali Village. There has not been any provision of cross drainage along this road and proper outlet for the drain in downstream area which is the major causes for severe flooding every year.

To solve this problem the diversion of storm flow at different locations are proposed. The storm flow from Murali and National Treading road has been proposed to divert to Diversion 12 along Kabi Siromani Marg. A second diversion has been proposed at Diversion12 near Vishwa Road Junction. The remaining flow has been proposed to be diverted to Diversion 12 near Bhanu chowk. This storm drain will pass from Dr. R P Sah Chowk/clinic to Diversion 12 A. All these diverted flow will be collected by Diversion 12 and will be discharged to Singha River at the proposed Outfall No.6 located south east corner of National Medical College.

e. Location Map Inside Core Area



Catchment	code	Designation
9	AN	Aadarsh Nagar
9	DA	District Administration Office
4	TC	Trimurti Cinema Hall
4	MT	Murali Tole [Ranighat Area]
9	DK	Panitanky Daak Road
8	BC	Bhanu Chowk
10	KT	Kumal Tole

Figure 5- 4: Location Map of Flooding Area Inside Core Area

Flooding Areas Outside Core Area

a. Thulo Pipara – Catchment 3

It is a densely populated village located in Ward No. 17 of Birgunj Municipality. It is bordered by Main Bypass road in east and north and by Tribhuvan Rajpath (TRP) in west. In the western part of the village there is an elevated area hence, the storm flow from this village flows partially both to TRP and Main Bypass road side. The existing road side drain in this village is of inadequate in size to drain out the surface runoff during the peak precipitation hours of the monsoon seasons. Also provision of cross drainage in Main Bypass road has not been made. Hence the surface runoff accumulates in the village area causing the flooding of the streets.

In PPTA there is provision for the reconstruction of drain from Thulo Pipara village to Powerhouse Chowk. This drain only will not be able to evacuate the all storm water flow from

Tholo Pipara village. To evacuate the water logged area in the eastern part of the village, road side drain in western side of main Bypass road has been proposed. The proposed Diversion -4 starting from Pratima Chowk running along Padam Road to Sirsiya River will collect the flow from the drain along TRP and Main Bypass road and will finally discharge it into the Sirsiya River downstream of the existing RCC bridge. This provision made in the design is supposed to be sufficient for storm water evacuation.

b. Stadium Area – Catchment 3

This area is bordered by Thulo Pipara village in north, By Pass Link road in south, Main Bypass road in east and TRP in west. Due to the construction of road on all four sides this area is surrounded and due to unavailability of cross drainage structures in these roads at proper locations the whole area gets water logged during the monsoon season. Urbanization is taking place in some of the part of this area but most of the area is still under the use of cultivation.

The areas used for cultivation has low elevations and water accumulation takes place in the low land areas during monsoon season. Provision of storm drain along the existing streets and on By Pass Link road has been made with a capacity to drain off the storm water of the area. It has been assumed that with the rapid rate of urbanization, the low land areas will be filled for new construction and street development works which will bring ultimately the end of water logging in this area.

c. Tallo Naguwa Village – Catchment 8

This village is situated under ward No. 19 of Birgunj municipality and has no adequate drains and drainage outlets. The most low land area in this village is the area just in east of Naguwa pond where a small road culvert has been constructed on the road. During the heavy precipitation during 2012 year monsoon, about 0.70m depth of flow above the road was observed at this point. The storm flow reaching to this point is the combination of the surface runoff coming partially from Ward No.10, 15, 18 and 19 due to unavailability of proper drainage system in these wards. After the construction of drainage system in these wards, the surface runoff at this location will significantly reduce and can be managed after provision of drainage facility in this area. The proposed Diversion 13 A along the Canal Road has been proposed to provide facility to collect the surface run off from Tallo Naguwa area and to discharge it to Singha River through Outfall No 7.

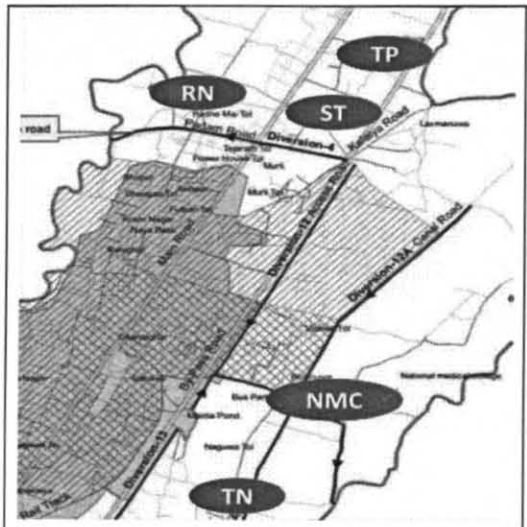
d. Kumal Tole Area – Catchment 8

This area is situated between the Railway Road in east and No. 3 Road in west. Railway Road was constructed along the demolished railway track. It starts from main Road (TRP) from Idgah

near Chhapkaiya Pond and ends at Ghantaghar Chowk. The level of the road surface is about 1.5 m higher than the low level flooding area in Kumal Tole. Due to be located on low elevation and unavailability of proper cross drainage structures along the Railway Road this area gets flooded even after a low precipitation. Some part of this area was observed water logged even during dry season.

To evacuate this area from water logging a storm drain along the western side of the Railway Road has been proposed. This drain starts from the low land area near Hanuman temple (close to Naguwa Chowk) and runs along the western side of the road till Railway Road Chowk. From this Chowk it takes turn towards east and with the help of provided Cross Drainage Structures at Railway Road, Main Bypass Road it joins the Storm Drain 13 proposed along the Second Bypass road. The Diversion 13 drain has been proposed to discharge its flow at Singha River through Outfall No.8.

e. Location Map Outside Core Area



Catchment	Code	Designation
3	RM	Radhe Mai Tol
3	ST	Stadium Area
3	TP	Thulo Pipara
6	NMC	NMC Road – Vishwa college
8/7	TN	Tallo Nagawa Village

Figure 5- 5: Location Map of Flooding Area Outside Core Area

Drainage of the extreme flood Areas

The areas identified as extreme flooding areas have been considered as priority area for the design of the drainage scheme the DSC. Appropriate considerations have been taken for the corresponding flow to be discharge to the proposed new drain to be constructed in each respective catchment.

5.2 DRAINAGE GENERAL CONCEPT

The Consultant followed the same methodology as presented in the Concept Plan Report. Subsequently, the hydrological and hydraulic reports for Birgunj have been prepared and presented in separate volume. These reports will be followed by the draft and final detailed design and the necessary tender drawings and documentation will be prepared.

5.2.1 Concept Definitions

Table 5- 2: Table of Definitions

Concept	Definition
Bypass Flow	Flow which bypasses an inlet on grade and is carried in the street or channel to the next inlet downgrade.
Check Storm	The use of a less frequent event (e.g., a 50-yr storm) to assess hazards at critical locations where water can pond to appreciable depths is commonly referred to as a check storm or check event.
Combination Inlet	A drainage inlet usually composed of a curb-opening inlet and a grate inlet/Catch pit.
Crown	The crown, sometimes known as the soffit, is the top inside of a pipe.
Culvert	A culvert is a closed conduit whose purpose is to convey surface water under a roadway, railroad or other impediment.
Curb-Opening:	A drainage inlet consisting of an opening in the roadway curb.
Drop Inlet	A drainage inlet with a horizontal or nearly horizontal opening.
Equivalent Cross Slope	An imaginary straight cross slope having conveyance capacity equal to that of the given compound cross slope.
Flow	Flow refers to a quantity of water that is flowing.
Grate Inlet	A drainage inlet composed of a grate in the roadway section or at the roadside in a low point, swale or channel.
Grate Perimeter	The sum of the lengths of all sides of a grate, except that any side adjacent to a curb is not considered a part of the perimeter in weir-flow computations.
Gutter	That portion of the roadway section adjacent to the curb which is utilized to convey storm water runoff. It may include a portion, or all, of a travelled lane, shoulder or parking lane, and a limited width, adjacent to the curb, may be of different materials and have a different cross slope.
Hydraulic Grade	The hydraulic grade line is the locus of elevations to which the water

Concept	Definition
Line (HGL)	would rise in successive piezometer tubes if the tubes were installed along a pipe run (pressure head plus elevation head).
Inlet Efficiency	The ratio of flow intercepted by an inlet to total flow in the gutter.
Invert	The invert is the inside bottom of the pipe.
Lateral Line	A lateral line, sometimes referred to as a lead, has inlets connected to it but has no other storm drains connected. It is usually 2 ft or less in diameter and is tributary to the trunk line.
Lateral	The underground conduit that connects the inlet to the main trunk line of a storm drain.
Major Storm	The 50 to 100-year runoff to be assessed for with a storm drain design for minimum ponding depth and property inundation
Minor Storm	The common storm that is used for designing the inlet size and location, the trunk line size and the spread width.
Sag Point/Major Sag Point	A low point in a vertical curve. A major sag point refers to a low point that can overflow only if water can pond to a depth of 2 ft or more.
Scupper	A vertical hole through a bridge deck for deck drainage. Sometimes, a horizontal opening in the curb or barrier is called a scupper.
Slotted Drain Inlet	A drainage inlet composed of a continuous slot built into the top of a pipe that serves to intercept, collect and transport the flow. Two types in general use are the vertical riser and the vane type.
Storm Drain	A storm drain is a closed or open conduit that conveys storm water that has been collected by inlets to an adequate outfall. It generally consists of laterals or leads and trunk lines or mains. Culverts connected to the storm drainage system are considered part of the system.
Trunk Line	A trunk line is the main storm drain line. Lateral lines may be connected at inlet structures or access holes. A trunk line is sometimes referred to as a "main."
Velocity Head	Velocity head is a quantity proportional to the kinetic energy of flowing water expressed as a height or head of water (V2/2g).

5.2.2 Data Collection Process

The following data is vital to perform a comprehensive and meaningful detailed level design of the drainage system for Birgunj.

Topographic Data

Most updated topographic data of Birgunj is required to understand the catchment behavior, identifying potential areas for retention ponds and in proposing new drainage channels within the catchment. Birgunj catchment has no detailed comprehensive topographic data with digital contour levels. The only data which is available is the spot heights.

Existing Drainage Data

Existing drainage data helps to understand the performance of the drainage system under medium-severe storm conditions. Since, the current study is planning to propose new drainage facilities in areas where there is no drainage network before; it would be ideal to have the current drainage system to date. It is also envisaged that the current proposals for new drainage system will be connected to the existing drainage system where possible and required to develop an integrated drainage network for whole Birgunj catchment.

Land use Plan

The current scheme is aimed to address the growth and demands of Birgunj Urban Area in 2035. At the moment, Birgunj Sub-Metropolitan is actively working on the short-term to long-term planning options for Birgunj that reflects a progressive growth of the city over a period of time along the design life period which is 2035.

The proposed land-use plans for the city are vital in estimating the rainfall run-off from the various new developments. Since, there is no such information available at this stage; the hydrologist has made an allowance in the estimation of the rainfall runoff to reflect potential 2035 growth of the city.

Contributing Area Study

Contributing areas again are the factors of the proposed land-use plan. At the moment, a desktop Impermeable Area Surveys (IAS) has been undertaken to determine the connectivity of impermeable areas in catchments where there is doubt. This exercise has been performed based on digital background mapping.

5.2.3 International Standard Used for Current Study

The following table summarizes the international standards followed for the design of the drainage scheme:

Table 5- 3: Standards Adopted for Current Drainage Study

Code	Description
BS EN 752	Drainage and sewer systems outside buildings (supersedes BS 8005, which is withdrawn, and part of BS 8301).
BS EN 1610: 1998	Construction and testing of drains and sewers
WRc Code	Sewers for Adoption – 5th Edition
BS EN124: 1994	Rain inlet tops and manhole tops for vehicular and pedestrian areas – Design requirements, type testing, marking, quality control
BS 8301:1 1997	Code of practice for building drainage

5.2.4 System Main Criteria

Minimum inclination and hydraulic roughness

CIRIA Report R141 Design of Sewers to Control Sediment Problems 1996xxvi defines self-cleansing drains as follows. An efficient self-cleansing drain is one having a sediment-transporting capacity that is sufficient to maintain a balance between the amounts of deposition and erosion, with a time averaged depth of sediment deposit that minimizes the combined costs of construction, operation and maintenance.

This gradient can be relaxed to where significant surface areas are connected to the head of the drain, but in this case the standard of workmanship during construction must be high.

British Standards have been adopted for the current study especially for minimum slopes to be adopted for the pipes. Since the topography of the Birgunj catchment does not require any steeper section to achieve self-cleansing velocities, it is considered to adopt BS code where with the minimum slopes the required velocities can be achieved.

The quality of pipes can vary considerably from one manufacturer to the next, and that condition of pipes can vary with time. Designers should avoid using the optimistic values quoted by some plastic pipe manufacturers, as these invariably refer to new pipes under laboratory conditions. Sewers for Adoption xxii (UK) recommends the following range of values for all new design and existing collectors, which allows for deterioration in pipe surface and normal wear.

Drains Design

The design of the drains is dependent on their location and depth. In general due to the slight slope and relatively important flow to collect/discharge, drains are surface rectangular in the town and covered with precast concrete slabs. The drainage of new road to be constructed may be done with pipe circular drains. Existing natural drains are trapezoidal or rectangular.

Rectangular shallow depth drains are to be constructed in brickwork. Deeper drains are designed individually in reinforced concrete (RCC) such as rectangular or pipe drains. The detailed arrangements of the drains and components of the scheme are presented in **Volume 1E Drawings**

Surface Rectangular covered Drains

The following type of standard rectangular masonry drains is proposed to be use in the present project:

Table 5- 4: Standard masonry surface rectangular Drain

Masonry Branch Sewer –small to medium [secondary and tertiary]

Type	Size W x H	Material	Designation	Normal[1]	Deep[1]	Extra Deep[1]
1	0.4 X 0.4	Bricks masonry	BM0	1.650	1.650	NA
2	0.6 X 0.5	Bricks masonry	BM1	1.650	1.650	1.850
3	0.8 X 0.6	Bricks masonry	BM2	1.650	1.650	1.950
4	1.0 X 0.8	Bricks masonry	BM3	1.750	1.650	2.950
5	1.2 X 1.0	Bricks masonry	BM4	1.750	1.750	3.150
6	1.5 X 1.2	Bricks masonry	BM5	1.800	1.750	3.400

Note [1]: the three last columns of the table above indicate the category of drain in relation to the invert level. The corresponding characteristics of the drain is presented in **Volume 1E Drawings** and the structural calculations notes are included **in Appendix D** of the Volume 1B of the Hydraulic Report as part of the present Final Engineering Report.

In general when the drain becomes deep and its wall thickness insufficient, it shall be constructed as an underground drain with a backfilling on his top; access point shall be required at standard distance.

The location of drain is generally on footpath next to the road kerb and the cover top slab shall be design for vehicle passing over. On narrow streets the drains is executed on one side of the road at the location of the existing drain which he shall replace. The other drain on the other side (if any) may be re-commissioned or decommissioned depending of the local conditions. The figure hereafter presents a schematic of the masonry surface drain.

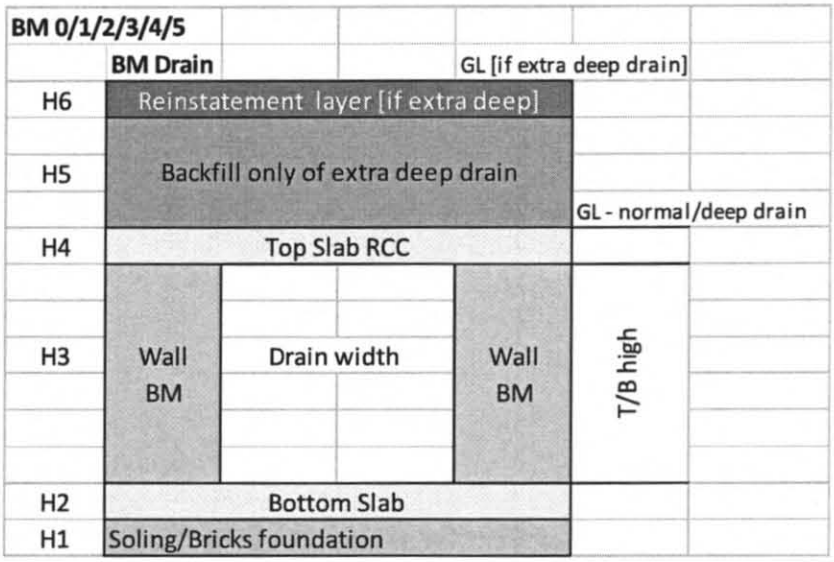


Figure 5- 6: Standard Masonry surface rectangular Drain

The notation T/B indicate the internal height of the drain (Top to Bottom, H3), the invert level is the total distance including H3 to H6.

Surface Rectangular Drains – Main drain [RCC]

The following type of standard rectangular RCC drains is proposed to be use in the present project:

Table 5- 5: Surface rectangular Drain – Main line drains [RCC]

Type	Size W x H	Material	Designation	Normal[1]	Deep[1]	Extra Deep[1]
1	1.5 X 1.2	RC Concrete	RCC1	1.450	1.950	3.200
2	1.8 X 1.4	RC Concrete	RCC2	1.600	2.100	3.400

Type	Size W x H	Material	Designation	Normal[1]	Deep[1]	Extra Deep[1]
3	2.0 X 1.5	RC Concrete	RCC3	1.800	2.300	3.600
4	2.5 X 1.9	RCC Box Culvert	BX1	2.200	2.000	4.000

Note [1]: the three last columns of the table above indicate the category of drain in relation to the invert level. The corresponding characteristics of the drain is presented in **Volume 2B Drawings** and the structural calculations notes are included **in appendix 4** of Volume 1B of the Hydraulic Report as part of the present Final Engineering Report.

Reinforced concrete drains are designed on an individual basis. They are normally provided where the depth of the drain exceeds 1.20m as per prudent practice in SAARC countries in natural soil and for larger width. They may also be needed where space is not available to construct a standard brick drain. Reinforced concrete drains that have a precast top slab, extra deep drains can be designed as box culvert monolithic.

The figure hereafter presents a schematic of the RCC surface drain.

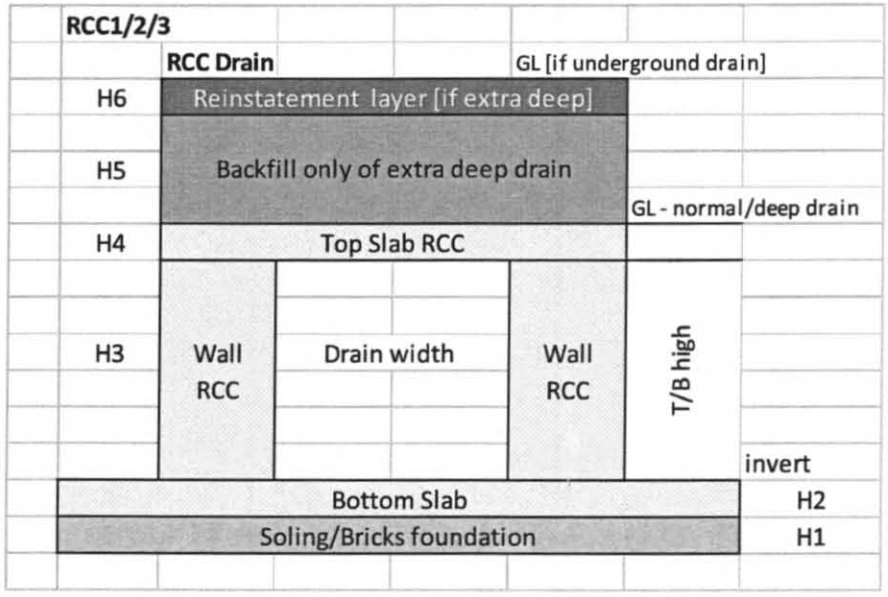


Figure 5- 7: Standard RCC surface rectangular Drain

The notation T/B indicate the internal height of the drain (Top to Bottom, H3), the invert level is the total distance including H3 to H6. Both sides of the drains shall have lateral extension on the bottom slab to prevent lifting (buoy effect) as ground water is high.

Road crossing – Culvert [RCC]

When a drain is crossing a street, a special Road crossing culvert is constructed. For any drain's size the crossing shall be executed in RCC of monolithic type. As open channel drains, the size shall be made for the 5 years return period. For simplicity and quick assessment a conversion factor i.e. a ratio with 2 years and 5 years return period is determined and shall be $Q_{5y} = 1.4\ Q_{2y}$.

Therefore the section of the culvert shall be larger and the drains width increased by 1.4m. To secure the flow and additional free board of 15 cm shall also be included in the drain section. The internal section of the Road crossing is shown in the following table:

Table 5- 6: Road crossing – Characteristics w x h

Drain		Wall	Int. Heigtht drain		Drain		Wall	Int. Heigtht drain	
Type	width	Thickness	Standard	max T/B	Type	width	Thickness	Standard	max T/B
BM0	0.630	0.200	0.45	0.45	BM5	2.100	0.200	1.350	1.35
BM1	0.840	0.200	0.650	0.65	RCC1	2.100	0.200	1.350	1.35
BM2	1.120	0.200	0.600	0.6	RCC2	2.520	0.200	1.400	1.4
BM3	1.400	0.200	0.800	0.8	RCC3	2.800	0.200	1.600	1.6
BM4	1.680	0.200	1.150	1.15					

The figure hereafter presents a schematic of the RCC monolithic road crossing.

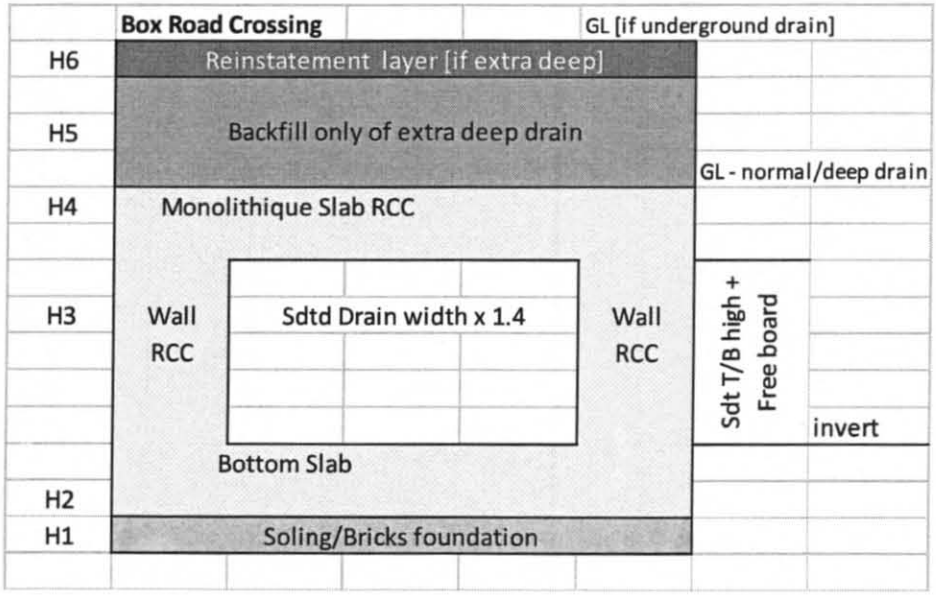


Figure 5- 8: Road Crossing Culvert Type

Pipe drains

Pipe drains on road are used where space is available and closed drain needed; a minimum cover is generally required. The maximum pipe size to be use shall be 1400 mm RCC pipe.

Most of the arrangements for pipes installation are shown on the set of typical drawings presented in Volume 1D drawings of the present report.Pipe drains on road are used where space is available and closed drain needed; a minimum cover is generally required.

In principle due to the diameter, all pipes to be used in the drainage/sewer network are proposed to be RCC pipes with spigot and socket ends, jointed through rubber gaskets (NP3). The minimum cover above the crests of the pipe is to be 1.0 m but deep sewers are the inevitable result of relatively flat catchment/gradient

The general characteristics of the pipe installation, trench width and depth, pipe bedding categories, sheeting and bracing, dewatering are similar as described in the Sewerage report. The trench schematic is presented in the following figure

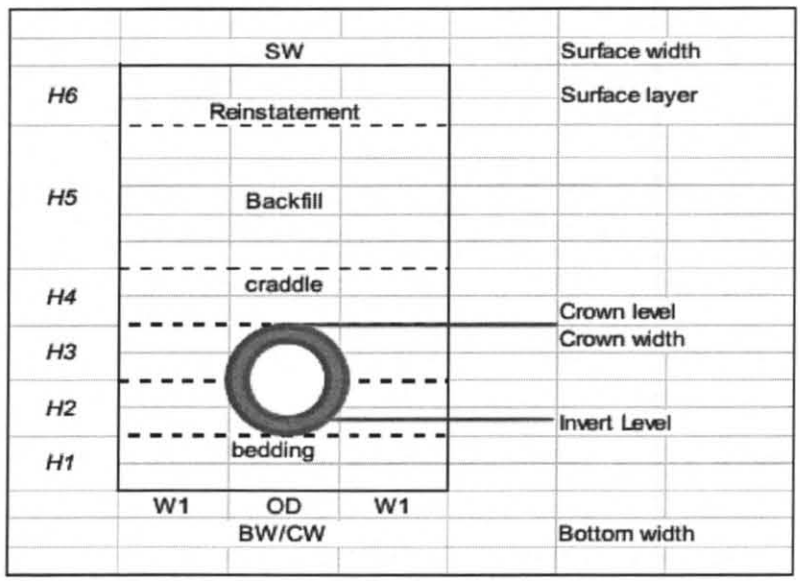


Figure 5- 9: Trench schematic dimension

Where,

H1 is related to the pipe diameter.

H2 and H3 are related to the type of bedding

H4 is related the pipe diameter

H5 depend of the bedding arrangements and the surface reinstatement

H6 is defined by the characteristics of the surface finishing.

H2 + H3 is equal to the outside diameter of the pipe

Natural drains

Some natural drain shall be integrated in the drainage scheme. In general natural drains are brick drains with vertical face or trapezoidal lined drains with PCC/RCC bottom slab (in situ concrete). Along natural drain if the right of way allows it, a road path can be constructed for easy maintenance. Access can be restricted with the installation of fencing long the drain to protect the drains for garbage disposal.

The trapezoidal drains shall have a width of 2.5/3.0 and generally the height is 1.0/1.5m. The specific arrangements, size material of the drains are presented and described in each catchment

Storm Inlet - Catch Pits along the Road

When the drain is closed line such as pipe and/or covered drain the storm inlet is done by the use of different types of road rain inlet. Preventing the ingress of sand into the rain inlet is one of the most important considerations during design. The different types of road rain inlet were introduced in the interim report. The proposed drainage inlet is a **Conventional inlet pit with surface grating:** This type of rain inlet can be protected from sand ingress by the attachment of a flat sealing plate over the grating that would have to be removed for the rainy season. The inlet pit can be individual installed along the road border or lateral adjacent to the drain. The corresponding characteristics of the storm inlet pit is presented in **Volume 2B Drawings**

The rain inlet connection in 160 mm dia uPVC with a slope minimum slope 1 in 50 shall be direct to the street manhole id the drain is a pipe or to the rectangular surface drains depending of the site conditions. The pipe installation shall be conforming to the specifications for trench width/depth and for bedding as defined in the specifications.

Manhole for pipe drains

A manhole is an opening constructed on the alignment of a drainage pipe at frequent intervals to provide connection to catch pit, access for maintenance purposes like inspection, testing, cleaning and removal of obstructions from the sewer pipeline etc. Manholes are located at each sewer junction or change of sewer direction, diameter or gradient.

Manholes are generally constructed in circular shape. The manholes are in brick masonry walls with plastered inside, RC concrete bottom and top slab with cover and finished with a benching. Alternatively small size masonry manholes can be rectangular for easy construction

Where the water table is high and the pipe sewer is laid in open field or along the side of the drain, the RCC circular manholes would be constructed to avoid any leakages into or out the

manholes. Steel Fibre Reinforced Concrete (SFRC) manhole cover should be used for covering manhole.

The general characteristics of the manhole, size, material, sheeting and bracing, dewatering are similar as described in the Sewerage report

Table 5- 7: Manhole Size, Shape and Material

Internal Diameter of Manhole

Pipe	≤ 1m	≤ 2m	≤ 3m	≤ 4m	≤ 5m	≤ 6m	≤ 7m	>7m
500-900		1.5	1.5	1.5	1.5	1.5	1.5	
1000-1200		1.8	1.8	1.8	1.8			
1400		2.1	2.1	2.1	2.1			
Wall Thickness of manhole			**≤ 3m**	**≤ 4m**	**≤ 5m**			
500-900		.0.20	0.20	.0.20	.0.20	0,25	0,25	
1000-1200		.0.20	0.20	.0.20	.0.20			
1400		.0.20	0.20	.0.20	.0.20			
	Bricks Masonry structures							

The spacing between manholes is adopted as per standard engineering practice and recommendation of SAARC Country's manual. Mechanical cleaning has been considered for which manhole. A spacing of 30 m to 40m in relation to the spacing of inlet pits is acceptable.

Access chamber/shaft

Access chamber/shaft may be provided for extra deep drain or culverts constructed underground. The shaft may be constructed in BM for low access and in RCC for deep access. The covers shall be removable rectangular Pre-cast / SFRC RC slabs with hooks or handle and suitable to withstand heavy traffic loads. The location of access service manhole shall be decided during the construction of the works at appropriate location.

Others

In addition to the structures defines previously, some others additional arrangements shall be executed along the drains. This shall cover the following arrangements as:

- Start of the drain [transversal closing wall] generally masonry drains,
- Drain changing of size [additional lateral wall] between masonry and/or RCC drains.

The detailed arrangements are presented in **Volume 1E Drawings.**

Outfall/Gabions

At the discharge of the drainage drain to its outlet, a special outfall structure shall be constructed. The detailed drawing of each respective outfall is presented in **Volume 1E Drawings.** The Outfall shall include a energy dissipation channel, lateral wings walls, protection to the embankment with gabions and a rip-rap bed at its connection to the river.

5.2.5 Design Criteria

The following table summarizes the design criteria followed for the design of the drainage scheme

Table 5- 8: Table of Design Criteria

Parameter	Criteria Followed
Design Flow	The 2yr return period storm event was chosen to be the design storm. The flows were determined by delineating the design area and applying the 2yr storm event. The hydraulic model was thus run for extended period simulation to account for lag travel times in the drains.
Pipe Material	-Concrete for rain inlet and connecting uPVC pipes 160 mm - RCC pipes, -Lined bricks masonry or RCC drains
Section shape	-Circular from 300 mm until 1400 mm max -Rectangular covered drains or box culvert drains for surface drains. -Trapezoidal drains for reshaped existing natural drains (covers may be required in some special locations)
Velocity	During a 2 yrs return period storm event, which is the basis of the design, the minimum velocity allowed is 0.6 m/s for storm drains flowing full.
Minimum Diameter	For storm drains circular DN 300 mm or rectangular BM0 W 0.40x H 0.30m
Maximum Diameter	For storm drains box culvert 2500 mm x 2000 mm (Bx1)
Slope (%)	For gravity storm drains: min slope = 0.05 % depending of the section and the local conditions.
Minimum Depth to Cover	Minimum Depth to Cover - 1.0 m for pipes -.0.50 or reduced for drain at starting point.

Parameter	Criteria Followed
Depth of drain	- Deep excavation shall be avoided.
Max Spacing between Manholes	For storm drains with a diameter up to DN 1400mm the maximum spacing between manholes is 100 m. Normal spacing for inlet connection 30/40m
	For larger diameter pipes which in fact can be visited, the manhole positioning was dictated by the need to place a manhole to accommodate joint with another drain or due to road bend.
Manholes Types	Circular, or rectangular for pipes 1.20 m/1.50 m/ 1.80 Diameter Special chamber such as diversion, connections and/or outfall
Inlet chamber /Catch pit	See typical details, lateral, individual, brick or RCC In principle Inlet chamber does not exceed a distance of 40m and in general are installed both side of the road. Their positioning was dictated by the road network in accordance with the topography of the design area. For the town centre or on new roads to be constructed the rain inlet positioning may be is denser and will be decided during construction

5.2.6 Additional Criteria

Some additional assumptions have been considered and are discussed in the following paragraphs.

Type of drains

- Primary drains — Major Nalla and drains that convey surface water to Main River.
- Secondary drain — Small stream, Nalla and artificial drain collecting surface water from road side drains and convey to primary drain.
- Tertiary drains — Tertiary drains are mostly road side drains, market drains and plot drains

Drainage Options

- Underground drains [circular pipes or rectangular drains]
- Surface drains Open or covered [ditch, channels, ...]

Drainage Planning

a. **Drainage systems should be seen as a whole**. The flow through a drain must be considered in relation to its whole catchment area. If that catchment area extends beyond

the limits of the particular area to be serviced, the design of the drain requires analysis of the whole catchment. This is true even if the catchment extends beyond the municipal limits.

b. **Drainage systems must be designed to be compatible with what already exists**. This means that:

- Collector drains should be located as close as possible to natural drainage paths.
- Drainage designs should take account of, and where possible use, existing drainage facilities
- Designs must take account of water levels in existing drains and sewers to which new drains and sewers might discharge.

5.2.7 Limitation of the Drainage Design

This study has been undertaken at preliminary level, consequently, has a number of inherent limitations. Preferred drainage pipe routes and retention ponds have been identified using available spot heights as provided by the team; however, the sites and routes have been directly inspected and surveyed at this level and the final route finalized and confirmed at final design stage.

The following additional comments are also be highlighted:

a. **The level of protection for flooding** is define by the performance criteria for design flooding frequencies **[2 years return on rain]** or design storm events used in calculation including the site conditions [gradient, levels,...].

b. The surface water drains and sewers are dimensioned in order to limit flooding based on the design's assumption. **It is usually impracticable to avoid flooding** from very severe storms.

c. **At any outfall backwater flow/tail water** during extreme events will increase the risk of flooding and the performance of the new drainage. The hydrologic conditions of the rivers are unknown and may impact the normal outfall flow. Proper river protection embankment and cleaning of the river bed are required for the designed system to work efficiency/correctly during extreme events.

d. **The lack of possible storage** to limit the peak discharges to acceptable flow rates (e.g. by use of detention tanks and ponds) to minimize the hydraulic impact on receiving waters increases the risk of flooding during extreme events.

e. **The restriction for the use of possible pumping** to protect the system during the peak events to minimize the impact of backflow imposes extreme conditions to the network.

f. Flow routes for excess flows in extreme event may be required and land acquired to minimize the impact. [Retention pounds and/or flooding of the adjacent fields of the outfall.

g. The depth of the drainage system may not be compatible with paddy field level for complete drainage of the area and existing ponds and low pocket will act as retention ponds serving to delay the peak floods during heavy storms. To continue to serve as reservoir, the city should endeavor to remain those ponds or low land in the future

h. In area without sewerage network, there is a high risk of the foul water is introduced into the drainage sewer by inhabitants and contaminated water send through the rivers[dry pond may be planned]

These limitations and comments pose a degree of risk to the accuracy of the drainage network planning and to the resulting costs of proposed infrastructure. It is expected that some of these limitations will be overcome during the execution of the works as more data been available.

5.3 HYDROLOGY – CONCEPT AND METHODOLOGY

5.3.1 Hydrology

The main aim of studying hydrology in any drainage system is to know the behavior of the precipitation that occur within the catchment area of that drainage system which is very helpful to drain out the surface runoff as soon as possible preventing the possible flooding or pounding of urban areas. Flooding has a great impact on the transport, infrastructure and on many other aspects of people's day to day life. So the proper study of hydrology for managing urban drainage system plays vital role in flood risk management.

Birgunj lies in southern (Tarai) belt of Nepal. The Tarai Zone is drained by almost of 2nd to 4th order streams where headwater is located in the Siwalik hill. Even these streams are seasonal, during monsoon these streams are heavily flooded and some time is disastrous. During this period, the existing Birgunj Town drainage infrastructure is on huge pressure. Birgunj annual rainfall is defined by two seasons, the Wet and Cold seasons. The Wet season (also the cyclone season) occurs from May to October and the Cold season occurs from November to April. The Wet season contributes to about two thirds of the total annual precipitation. Rainfall is highly variable from year to year. Very low or high rainfall rarely persists for more than three months.

The runoff generated within the different catchments of Birgunj is drained to two rivers – Sirsiya in the west and Singha in the east. The prevailing features of the catchments and corresponding outfall are identifies and the area has been divided in 11 catchments/Catchments as presented in the figure hereafter.

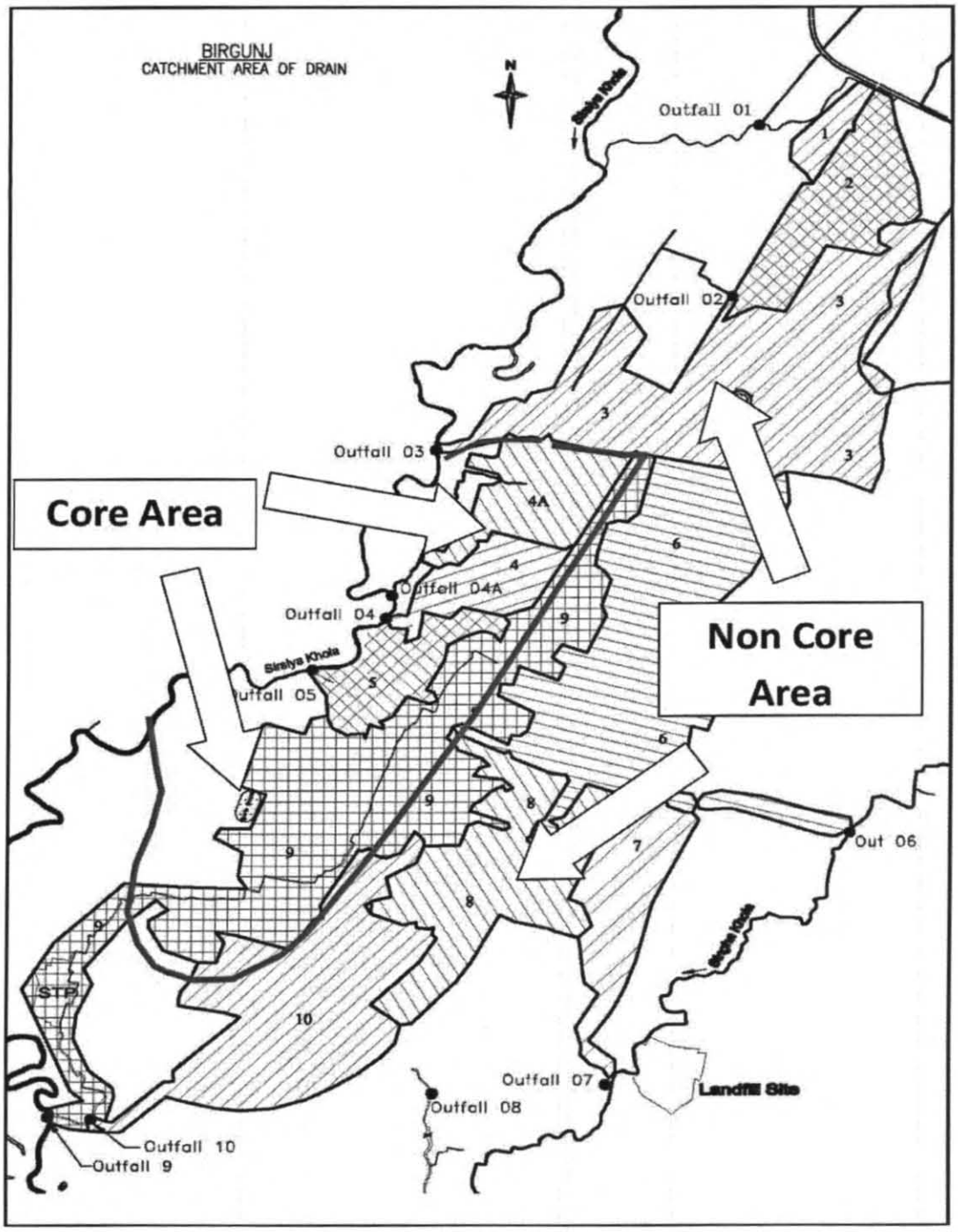


Figure 5- 10: Catchments

The general assumption and guideline for the design of the storm drain will mainly focus on utilizing the improvement of the existing infrastructure storms drains and channels; construction of lateral covered rectangular channels and installation of pipe drains where necessary to provide the necessary trunks for the system of the city with inlet catch pits.

The objective of the hydrological study of Birgunj sub-metropolitan city area is focused on 2 year return period for open channel drain and 5 years return period for culverts and natural drains. A return period of 2 years means that rainfall of this intensity and with this duration can be expected to occur on average once every 2 years. The assessment of methods has been based on the following three critical criteria, i.e. desired objective, available data and watershed characteristics.

- Rainfall intensity duration frequency analysis by WMO's standard method.
- Time of concentration by USGS
- Runoff generating / sub Catchment area at structure location from the 1:250.000 topographical maps using GIS tool.
- Flood peaks estimate by rational formula, $Q = 2.78 \times C \times I \times A$

Where

Q = runoff rate (m3/s)

C = runoff coefficient

I = rainfall intensity (cm/hour) of a storm whose duration is equal to the time of concentration of the Catchment

The run-off co-efficient 'C' depends on various factors such as the permeability of the surface, catchment slope, duration of rainfall, etc. The detail analysis and hydrologic calculations of Birgunj is presented on Hydrology Report in Volume 1A as part of the present Final Engineering Design.

5.4 HYDRAULIC CALCULATIONS

5.4.1 Need for Hydraulic Model

Based on the understanding of the current drainage system in Birgunj town and discussions with various developing agencies in Birgunj, it is recommended to build a numerical hydraulic model of the entire drainage system for Birgunj Town. The model can be built using the available asset data which was generated by various asset surveys.

The principal objective of the model built is to understand the system performance and hydraulic capacity issues within the catchments. The hydraulic model would also help in identifying innovative solution options for the catchment. The constructed model can replicate the true picture of the existing system and can be used as a tool for Capital Investment Programs which would enhance the cost effectiveness of the investment.

The hydraulic model provides the following benefits to Birgunj Metropolitan Municipality:

- Better understanding of the catchment including bottlenecks, system capacity issues *etc.*;
- Helps in better asset management planning and implementation of engineering solutions;
- Helps in efficient operation and maintenance principles;
- Helps in maximizing the benefits in hydraulic performance and system reliability.

In short, hydraulic model offers an impressive and reliable solution to their current issues with the catchment.

5.4.2 Modeling Software

At interim stage the model was prepared and verified using Environment Protection Agency (EPA) Storm Water Management Model (SWMM), as supplied by EPA, USA. This software is considered suitable for modeling drainage networks and complex ancillaries. SWMM is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas.

The runoff component of SWMM operates on a collection of sub-catchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. SWMM tracks the quantity and quality of runoff generated within each sub-catchment, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps.

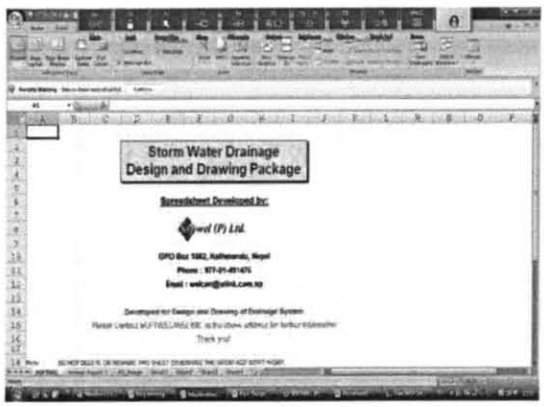
5.4.3 Base Data for Birgunj Drainage Model

General assumptions used in the interpretation of model build data include the following:

- For drainage rectangular drains are use and standard drain width are selected. The results of the previous modeling where used and optimized/adjusted in relation to the final flow and site conditions

- → Rectangular drains shall be covered and constructed in masonry for small size drain and in RCC for larger drains;
- → The line drain gradient is assumed to be constant between node i.e. an average gradient is used between upstream and downstream nodes;
- → Drain /pipe size and shapes do not change between nodes;
- → Drain /pipe size increase down the system.

Where possible, the interpolation of missing data was carried out by manual calculation. It is necessary to emphasize that any hydraulic computer model output accuracy dependent on the data used in its construction. The rainfall inputs used for this study are those discussed in the earlier chapter of this report.



The verification of the drain size where carried out using SoftWel, the Software package prepared by SOFWELL[7] , The software is used for storm water design and design sewerage.

The hydraulics characteristics of each section are entered into the software which will give the final result of the size of the drain and invert level. The user-friendly interface, as an AutoCAD add-on, makes it relatively simple to access data tables and will produce the long section including site information such as ground elevations, length of sewer pipes and diameters, slope, flow and even more importantly can present the result in a clear and professional manner.

5.4.4 Data Entry

Time of entry

The time of entry will be calculated by the software based on the catchment parameters and the sections lengths. The model calculated time of entry and travel will be applied to the catchment in establishing the flows through the run-off from catchment.

Contributing areas

Contributing areas contained within the model were as provided by the Hydrologist.

[7] *SOFTWEL (P) Ltd. is a company dedicated in the development of Engineering Software and formally registered in the Department of Industry HMG/Nepal.*

Infiltration

Default software values for Horton infiltration parameters have been chosen for the current study. It is assumed that infiltration rates will remain stable over time. Thus, the rate of infiltration in the future model is the same as existing model.

Birgunj Model Setup

The Birgunj Drainage Model has been built for each Outfall and its subsequent sub-catchments that are draining to the respective outfall. The network model for each outfall includes the nodes, conduits as channels and pipes and retention areas as storage Catchments if any.

Prior to the verification process, the stability of the Birgunj model was tested using the 2 years return period storm with 10 minute duration. Inspection of the model at selected sections of the model found no evidence of any significant numerical instability.

5.4.5 Sizing

Open drains are designed to flow full when carrying the design flow with an allowance for freeboard. Pipe drains and box culverts are designed to flow full with the additional capacity available when the flow depth is just below the top of the drain not taken into account. Box culverts should normally be designed to flow full. However where a rectangular reinforced concrete drain is required with a top slab and therefore constructed as a box culvert, the drain should be designed as a rectangular drain with standard freeboard. A check must be made to ensure that the top slab level is above the freeboard level.

The capacities of the required drains and culverts are calculated using Manning's equation. Manning's formula states that the velocity of flow in an open channel section is given by the equation:

$$V = 1/n\ R^{2/3}\ S^{1/2}$$

Where; V is the velocity (m/s),

R is the hydraulic radius (m) - equal to the area of flow divided by the wetted perimeter,

S is the slope (m/m) and n is the Manning's roughness coefficient (which has no units).

The hydraulic roughness 'n' values to be used in the calculation of capacities are dependent on the type of material used to construct the drain and the standard of maintenance. For design

purposes, the drains are assumed to be in good condition. The values of Manning's 'n' to be used in the equation are set out in Table below.

Table 5- 9: Design Roughness Factors

Type of drain	Manning's Roughness factor 'n'
RCC Pipe drain	0.013
Plastered brick & Concrete drains	0.015
Brick drains (un plastered)	0.017
Kachha drains (earth)	0.025
Kachha drains (grass)	0.030

Drain Capacities

Each drain in the system must be sufficiently large to carry the design flow. Its cross- section must be such as to ensure self-cleansing velocities at the range of flows that are likely to be carried by the drain. But on the contrary there will be overflow on occasions when the rainfall intensity exceeds that assumed in the design.

The general shapes of surface drain are semi circular, horse shoe (U section) and V section, rectangular and trapezoidal section. Underground drains are RCC box culverts or RCC circular pipes.

For a maximum efficiency for a rectangular storm drain presents in general a depth/width ratio of 0.75 (H=0.75 W) i.e. the depth (H) is equal to 0.75 times the width (W). This defines the minimum T/B [top to bottom] or minimum vertical length of the drain.

Hydraulic Gradient

The hydraulic gradient is the slope of the water level along the drain: For a channel of constant depth, the bed slope of the drain is the same as the hydraulic gradient. This is not correct however when there is a downstream water level higher than the normal depth of flow in the drain (outfall conditions to be verified).

Slope/Gradient

The minimum gradient or slope should normally be as follows to ensure where possible the ***minimum velocity in drains***:

Table 5- 10: Minimum Gradient

Type of drain	Slope in %	Range of pipes	Rect.drain
Tertiary	Mini 0.50 %	200 - 400 mm	< 0.40m width
Secondary	Mini 0.10 %	500 – 800 mm	BM1/BM2
Primary	Mini 0.05 %	Above 800 mm	BM3 and above

In order to minimize the maintenance requirements of any given length of surface water drain, it is normal to design the drain to be "self-cleansing" at design flow. This means that the drain should be designed to achieve a velocity that will carry all solid deposited material along the pipe and not leave any materials deposited in the invert of the drain.

In Birgunj it is very difficult to achieve self-cleansing velocity under large pipe diameter due to flat terrain and high ground water table issues. However, it is proposed to lay closed channel system with frequent jetting facilities to achieve velocities at required section of the system. Where possible a minimum self-cleaning velocity of ***0.6 m/sec should be considered*** for storm drains to ensure for not silt deposition taking place in the drain.

The maximum gradient is determined by the type of drain lining and maximum velocity for lined drains should not exceed 3m/sec or preferably 2.5 m/sec (1.5 m/s for Kachha (earth) drains). Where these velocities are exceeded, drop structures should be provided. The minimum depth at starting point of the drain is of 0.50m below ground level (ultimate level).

5.4.6 Results of the Computations

The results of computation of all the drainage sections are presented with the result's table in the Hydraulics Calculations in **Volume 1B** SOFTWEL Data/Results of the present Final Report.

5.5 MODEL RESULTS – PROPOSED DRAINAGE NETWORK

5.5.1 General

An effective comprehensive drainage system is visibly vital, that enhances the environment for economic growth and sustaining quality living conditions to the residents of Birgunj.

In order to achieve the key objectives and address the project drivers, an attempt has been made to emanate a comprehensive drainage system that would alleviate flooding and public health risks within Birgunj Town. The existing land-use plans have been used to set the design

horizon for assessing the future system performance although the anticipated future development for Birgunj was unknown.

The proposed drainage system concepts are estimated to cater for 1 in 2 years return period storm event. The following sections describe the proposed drainage system and retention sites per Outfall.

The entire Birgunj has been divided into 11 groups or catchments, starting from the north leading to the south. The different Catchment areas are divided in accordance to the potential outlet points to the two rivers, Sirsiya river and Singha river, flowing along the both sides of Birgunj. The total area covered in Birgunj is about 927.87 ha.

In all 11 sections have been selected as potential outlet for the storm water drainage. 8 outlets (1, 2, 3, 4 and 4A,, 5, 9 &10 drains out to the Sirsiya river; whereas the remaining 3 outlets (6, 7 and 8) drains out to the Singha river.

The table hereafter summarized the findings and the presents the total flow at each catchment.

Table 5- 11: Outfall area and Flows

Outfall No.	Ward No.	Main Drain	Area in ha	Flow in m3/s	Area in ha	Flow in m3/s
3	16,17,18	Diversion 4	171.9	6.03	**145.5**	**7.1**
4	14,16	Rect. Drain	41.7	1.71	-	-
4A	14	Shreepur	27.2	3.32	-	-
5	10,12,13,15,16	Overflow MD1	34.9	3.8	No info	8.0
		Catchment 5		1.6		1.3
6	10,15,18	Diversion 12	160.2	5.81	**116.9**	**5.7**
7	19	Diversion 13	46.4	2.30	**120.4**	**5.9**
8	4,6,9,19	Diversion 13A	88.1	7.25	**116.1**	**5.6**
9	1,3,7,8,11,12,13,	MD1	215.1	20.52		In 10
10	1,2,3,4,5,	Rect. Drain	115.3	5.16	"390.0"	25.0

Note: (1) Highlighted in gray PPTA data from Volume 2 [Table 14 page39 and Table 11 page36]; the outfall 9 includes the flow of outfall 10 discharging to the River. (2) The table has been revised following the modifications made on the catchment and corresponding drains as presented in the following section.

Light modifications/improvements have been made from the initial flow presented as the interim report due to the modification of some line and limits of catchments. The detailed flow calculations are presented in the Hydrologic Report in separate Volume 1A

A summary of the results of the hydraulic computation of the main storm drainage collectors for the project area is presented in Volume 1B to this report. The drawings found in Volume 1E of the Final report present the route and sections/diameters of the main storm system. The drainage system sizing has been performed based on 2 years return period storm event for channels. The proposed network details within each outfall are presented in the following sections.

5.5.2 Modifications/improvement from previous report

During the verification and sizing of the drains two important modifications have been made necessary and the model has been adjusted accordingly from the interim and/or draft report:

Catchment 9/6: Daak Road

In relation to the discharge of the extreme flow from Daak road the alternative to discharge the Daak road's drain to the outfall 8 was evaluated. It was found that without modification of the main line of catchment 6, the total flow of Daak Road can be discharge to the outfall 6 instead of catchment 9. This alternative will secure the discharge of Daak road from its previous proposed discharge to the MD1 catchment 9.The flow in MD1 is critical due (1) to the limitation of the capacity of the drain to Outfall 5 and (2) the critical section of MD1 in Mahabirsthan Chowk.

Therefore the sub-catchment of Daak road shall be removed from the catchment 9 and will be included in the catchment 6. The area and flow have been adjusted in corresponding table "outfall area and flow" presented above.

Catchment 9: Catch drain

In order to secure the discharge of the Aadarsh Nagar area the feasibility of the catch drain which should also by-pass the MD1 in Mahabirsthan Chowk was checked. It was found that with the required slope the finishing level of the drain at its connection with the MD1 downstream the Khetan Campus would be critical and would required the MD1 bed level to be modify. Therefore the scheme has been revised and it is proposed to drain the Aadarsh Nagar area through the Hadji Ali road to discharge in the MD1 in order (1) to secure the discharge and (2) reduce the flow entering the double culvert [-3.0 m3/s] and minimizing the risk of overloading of this drain constructed under the recreational park.

Prioritization – Lines of the Project

Due to Budget constraints the DSC has prioritize the construction of some drains and only essential drains have been and others presented in the interim and/or draft report have been postponed and shall be executed in further phase of the scheme. The selected lines of each catchment are presented in each respective catchment.

Existing drains system

In general the existing drain located along the new drain and/or parallel shall be abandoned[8] as too small and/or inadequate to be part of the new drainage scheme. Some existing drain in road where no new system is developed may be cleaned, covered and integrated in the new system. The detail instructions shall be given case by case by the Engineer during the construction of the works.

5.5.3 Catchment 1 and 2

Outfall 1 is located in the north section of Birgunj. The Outfall is located at Bahuari Village, which is in the ward no.1 of Birgunj. The total catchment area is of 11.5 ha. Longest length for the time of concentration is approximately 571.7m. The Catchment area has further been subdivided into 3 smaller sections with the longest section. Population density of this location suggests this location primarily be cultivated land, and thus the Runoff coefficient for the purpose of discharge calculation is taken to be as 0.35. Projected future population growth indicates that there isn't going to be change in the land use pattern, and the runoff is taken to be as 0.35 for the year 2035.

Outfall 2 encompasses around 52.24 ha of catchment area. The road collects storm water from the collective catchment from sections of Tribhuvan Rajpath, Sano Pipra, Bypass and outer Bypass road. Longest route along this catchment is approximately 1,865.8 m. The overall catchment of the outfall is within ward no. 17 as well also current and projected land use in Outfall 2 is also cultivated land and thus the runoff coefficient is also taken to be as 0.35.

Due to budget constrain the relatively small catchments 1 and 2 located at the extreme northern part the project not presenting a real risk of flooding has not been included in the priority lines to be constructed at this final design stage.

[8] *The improvement of the drainage system with the lack of sewerage system and the abandon of the existing drain generally use for the discharge of grey water will expose the new drainage system to be use as sewerage for which it has not been designed.*

5.5.4 Catchment 3

Location

Outfall 3 catchment area consists of the remainder of land north of the D4 road.

Land use in this location is considered to be taken as cultivated land at the moment resulting in runoff coefficient to be 0.35, but in the future it is seen to be a mix of cultivated and multiunit residential location. Thus the respective runoff coefficient is 0.35 and 0.5. Total catchment area for this location is 171.88 ha. Diversion 4 in the main road leading to the outfall, it's also the main collection drainage artery for the discharge of all the storm water north of this road. Discharge of the drain flows into the Sirsiya River in Outfall 3.

Description of the Proposed Scheme

Initially the proposed storm system in catchment 3 includes initially one main line 3L1 and 11 branches named lines 3L1A to 3L1K. The proposed drain to be constructed shall be only the main line 3L1 starting on the right site of the by-pass road until the crossing with Padam Road at Pratima Chowk.

Only the branches 3L1E from the Thulo Pipra Road and along the Tribhuvan Rajpath Road Left, and 3L1I on the left side of Padam Road shall be constructed. At 200 m upstream of the discharge point in the Sirsiya River at Outfall 3, the main line 3L1 on the right side of Padam Raod crosses the street and is connected to the branches 3L1I. The branch 3L1I follows the left side of Padam road until the Pratima Chowk

The part of the branch 3:1I continuing upstream through the Kalaiya Road until the right side of the 2nd By-pass where it collects the branch 3L1J shall not be constructed. The PPTA's diversion D4 consists of the section of the branch 3L1F and the section of the main line 3L1 respectively on the left and right site of the Padam Road. (See below Diversion 4).

Summary of proposed lines

The schematic plan of the catchment showing the nodes and sections of the scheme are presented in the Hydraulic Report Appendix 1B in separate document. The table hereafter presents the list of proposed lines (Main line and branches) to be constructed as part of the new scheme.

Table 5- 12: Summary of the proposed lines - Catchment 3

	Interim	Final					
Total	**13,124.47**	**6,085.59**	**Drain Size**				**Comment**
Line	**3,308.55**	**3,308.55**					**1 Main line**
3L1	3,308.55	1,692.00	RCC2	RCC3			Padam Road
3L1		1,616.55	RCC1	RCC2	RCC3		Bypass Road Right
Branch	**9,815.92**	**2,777.04**	**Drain Size**				**2 Branches lines**
3L1A	225.73	0.00	BM1				Tribhuvan Rajpath Road
3L1B	186.70	0.00	BM1				Thulo Pipra Road
3L1C	191.97	0.00	BM4				Bypass Link Road
3L1D	199.22	0.00	BM3				Bypass Link Road
3L1E	1,274.56	1,274.56	BM3				Thulo Pipra Road - Tribhuvan Rajpath Road Left
3L1F	1,024.12	**0.00**	BM3				Tribhuvan Rajpath Road Right
3L1G	557.43	0.00	BM3				Radhemai Road
3L1H	171.45	0.00	BM4				Parsauni Road
3L1I	1,938.89	0.00	BM4				2nd Bypass Road Right
3L1I	1,502.48	1,502.48	RCC1				Padam Road/ D4 Left
3L1J	926.70	0.00	BM3				2nd Bypass Road Left
3L1K	1,616.66	**0.00**	BM2				Bypass Road Left

From initially 13.1 km of proposed drains, the total length of new surface drains for the **Catchment 3 is 6,085 m** [3L1, 3L1E, 3L1I part]. Te size of the main line in Outfall 3 is a rectangular drain type RCC3 2.00 m width. The layout of the drains lines are shown on the General Layout drawing of the drainage scheme. The lines

Diversion 4

The Diversion 4 as named in PPTA along the left site of Padam Road, consits now with two rectangular drains left and right of the Padam Raod for a total length of 3.194m of RCC2 and RCC3. The last section is a combined line of 190 m discharging to the Outfall 3.

Table 5- 13: Diversion 4 (length in m)

Description	Catcht	unit	PPTA		DSC		Comments
			Qty	Size	Qty	Size	
Diversion 4	3	m	2,242	2.0 x 2.0	1,692	RCC1/2 and 3	Padam right
					1,502	RCC3	Padam Left
			2,242		3,194		

The total length of the Diversion 4 is 3,194 m, [2,242 m at PPTA]

5.5.5 Catchment 4A and 4

Location

Outfall 4 and Outfall 4A collect the storm water on the west side of the Tribhuvan Rajpath. The drain cover three different wards: 14, 16 and 17.Overall catchment area of the outfall is about 68.9 ha. Individually Outfall 4A catchment lies on the north and has an overall area of 41.68 ha and the Outfall 4 has the catchment area of 27.2 ha. The catchment of this outfall currently has all three types of settlement cultivated, residential and multi units, resulting in three different runoff constants 0.35, 0.4 and 0.5.

Description of the proposed scheme 4 and 4A

Catchment 4A

The proposed storm system in catchment 4A includes one main line 4AL1 and 8 branches named lines 4AL1A to 4AL1H. The main line 4AL1 is starting on the natural drain in Tejarath Tole until Radhemai road where it collects the branch line 4AL1A. The main is continuing to the Shreepure main natural drain and collects the branches 4AL1D and 4AL1E. The branch line 4ALF in following the Shreepur road collects the branches 4AL1G and the Branch 4AL1B and 4AL1H at the Shreepur Tinepedia chowk. The line attains the Shreepur River in the Vidayapati road.

Catchment 4

The proposed storm system in catchment 4 includes one main line 4L1 and 3 branches named lines 3L1A to 3L1C. The main line 4L1 is starting on the right site of Tribhuvan Rajpath and follows the Nayabasti area until Om Ashram Road where it connect with the branch 4L1A. The *main line is then following the Om Ashram Road, where it is connected with the branches 4L1B and 4L1C. The last section of the main line is following the Ranighat Road until the Ranighat Chowk where it turns to the right and discharge to the outfall 4 in the Sirsiya River.

Summary of proposed lines

The table hereafter presents the list of lines (Main line and branches). No alternative has been considered in these areas and all designed drains should be constructed as certain area subject to flooding should be discharged to the drain scheme.

Table 5- 14: Summary of the proposed lines - Catchment 4A

	Interim	Final					
Total	**4,967.66**	**4,967.66**	**Drain Size**				**Comment**
Line	**1,479.89**	**1,479.89**					**2 Main lines**
4AL1	359.53	359.53	BM3	RCC1			Natura Drain Tejarath
4AL1	1,120.36	1,120.36	Trap2.5	Trap3.0			Shreepur Natural Drain
Branch	**3,487.77**	**3,487.77**	**Drain Size**				**8 Branches lines**
4AL1A	651.91	651.91	BM3	BM5			Tejarath Tole Road
4AL1B	439.27	439.27	BM3	CH44			National Trading Raod
4AL1C	645.66	645.66	BM1	BM3			Tribhuvan Rajpath Road - Tejarath Tole
4AL1D	283.60	283.60	BM3				Ranighat Road
4AL1E	92.30	92.30	BM1				Ranighat Road
4AL1F	1,063.70	1,063.70	BM0	BM2	BM4		Tribhuvan Rajpath, Shreepur, Ranighat, Vidyapati
4AL1G	146.65	146.65	BM2				Dhangad tole
4AL1H	164.68	164.68	BM1				Ranighat Road

The total length of proposed drains is 4,967m for the Catchment 4A with 3,847m of rectangular surface drain and 1.120m of natural Drain. The Shreepur natural drain shall be used and refurbished (cleaning, reshaping, stone pitching wall and bed, etc.) to accommodate the flow of the outfall 4A with adequate trapezoidal sections. The total length of the **natural drain is 1,120m** and its different section is presented hereafter.

Table 5- 15: Summary of the proposed lines - Catchment 4

	Interim	Final					
Total	**2,669.53**	**2,669.53**	**Drain Size**				**Comment**
Line	**1,305.76**	**1,305.76**					**1 Main line**
4L1	1,305.76	1,305.76	BM3	BM4	BM5		Tribhuvan Rajpath, Nayabasti,

							Om Ashran, Ranighat
Branch	**1,363.77**	**1,363.77**	**Drain Size**				**3 Branches lines**
4L1A	730.19	730.19	BM2				Tribhuvan Rajpath, Om Ashran
4L1B	223.47	223.47	BM1				
4L1C	410.11	410.11	BM2				Ranighat Road
4L1D	0.00	0.00	BM3				Ranighat Road
4L1E	0.00	0.00	BM3				Nayabasti

The total length of new surface drains for the **Catchment 4 is 2,670m** and the size of the Outfall 4 is a rectangular BM drain BM type 1.50x 1.20 m

Natural Drains

The existing conditions of the natural drain, the planned actions and the proposed size of the trapezoidal drain are presented in the following table:

Table 5- 16: Improvement of Shreepur Natural Drains

Node		Distance	Drain - Existing and planned actions			
From A	To B		Existing Conditions	Planned actions	Proposed size	Height
Outfall 4A - Shripur Natural Drain				-	-	m
DR06-1/3	CS	218.47	Earth drain	Stone/ RCC beams/Gabions	TRAP2.5	1.5
CS	ND1-0	13.55	Earth drain	Stone/ RCC beams	TRAP2.5	1.5
ND1-0	CS	332.66	Earth drain	Stone/ RCC beams	TRAP2.5	1.5
CS	Bridge a	52.77	Earth drain	Stone/ RCC beams	TRAP2.5	1.5
Bridge a	Bridge b	5.00	Concrete Bridge	Repair existing concrete	CULV3.0	2.5
Bridge b	CS	312.64	Earth drain	Stone/ RCC beams	TRAP3.0	1.5
CS	Overflow1	72.95	Earth drain	Stone/ RCC beams	TRAP3.0	1.5
Overflow1	Overflow2	9.44	Masonry structure	Repair existing BM structure	MAS05.0	3.0
Overflow2	CS	47.86	Earth drain	Repair existing culvert	TRAP3.0	1.5
CS	Bridge	28.14	Earth drain	Stone/ RCC beams	TRAP3.0	1.5
Bridge1	Bridge2	5.00	Concrete Bridge	Repair existing concrete	CULV2.8	4.0
Bridge	CS/Outfall4A	21.89	Earth drain	Stone/ RCC beams	TRAP3.0	1,5
CS/Outfall4A		**1120.36**	River	Gabions outfall	TRAP3.0	

The planned drain is trapezoidal with a bottom width of 2.5 and 3.0m. The height is 1.50 m with lateral slope of 1/1. After cleaning and removal of vegetation the new drain shall be restored in stone pitching with mortar. The stones shall be installed in a concrete frame consisting of RCC beams of 20x20 cm on the bottom and the edge of the drain. Transversal beams shall be installed each 3 m along the section of the drain.

It has been noted the presence of an over fall structure in masonry in the natural drain. The DSC proposes to rehabilitate this masonry structure which is protecting the drain from back flow and works as retention pound. A line of gabions shall protect the outfall and the first culvert at its junction with Sirsiya River.

5.5.6 Catchment 5

Location

Outfall 5 is nearly 800 m downstream from the outfall 4. Five different wards: 12, 13, and 14 fall within the catchment boundaries of this outfall. The water from west side of the Tribhuvan Rajpath flows out to this particular outlet. All the areas fall under semi-residential area having the runoff coefficient as 0.4 and will remain the same in the future as well. Storm-water from approximately 32.72 ha flows towards the outlet.

Description of the proposed scheme 5

The designed storm system in catchment 5 initially includes one main line 5L1 and 6 branches 5L1A to 5L1F. The proposed main line 5L1 start at the northern part of the catchment in the south of Nayabasti, follows the Goshwara Road and the Rani Ghat road with the connection with the branch line 5L1C. At the Pan Gali crossing the main line collects the diversion line 5L1F coming from the MD1. The main line is located in the Ashok Batika road and the Aryaghat road until the outfall 5 in the Sirsiya River.

Summary of proposed lines

The table hereafter presents the list of lines (Main line and branches) to be constructed as part of the new drainage scheme.

Table 5- 17: Summary of the proposed lines - Catchment 5

	Interim	Final					
Total	**3,305.34**	**2,086.89**	**Drain Size**				**Comment**
Line	**1,809.27**	**1,809.27**					**1 Main line**
5L1	1,809.27	1,809.27	BM3	BM4	RCC3	BM3	South Nayabasti, Goshwara,Ranighat, Ghadiharwa, Ashok Batika, Aryaghat
Branch	**1,496.07**	**277.62**	**Drain Size**				**2 Branches lines**
5L1A	300.64	0.00	BM1				Ranighat Area
5L1B	646.81	0.00	BM1				Ranighat Road

5L1C	152.81	152.81	BM1				Ranighat Road
5L1D	99.00	0.00	BM2				Ghadiharwa Road
5L1E	172.00	0.00	BM3				Ghadiharwa Road
5L1F	124.81	124.81	RCC1				Pangali Road/Diversion

The total length of new proposed drains for the **Catchment 5 is 2,086m** [including the overflow drain from MD1] and the size of the Outfall 5 is a rectangular RCC3 covered drain 2.0 width.

New Diversion Channel – Overflow Drain

In order to achieve the best optimization of drainage system and use of existing assets, an attempt has been made to divert portion of flows that are arriving from the upper part of Catchment 9 catchment through Outfall 5. By doing so, Outfall 9 catchment will be relieved from huge flows that are generated by the upper catchment. In view of this, model has been built and Outfall 5 sizing has been made to reflect the overflow from Outfall 9. This new overflow will divert the discharge from a repartition chamber to discharge to the Sirsiya River near to the Aryaghat.

The arrangements and the repartition of flow are shown on the following figure:

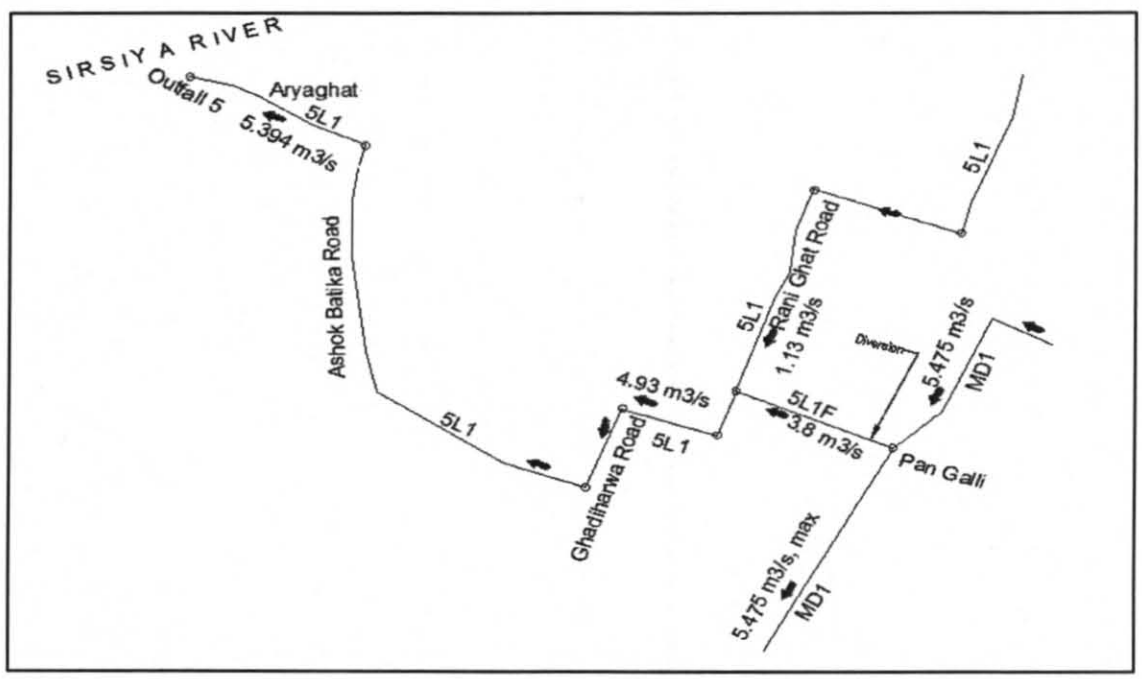


Figure 5- 11: MD1 Diversion – Overflow to Outfall 5

But due to the low gradient, the width of the street and the need to discharge the catchment 5, the overflow drain, the line 5L1F will have a limited size RCC3. The total length of this **overflow**

drain of a size 2.0 x 1.60 is about 740 m from the diversion chamber in MD1 until the outfall 5. The line will carry a discharge flow of 3.8m3/s maximum at the starting point at MD1 and the total flow at the Outfall 5 shall be 5.5m3/s. The inlet flow in the diversion chamber is 5.5m3/s [reduced flow from interim report due to the discharge of Daak road in Outfall 6] and it is planned that this total flow will transit to the downstream a section of MD1 after the diversion chamber.

The arrangement planned at interim report to by-pass partially the MD1 through the catch drain will not be feasible. The initial proposal as per PTTA will be followed and the catch pit drain will collect the run-off of the Aadarsh Nagar Main road to MD1.

5.5.7 Catchment 6 – Diversion 12

Location

Outfall 6 consists of the catchment area of ward 10, 15 and 18, with the total catchment area being 160.2ha [initially 132.77 Ha]. The Catchment area includes cultivated land and semi residential areas as well. The enclosed catchment, both current and future, contains cultivated and semi-residential areas thus have two runoff coefficient of 0.35 and 0.4. The discharge from the outlet drains out into the Singha River. The catchment has been slightly modify from the initial catchment presented at interim report due to the modification of the discharge of Daak road in the Diversion 12/outfall 6 instead of the catchment 9 to MD1.

Description of the proposed scheme 6

Initially the designed storm system in catchment 6 includes one main line 6L1 and 7 branches 6L1A to 5L1G. The main line 6L1 starts at the northern part of the By-pass road at Padam road and follow the right site of the by-pass until the Bhanu Chowk. The line collects the branch line 6L1D et 6L1G along the left site of the by-pass road, the lines 6L1 E in the 2nd By-pass. At the Bhanu Chowk point the main line 6L1 is following the NMC Road until its outfall 6.

Summary of proposed lines

The table hereafter presents the list of lines (Main line and branches) to be constructed as part of the new drainage scheme.

Table 5- 18: Summary of the proposed lines - Catchment 6

	Interim	Final					
Total	**11,380.61**	**7,393.52**	**Drain Size**				**Comment**
Line	**3,580.65**	**3,580.65**					**1 Main line, end part of Diversion 12**
6L1	3,580.65	3,580.65	BM2	BM5	RCC2	BX1	Bypass Road Right, D12 NMC
Branch	**7,799.96**	**3,812.88**	**Drain Size**				**4 lines**
6L1A	1,129.20	0.00	BM3	BM5	RCC2		Murli Road
6L1B	1,993.06	**0.00**	BM2	BM3			Bypass Road Left
6L1C	864.82	0.00	BM4				Bishwa road
6L1D	637.93	637.93	BM1	BM4			Ghantaghar link road
6L1E	1,988.61	1,988.61	900	1200			D12 North starting 2nd BP
6L1F	278.07	278.07	900				D12 southern part 2nd BP
6L1G	908.27	908.27	BM3	RCC1			**Daak Road, to Bhanu Chowk**

The total length of proposed new drains for the **Catchment 6 is 7,394m** with 5,126m of rectangular drain and 2,267 m of circular drain [Diversion 12 part]. The size of the Outfall 6 is the largest size of the drainage of Birjung with a box culver BX1 of 2.5m width.

Diversion 12

The Diversion 12 is included in the present catchment 6. It follows the northern part of the 2nd by-pass road with two pipe sections 900mm and 1200mm. The last section is in the MNC road to the Outfall 6 in a large Box culvert drain. The Diversion 12 includes 278 m of circular drain of 900mm in the southern section in the 2nd By-pass road. The total length of the Diversion 12 as studied by the DSC is 3.8 km [3.6km in PPTA].

Table 5- 19: Length of Diversion 12 in Catchment 6

Description	Catcht	unit	PPTA		DSC		Comments
			Qty	Size	Qty	Size	
Diversion 12	6	m	3,617	2.5 x 1.5	1,989	Dia 900/1200	North 2nd By-pass
	6		-	-	278	Dia 900	South 2nd By-pass
	6		-	-	1,538.68	Box1	MNC Road
			3,617		3,805		

5.5.8 Catchment 7 – Diversion 13A

Location

Outfall 7 solely consists of cultivated land areas with the runoff of 0.35, which in the future has the potential of being a semi-residential area and thus changing the runoff coefficient to 0.4. The approximate catchment area for the outfall is about 73.55 Ha with the longest length of the pipe reaching1833m. The outfall drains out in to the Singha river. The water primarily comes from the east side of the Tribhuvan Rajpath.

Description of the proposed scheme 7

The proposed storm system in catchment 7 includes only one main line 7L1. The main line start at the intersection of the MNC road and the Canal Road at the National Medical Chowk follow the canal road until the Singha river at the access to the Landfill. The drain shall be installed prior to the execution of the new access road to the landfill. The Line will be a circular drain with manholes and catch pit located at each side of the road. The line refers to the Diversion 13 from PPTA report.

Summary of proposed lines

The table hereafter presents the list of lines (Main line and branches) to be constructed as part of the new drainage scheme.

Table 5- 20: Summary of the proposed lines - Catchment 6

	Interim	**Final**					
Total	**1,681.78**	**1,681.78**	Drain Size				Comment
Line	1,681.78	**1,681.78**					1 Main line, Diversion D13A
6L1	**1,681.78**	1,681.78	900	1,400.00			Access to Landfill D13A
Branch	**0.00**	**0.00**	Drain Size				
							Naguwa Road
							Naguwa Fulbari Road

The total length of new surface drains for the **Catchment 7 is 1,682m** and the size of the Outfall 7 is a pipe Diameter 1,400mm. The Diversion 13A is a pipe line of a total length of 1,682m. [PPTA 2.3 km]

5.5.9 Catchment 8 – Diversion 13

Location

Outfall 8 has water flowing in from all cultivated area, semi-residential area and residential areas with runoff corresponding to 0.35, 0.4 and 0.5. However in the future it is projected that the cultivated areas within this site will be replaced by either semi residential or residential areas which results in only two different runoffs resulting to a higher flow in the future. The overall catchment area is approximately 66 ha.

Description of the Proposed Scheme

The proposed storm system in catchment 8 includes one main line 8L1 and 8 branches. The main line 8L1 is starting on the right site of the Railway Road close to Ghantaghar Chowk. Along the Railway Road the line 8L1 is collecting the branches lines 8L1C and D. At the Laxmi Narayan Chowk the main line turns on the left to the Narwa Chowk located on the by-pass road. After connecting the branch 8L1G the main line is located on the right site of the by-pass road until the main culvert where it is connected to the branches 8L1H [left site of the by-pass road] and 8L1J the drainage line of the 2nd by-pass [Diversion 13]. The branch line 8L1I is collecting the flow from the Naguwa Road.

Summary of proposed lines

The table hereafter presents the list of lines (Main line and branches) to be constructed as part of the new drainage scheme.

Table 5- 21: Summary of the proposed lines - Catchment 8

8	**Interim**	**Final**					
Total	**9,013.09**	**6,542.58**	Drain Size				Comment
Line	**2,627.72**	**2,627.72**			**1,809.27**		**1 Main line, Diversion D13**
8L1	**2,627.72**	2,627.72	BM1	BM2	BM3	RCC1	Railway Road, road crossing
8L1			RCC2	RCC3	Trap2.5		By-pass road Right, 2nd By-pass, Natural drain

8 Interim Final

Total	9,013.09	6,542.58	Drain Size				Comment
Branch	**6,385.37**	**3,914.86**	**Drain Size**				**6 branches lines**
8L1A	199.64	0.00	BM0				Ram Tole Area
8L1B	331.22	0.00	BM1	BM2			Ram Tole Area
8L1C	186.19	186.19	BM2				Ram Tole Gali Road
8L1D	350.55	350.55	BM3				Kumal Tole Road
8L1E	273.27	0.00	BM1	BM2			Birta Link Road
8L1F	530.43	0.00	BM1	BM3	BM4		Jail Road
8L1G	1,146.01	1,146.01	BM1	BM2	742.79	BM1	By-pass road Right
8L1H	1,735.95	600.00	BM3				By-pass road Left
8L1I	384.12	384.12	BM4				Naguwa Road
8L1J	1,248.00	1,248.00	700	1400			D13 2nd By-pass

The total length of new drains for the Catchment 8 is 6,543m including 4,938m of rectangular drains, 1,248 m of circular drain (D13) and a section of 357 m of natural drain, outfall 8 until the Singha River.

Natural Drains

The existing conditions of the natural drain, the planned actions and the proposed size of the trapezoidal drain are presented in the following table:

Table 5- 22: Improvement of Natural Drains

Node		Distance	Drain - Existing and planned actions			
From A	To B		Existing Conditions	Planned actions	Proposed size	Height
Outfall 8-Natural Drain						
D13-2/4A/CS	CS 1	88.62	Earth drain	PCC and stabilized soil	TRAP2.5	1.00
CS 1	D13-2/4B	52.35	Earth drain	PCC and stabilized soil	TRAP2.5	1.00
D13-2/4B	CS 2	19.32	Earth drain	PCC and stabilized soil	TRAP2.5	1.00
CS 2	CS 3	98.19	Earth drain	PCC and stabilized soil	TRAP2.5	1.00
CS 3	CS/Out 08	98.58	Earth drain	PCC and stabilized soil	TRAP2.5	1.00
CS/Out 08		**357.05**	Earth drain	Gabions/Outfall 8	TRAP2.5	1.00

Diversion 13

The Diversion 13 is included in the present catchment 6. It follows the 2nd by-pass road with two pipe sections 700mm and 1400mm. After the main culvert the last section is a natural drain of 357 m flowing to the Singha River. The total length of the Diversion 12 is 1.6 km [3.0 km in PPTA]

Table 5- 23: Diversion 13

Description	Catcht	unit	PPTA		DSC		Comments
			Qty	Size	Qty	Size	
Diversion 13	8	m	3,027	3.4 x 1.8	1,248	Dia 700/1400	2nd by-pass
	8				357	Trap 2.5	Natural drain
			3,027		1,605		

5.5.10 Catchment 9 – MD 1

Location

The catchment area of outfall 9 has water flowing in from an area which has all three types of the runoff within it. Total ward number within the outfall 9 are 1,3,7,8,11,12,13. The current and future projection shows all three runoff system to exist within the catchment area of the outfall. The approximate area is around 215 ha.

Description of the Proposed Scheme

The proposed storm system in catchment 9 includes one main line 9L1 MD1 Natural drain and 30 branches named lines 9L1A to 9L1AE.

The main line 9L1 is starting from the post office culvert in Ward 10 toward his Outfall [Outfall 9] in Sirsiya river near the customs house with a total length of 4918m [PPTA gives 4707m of a difference of 211m]. The branches 9L1A to K collect the flow from the eastern (road No3) the central (Tribhuvan Rajpath road left and right) and southern parts of the catchment. The area of Aadarsh Nagar shall be drained with a new network to the MD1 at the location of the bridge on Hadji Ali road with 19 branches 9L1L to AD.

All the branches of the catchment discharge in MD1. The outfall 9 of MD1 in the Sirsiya River is considered to be acceptable as a junction of two natural drains and further more the restricted access in the area of the border with India may not authorise any works

Summary of proposed lines

The table hereafter presents the list of lines (Main line and branches) to be constructed as part of the new drainage scheme in Catchment 9. No alternative i.e. reduction of the drains is proposed from the design due to the critical conditions of the area exposed to flooding.

Table 5- 24: Summary of the proposed lines - Catchment 9

	Interim	**Final**					
Total	**16,466.85**	**16,466.85**	Drain Size				Comment
Line	**4,918.61**	**4,918.61**			**1,809.27**		**1 Main Natural Drain MD1**
9L1	**4,918.61**	**4,918.61**	TRAP3.0	TRAP3.5	TRAP4.0	TRAP4.5	MD1
9L1			TRAP5.0				MD1
Branch	**11,548.24**	**11,548.24**	**Drain Size**				**30 Branches lines**
9L1A	1,442.73	1,442.73	BM2	BM3	BM4	BM5	Tribhuvan Rajpath Left
9L1B	370.60	370.60	BM1				Tribhuvan Rajpath Right
9L1C	0.00	0.00					
9L1D	421.05	421.05	BM1	DR20-R1	421.05	BM1	Tribhuvan Rajpath Right
9L1E	572.65	572.65	BM2	BM3	421.05	BM2	Tribhuvan Rajpath Left
9L1F	253.16	253.16	BM0		253.159	BM0	Tribhuvan Rajpath Right
9L1G	434.87	434.87	BM0	BM1			Tribhuvan Rajpath Left
9L1H	1,036.48	1,036.48	BM3	BM4	BM5		Road No3, No2, Kali Mandir / Pani Tanki Road
9L1I	552.77	552.77	BM1				Tribhuvan Rajpath Right
9L1J	531.90	531.90					Tribhuvan Rajpath Left
9L1K	800.92	800.92	BM2	BM3	BM4		Aadarsh Nagar Main Road, Pani Tanki Road

	Interim	Final					
Total	**16,466.85**	**16,466.85**	Drain Size				Comment
9L1L	148.38	148.38	BM1				Lath Gali Road
9L1M	147.11	147.11	BM1				Town hall Road
9L1N	147.82	147.82	BM1				Aadarsh Nagar Main Road
9L1O	148.83	148.83	BM1				Aadarsh Nagar Main Road
9L1P	148.90	148.90	BM0			BM0	Rangashala Road
9L1Q	149.24	149.24	BM1			BM1	Aadarsh Nagar Road
9L1R	1,072.51	1,072.51	BM2	BM3	BM4/5	RCC1	Pashupati Road, Pani Tanki Road, Hadji Ali Road
9L1S	75.15	75.15	BM1				Lath Gali Road
9L1T	149.26	149.26	BM1				Lath Gali Road
9L1U	296.16	296.16	BM1				Town hall Road
9L1V	150.28	150.28	BM1				Town hall Road
9L1W	299.64	299.64	BM1				Aadarsh Nagar Main Road
9L1X	148.98	148.98	BM1				Aadarsh Nagar Main Road
9L1Y	300.07	300.07	BM1				Aadarsh Nagar Main Road
9L1Z	148.33	148.33	BM1				Aadarsh Nagar Main Road
9L1AA	301.07	301.07	BM1				Rangashala Road
9L1AB	148.89	148.89	BM1				Rangashala Road
9L1AC	150.05	150.05	BM0				Aadarsh Nagar Road
9L1AD	149.85	149.85	BM1				Aadarsh Nagar Road

	Interim	Final					
Total	**16,466.85**	**16,466.85**	Drain Size				Comment
9L1AE	850.59	850.59	BM3				Chhaapkahiya Road

The total length of new rectangular drains for the Catchment 9 is 16,476m including 11,548m of surface drains [10,875m of masonry drains and 653m of RCC drains (RRC1)] and 4,918m of natural drain MD1.

Natural Main Drains MD1 channels and associated diversion

The network of open drains in the core area to the west of the highway in Catchment 9 has a central main drain, which is referred to as MD1 or otherwise as Diversion 6. The detailed calculations of the catchment's area, surface runoff and discharge to MD1 have been calculated and the required channel section has been defined.

a. **General Situation** The drain is comprised of BM brick masonry, RCC, earthen including 16 roads crossing with box culvert and/or bridges one outfall to the River. The actual condition of the MD1 is very bad [vegetation, garbage, mud, obstructions, wall collapsing] and several buildings have been constructed over it giving not access to the drain.

MD1 is an essential component of the storm system and its rehabilitation and reconditioning is urgently required as well any protection of further deterioration.

Moreover rapid urbanization has increased the paved and non-porous surface area within the catchment which in turn has amplified surface runoff to this drain. The capacity of the drain is already constraint, and overflow of water to flood potentially dangerous black-water into areas alongside MDI has been increasing over time.

In over all, it is clear that in Birgunj the existing drainage network must comply with the *National Urban Water Supply and Sanitation Sector* which states that: "Sewers and other sanitary systems that do not conform to sound environmental engineering practices shall be re-engineered for better environmental friendliness."

b. **Improvements to MD1** Full rehabilitation of the length of MD1 is required, including construction of a diversions chamber near to the head of MD1 at Gaushala culvert 0+752.00, a repartition chamber to divert the flow to the Outfall-5.

Cleaning includes the removal of garbage/solid waste, vegetation, mud, accumulated debris and any dumped construction's material. Fencing shall be installed to protect the drain against the drop of solid waste from culvert and bridges. Where possible along the drain especially

when the sewerage line is along the drain a service road shall be constructed for maintenance purpose. From the survey and site investigations of the existing conditions of the natural drain, the planned actions, the table hereafter summarized the type of existing section and the related actions to be carried out.

Table 5- 25: MD1 existing conditions and planned action

Category	Length	Action	Existing conditions
1	763.395	Repairs walls / PCC bed	BM, PCCB
2	36.188	Renew stone wall / RCC bed	RCC Drain
3	491.407	Repairs BM wall / RCC bed	Earthen drain., RCC
4	252.843	Renew/BM-RCC wall & bed	Repairs BM walls and RCC bed
5	266.098	Repair, scraping/plastering	BM/RCC Drain
6	360.735	Renew/BM wall & PCC	Renew/stone wall & PCC
7	1146.305	Stone pitching / RCC beams	Renew/stone wall RCC beam
8	1266.872	Stabilized soil wall / PCC bed	Earthen drain
9	216.825	New Box culvert	Earthen drain.
10	13.92	Repair BM structure	Repair existing culvert
11	78.672	Repair existing road culvert	Culvert
12	24.742	Diversion/overflow	Culvert/earthen
Total	**4918.002**		

Twelve categories of different actions have been defined in relation to the existing conditions and the planned structures to be constructed. The table indicates the length of the corresponding categories (example 78.7 m of road culvert, 1266.9 m of earthen drain, and 216.8 m of earthen drain where a new box culvert shall be constructed)

c. MD1 – summary of sections The MD1 has been investigated in detail when accessible [section C9B to C10A over 213m is inaccessible] the existing conditions of each sections and the planned actions and the proposed size of the trapezoidal or rectangular drain has been inventoried. The corresponding results of the different sections of the MD1 from start until the outfall 9 over the length of 4,918 m is presented in the following table.

Table 5- 26: MD1 detailed sections

Node		Distance	Natural Drain				
From A	To B		Road	Conditions	Planned actions	Size	Ht
Outfall 9-Natural Drain MD1			-	-	-	-	m
DR19	C0b	13.92	Tribhuvan	Bridge	Repair existing	CULV3.0	1.8

Node		Distance	Natural Drain				
From A	To B		Road	Conditions	Planned actions	Size	Ht
Outfall 9-Natural Drain MD1			-	-	-	-	m
			Rajpath		culvert		
C0b	CS	68.46		BM, PCCB	Repairs walls and bed PCC	TRAP3.0	1.5
CS	DRNB	38.93		BM, PCCB	Repairs walls and bed PCC	TRAP3.0	1.5
DRNB	CH178	14.62		BM, PCCB	Repairs walls and bed PCC	TRAP3.0	1.5
CH178	CS	39.76		BM, PCCB	Repairs walls and bed PCC	TRAP3.0	1.5
CS	C1A	57.87		BM, PCCB	Repairs walls and bed PCC	TRAP3.0	1.5
C1A	C1B	2.25		Culvert	Repair existing culvert	CULV4.0	2
C1B	CS	91.63		Earth, PCC	Renew/stone wall RCC beam	TRAP3.0	1.5
CS	C2A	57.66		Earth, PCC	Renew/stone wall RCC beam	TRAP3.0	1.5
C2A	C2B	4.13		Culvert	Repair existing culvert	CULV3.5	1.5
C2B	CS	49.22		Earthen	Renew/stone wall RCC beam	TRAP3.0	1.5
CS	C3A	32.14		Earthen	Renew/stone wall RCC beam	TRAP3.0	1.5
C3A	C3B	6.62		Culvert	Repair existing culvert	CULV5.0	1.5
C3B	DRNB	21.11		Earthen	Renew/stone wall RCC beam	TRAP3.0	1.5
DRNB	CS	20.00		Earthen	Renew/stone wall RCC beam	TRAP3.0	1.5
CS	C4A	32.01		Earthen	Renew/stone wall RCC beam	TRAP3.0	1.5
C4A	C4B	6.48	Ghantaghar (DO)	Culvert	Repair existing culvert	CULV5.2	1.5

Node		Distance	Natural Drain				
From A	To B		Road	Conditions	Planned actions	Size	Ht
Outfall 9-Natural Drain MD1			-	-	-	-	m
C4B	CS	36.19		RCC Drain	Renew/stone wall RCC beam	TRAP3.5	1.5
CS	CS	97.55		Earthen	Renew/stone wall RCC beam	TRAP3.5	1.5
CS	C5A	42.29		BM, PCCB	Repairs BM walls and RCC bed	Rect3.5	1.5
C5A	Diversion	18.40		Earthen	Diversion chamber	Ref drw	-
Diversion	C5B	6.34	Pan Gali	Culvert	Diversion chamber	Ref drw	
C5B	CS	101.08		Earthen RCC	Renew/BM-RCC wall & bed	Rect3.5	1.5
CS	C6A	109.48		Earthen RCC	Renew/BM-RCC wall & bed	Rect3.5	1.5
C6A	C6B	5.80	Geeta Mandir	Culvert	Repair existing culvert	CULV5.6	2
C6B	CS	37.28		Earthen RCC	Renew/BM-RCC wall & bed	Rect4.0	1.5
CS	C7A	38.84		Earthen RCC	Renew/BM-RCC wall & bed	Rect4.0	1.5
C7A	C7B	3.04	Lath Gali	Culvert	Repair existing culvert	CULV6.0	2
C7B	CS	52.06		RCC Drain	Renew/BM-RCC wall & bed	Rect4.0	1.5
CS	C8A	41.31		RCC Drain	Renew/BM-RCC wall & bed	Rect4.0	1.5
C8A	C8B	2.21	Mahabirsthan	Culvert	Repair existing culvert	CULV5.0	2.5
C8B	CS	51.72		Earthen	Renew/BM-RCC wall & bed	Rect4.0	1.5
CS	C9A	56.22		Earthen	Renew/BM-RCC wall & bed	Rect4.0	1.5
C9B	C10A	20	Classic Hotel	Culverts	Repair existing Culvert	CULV4.5	3.5
C9A	C9B	10	Aadarsh	Culvert	Repair existing	CULV4.5	3.5

Node		Distance	Natural Drain				
From A	To B		Road	Conditions	Planned actions	Size	Ht
Outfall 9-Natural Drain MD1			-	-	-	-	m
					culvert		
C9A	C9B	20	Bank	Culvert	Repair existing culvert	CULV4.5	3.5
		80		Earthen	Renew/BM-RCC wall & bed	Rect4.0	1.5
C9B	C10A	80	Campus Khetan	Culvert	Repair existing culvert	CULV4.5	3.5
C10A	02-1/9	4.26	Kali Mandir	Culvert	Repair existing culvert	CULV5.0	2.5
02-1/9	CS/C10B	6.65	Kali Mandir	Culvert	Repair existing culvert	CULV5.0	2.5
CS/C10B	CS	119.58	Recreat.Park	Earthen	Construct double culvert	RCC2.0	
CS	CS	90.34	Recreat.Park	Earthen	Construct double culvert	RCC2.0	
CS	C11A	6.90	Recreat.Park	Earthen	Construct double culvert	RCC2.0	
C11A	C11B	7.57	Bhagwati	Culvert	Repair existing culvert	CULV3.0	2.5
C11B	CS	76.71		BM/RCC Drain	Repair, scraping/plastering	Rect4.5	1.5
CS	CS	92.66		BM/RCC Drain	Repair, scraping/plastering	Rect4.5	1.5
CS	CH199	65.81		RCC Drain	Renew/stone wall & PCC	Trap4.5	1.5
CH199	CS	77.77		RCC/BM Drain	Renew/stone wall & PCC	Trap4.5	1.5
CS	CH199-A	48.10		RCC/BM Drain	Renew/stone wall & PCC	Trap4.5	1.5
CH199-A	CS	118.01		RCC/BM Drain	Renew/stone wall & PCC	Trap4.5	1.5
CS	C12A	51.05		RCC/BM Drain	Renew/stone wall & PCC	Trap4.5	1.5

Node		Distance	Natural Drain				
From A	To B		Road	Conditions	Planned actions	Size	Ht
Outfall 9-Natural Drain MD1			-	-	-	-	m
C12A	C12B	4.43	Hadji Ali	Bridge	Site protection/gabions	CULV6.0	3
C12B	CS	147.28		BM Drain	Renew/stone wall & PCC	Trap4.5	1.5
CS	CS	124.20		BM Drain	Renew/stone wall & PCC	Trap4.5	1.5
CS	C13A	174.74		BM Drain	Renew/stone wall & PCC	Trap4.5	1.5
C13A	C13B	5.95	Chhapkahiya	Culvert	Repair existing culvert	CULV2.0	1.8
C13B	MD12	1.69		BM Drain	Repair, scraping/plastering	Rect4.5	1.5
MD12	CS	54.08		BM Drain	Repair, scraping/plastering	Rect4.5	1.5
CS	CS	40.96		BM Drain	Repair, scraping/plastering	Rect4.5	1.5
CS	MD12A	142.08		Earthen	Dry stone/ RCC beams	Trap4.5	2
MD12A	CS	93.37		Earthen	Dry stone/ RCC beams	Trap4.5	2
CS	CS	202.13		Earthen	Dry stone/ RCC beams	Trap4.5	2
CS	C14A	205.73		Earthen	Dry stone/ RCC beams	Trap4.5	2
C14A	C14B	4.83	Entrance STP	Bridge	Site protection/gabions	CULV7.0	2.5
C14B	MD13A	116.75		Earthen	PCC and stabilized soil	Trap5.0	2
MD13A	CS	35.17		Earthen	PCC and stabilized soil	Trap5.0	2
CS	CS	205.12		Earthen	PCC and stabilized soil	Trap5.0	2
CS	Node	43.07		Earthen	PCC and	Trap5.0	2

Node		Distance	Natural Drain				
From A	To B		Road	Conditions	Planned actions	Size	Ht
Outfall 9-Natural Drain MD1			-	-	-	-	m
					stabilized soil		
Node	CS	109.59		Earthen	PCC and stabilized soil	Trap5.0	2
CS	MD14	26.26		Earthen	PCC and stabilized soil	Trap5.0	2
MD14	CS	204.37		Earthen	PCC and stabilized soil	Trap5.0	2
CS	MD14A	123.01		Earthen	PCC and stabilized soil	Trap5.0	2
MD14A	CS	31.23		Earthen	PCC and stabilized soil	Trap5.0	2
CS	CS	248.45		Earthen	PCC and stabilized soil	Trap5.0	2
CS	C15A	123.86		Earthen	PCC and stabilized soil	Trap5.0	2
C15A	C15B	4.35	Vansar Chowk	Culvert	Repair existing culvert	CULV2.5	3.5
C15B	CS	33.23		Earthen	Dry stone/ RCC beams	Trap5.0	2.5
CS	CS	81.96		Earthen	Dry stone/ RCC beams	Trap5.0	2.5
CS	Sirsiya	84.02		Earthen	Dry stone/ RCC beams	Trap5.0	2.5
Sirsiya			End Outfall 9		Survey, investigations	Trap5.0	2.5
		4918.00					

Diversion/overflow chamber

The diversion will divert some 3.8 m^3/s away from the head of MD1 which will improve the discharge in MD1. The Overflow chamber shall be constructed with an overflow wall, penstock gates. The gate will control the discharge to the RCC1 ending in outfall 5. The detailed description and function of the Chamber is present in the Catchment 5

The detail layout, section and plan of the proposed structures is presented in a separate Volume 1E Drawings of the present report.

Recreational park/area

At the length of MD1 in front of Khetan Campus at ch1+485, which is in the centre of town, is a particularly unhealthy eyesore; provision is made to convert this area to a green recreational park. This park shall be constructed over the MD1 which shall be completely covered and a double chamber culvert (RCC3 type) will be constructed underneath. For maintenance purpose the culvert will have provision for location of access point 1.0 x 1.5 m.

The Birgunj Recreational Park has been proposed to fulfill the recreational needs of general public and to create healthy environment in the existing unused water logged public land. The park attempts to accommodate various activities and age groups through segregation of spaces and zones.

The total area for park is estimated to be 0.55ha. A construction of a stone retaining wall 2.5/3.00m height shall be built on each site around the defined area. The area shall be backfilled, landscaped and covered with vegetative soil. Trees and grass plantations, walking area and play ground area shall be implemented. To complete the area additional fixtures such as sitting bench, pergola, bin and solar lighting shall be installed. The following paragraph gives the description of the

The main component of the park is the 2.5 meter flag stone paved jogging lane which loops throughout the park. Besides this there are tree covered seating spaces, provision for various gaming activities, public rest room etc. The site has been divided into 5 zones besides the main entry and parking area.

1. Social Zone,
2. Garden Zone & Park Area,
3. Kids Zone,
4. Fitness Zone &
5. Family gathering Zone/ Picnic Area.

The first zone is social zone and is a major social point where square platform (chautara) with tree shade has been provided. This zone is the main gathering point for the general visitors especially old age people. In this zone, separate rest room has also been provided along with a separate space for kiosk. This zone because of its higher traffic is served by 3 meter wide lane.

The second zone is the well maintained garden and the park zone. This zone is provided with some covered seating. A monument/ temple is provided at the core of this zone with a pathways connected to it. This zone is designed especially as a park with a very well maintained garden and is served by 2.5 meter wide lane. It is expected that this portion of park will be well maintained by municipality.

The third zone is the kid's zone, designed and planned targeting to the kids. Some covered seating and chautaras have also been provided. Different playing equipment such as see saw, slides, swings etc. has been provided. Some sand pits are also provided for the kids. This zone too is served by 2.5 meter wide lane.

The fourth zone is the Fitness zone, especially targeted to the young people. Different covered seating and the square platform has been provided. A light RCC badminton court and a couple of table tennis board are provided in this zone. This zone too is served by 2.5 meter wide lane. Low maintenance over the period has been key aspect of the component design.

The fifth and the final zone is the family gathering zone. This zone is also designed as a picnic area providing different covered seating and square platform. A separate raised platform (Dabali) has also been provided in this zone and is also served by 2.5 meter wide lane.

The detail layout, section and plan of the proposed structure is presented in a separate Volume Appendix 1E Drawings" of the present report.

5.5.11 Catchment 10

Location

The final outfall 10 exist in the extreme south location of Birgunj which currently has only cultivated and semi residential areas but has been foreseen to include multi-residential areas in the future as well which would result in the overall increase in the flow to the system . The outfall covers the catchment area of approximately 130 Ha.

Description of the proposed scheme 10

The proposed storm system in catchment 10 includes one main line 10L1 and 3 branches 10L1A to 10L1C. The main line starts at the northern part of the catchment 10 along the right site of the Tribhuvan Rajpath until its outfall 10 in MD1. The branch line10L1A is parallel to the main line, but on the left side of the Tribhuvan Rajpath. It is connected to the branch 10L1B coming from Road No. in Birta Mandir chowk, the branch 10L1C located in railway road and is ending with a connection with the main line 10L1 at the junction with the Bypass road.

Summary of proposed lines – Alternative

The table hereafter will present the list of lines (Main line and branches). All proposed lines should be executed at present stage.

Table 5- 27: Summary of the proposed lines - Catchment 10

	Interim	Final					
Total	**5,566.81**	**5,566.81**	**Drain Size**				**Comment**
Line	**2,269.08**	**2,269.08**					**1 Main line, Natural Drain MD1**
10L1	469.00	339.64	BM2	BM3	BM4	RCC1	Tribhuvan Rajpath Right
Branch	**3,297.73**	**3,297.73**	**Drain Size**				**3 Branches lines**
10L1A	1,668.31	1,668.31	BM2	BM3	BM4	RCC1	Tribhuvan Rajpath Left
10L1LB	629.71	629.71	BM2				Road No3
10L1LC	999.71	999.71	BM3	BM4	BM5		Railway Road

The total length of new surface drains for the **Catchment 10 is 5,567m.** The outfall of the Catchment 10 is done throughout the natural drain at the junction point with a RCC3 size drain and the Singha River.

5.6 DRAWINGS - LONG SECTIONS/PLAN VIEW

The preparation of the long section has been made using SOFTWEL software. From the topographical survey the ground level, the distance and design characteristics are entered into the software. The detailed results of the hydraulic computation for the gravity networks are presented in forms of tables and are given in the Volume 1B of this Final Report. An extract of the excel sheet is presented hereafter.

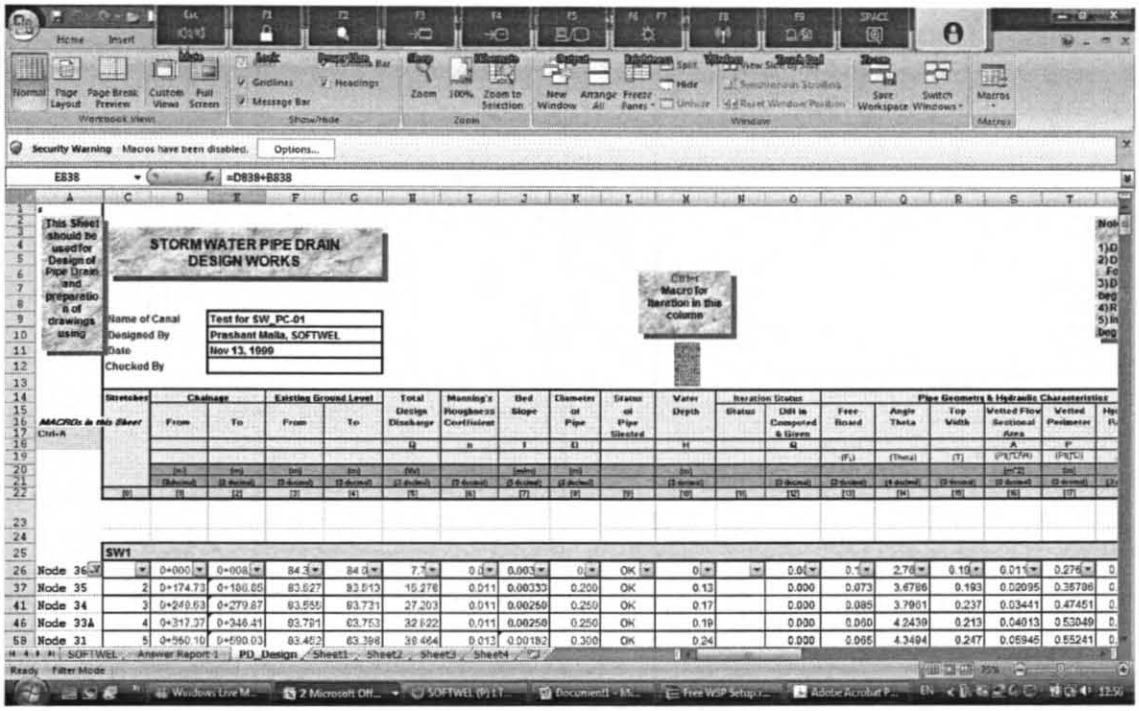


Figure 5- 12: Extract of the Excel sheet for the preparation of long sections

The corresponding long section with the design results such as the finish drain top level, the water level and the design invert level are presented in an automatic long section generated by the software. The long section will show the drain characteristics i.e. shape [rectangular, circular, trapezoidal, size/diameter, material, bedding, slope and length of each section. The related plan view and cross section will complete the design of the drainage lines. The corresponding drawings are included in the volume 1E of the Final Report.

5.7 SUMMARY OF LENGTH

5.7.1. Length as per Final Design

From a total length of 90.5 km of drains at interim stage, the DSC has study a length of 68.8km at draft design stage. Due to budgetary constraint an alternative reduce length of 53,5km is proposed to be constructed at Final Design stage. The summary of length by type of drain and catchment is proposed in the table 5-28.

Table 5- 28: Length of Proposed Storm Drains

All Catchments **Final Design**

Catchment	Drain	Pipe	Nat.drain	Total	Comment	Design	
Name	Rect.	Circular	Trapez.	Drains	Main drain	Interim	Draft
1	0	-		0	Postponed	798	0
2	0	-		0	Postponed	5,554	0
3	6,086	-		6,086	Including Diversion 4	13,608	13,124
4	2,670	-		2,670		2,728	2,670
4A	3,847	-	1,120	4,968	Natural drain Shreepur	5,510	4,968
5	2,087			2,087	Overflow MD1	3,135	3,305
6	5,127	2,267		7,394	Including Diversion 12	12,453	11,381
7	0	1,682		1,682	Including Diversion 13A	3,190	1,682
8	4,938	1,248	357	6,543	Including Diversion 13 and natural drain	9,296	9,013
9	11,548	0	4,919	16,467	Natural drain MD1	24,156	16,467
10	5,567			5,567	-	9,985	5,567
Total	**41,869**	**5,196**	**6,395**	**53,461**		**90,413**	**68,176**

5.7.2. Schematic of the drainage Length as per Final Design

The following schematic shows for each catchment the main lines, the dotted lines are the Diversion line identified at PPTA stage

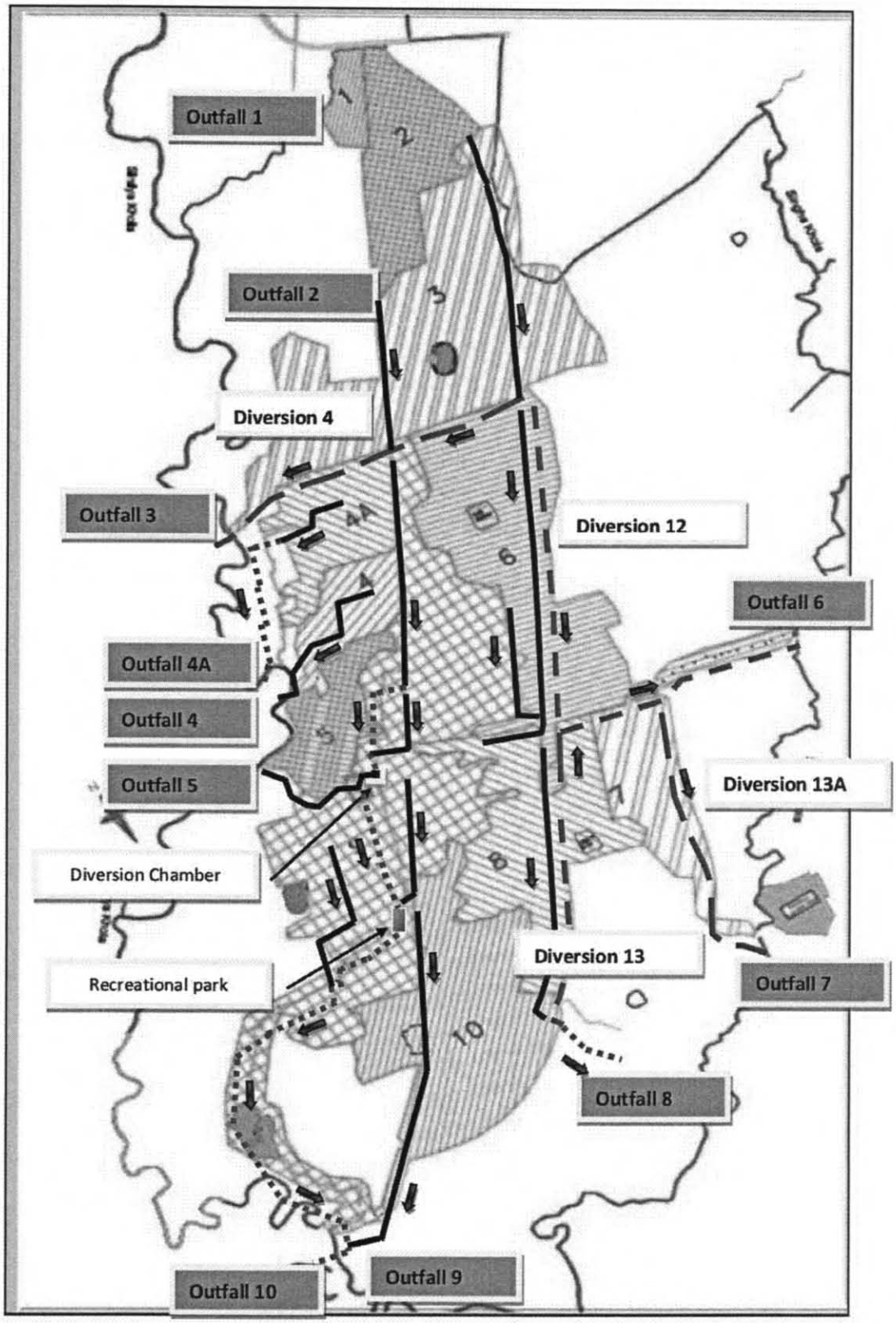


Figure 5- 13: Schematic of Main Storm drain lines

5.7.3. Storm Water Diversion Channels – Comparison with PPTA

Priority storm-water diversions shall be constructed in north and east of city. It is determined to construct four main storm-water diversion channels so as to draw away water from the zones prone to flooding and long term inundation. This will in turn enable the city to expand and grow to the east of the present built-up area, particularly with the proper and full construction of Diversions 12, 13 and 13A together with associated roads (see separate section). The drain data is tabulated below:

Table 5- 29: Characteristics of the Planned Diversion

Diversion Drains as per PPTA and DSC at Draft Design Stage							
Description	Catcht	unit	PPTA		DSC		Comments
			Qty	Size	Qty	Size	
Diversion 4	3	m	2,242	2.0 x 2.0	1,692	RCC1/2 and 3	Padam right
					1,502	RCC3	Padam Left
Diversion 12	6	m	3,617	2.5 x 1.5	1,989	Dia 900/1200	North 2nd By-pass
	6		-	-	278	Dia 900	South 2nd By-pass
	6		-	-	1,538.68	Box1	MNC Road
Diversion 12A	Not priority	m		2.5 x 1.8	-	-	Not in priority
Diversion 13	8	m	3,027	3.4 x 1.8	1,248	Dia 700/1400	2nd by-pass
	8				357	Trap 2.5	Natural drain
Diversion 13A	7	m	2,278	2.5 x 1.8	1,682	Dia 1200	Canal Road
			11,164		10,287		

The diversion 12A is not a priority drain and is not included in present study.

5.8 COSTS ESTIMATES

5.8.1 Quantities and unit Rates

Quantities

The quantities of works for the calculation of the cost estimates (CE) and the preparation of the Bill of Quantities (BOQ) are based on the technical assumptions and requirements defines to maintain the quality, live time and stability of the system. The standard drawings give the dimension of the structures and the long section the conditions for installation including location depth, length required for the calculations. The others assumptions for calculations are presented in the draft report and have been slightly modified to take into account the improvements and comments on the draft Report. In addition to the reduction of the length of drain line to be constructed, the main modifications are the following:

- Optimization of reinforcement in manhole bottom slab
- Use of M20 Concrete in general of reinforced concrete
- Execution of the soling in granular materials
- Improvement of the Outfall structures
- Reduction of the pipe surrounding and crown cover with selected materials
- Inlet chamber/service chambers in masonry

The quantities have been recalculated using the previous tailored model for each the work items such as excavation, backfill, pipe, concrete, surface removal and reinstatement, service pit, service pipe, house connections, etc...

A simple model made on Excel has been developed with automatic calculation of the quantities required to be entered in the CE taking into account the design criteria and assumptions. The assumptions are presented in the following chapter for pipe, manhole, reinstatement and house connections. Any modification of the assumption/standards will generate an automatic recalculation of the quantities of the estimate.

The Cost Estimate is divided in six (6) components. For each section a specific estimate has been developed with which basic prices and/or composite prices will be used. The unit prices multiplied by the estimated calculated quantities of works to be executed will give the cost estimate of the works. The six (6) mains schedules/BOQ is presented in the following table and has been individually divided in the parts/categories of works as follows:

- Schedule 1 Surface drains
- Schedule 2 Pipe drains
- Schedule 3 Natural drains
- Schedule 4 Outfall
- Schedule 5 Overflow chamber
- Schedule 6 Recreational Park

For each component of thee scheme, the respective quantities of the main items of works are presented in the following tables. The calculations of the quantities to be use for costing are presented in separate Volume 1D of the Final Design in Appendix C, C1 and C2 respectively for surface drain and pipe drains, including the assumptions and the details calculations of each respective component.

The respective quantities of the main items of works for each component of the drainage are presented in the following table:

Table 5- 30: List of main works items per project component

A-Surface drains

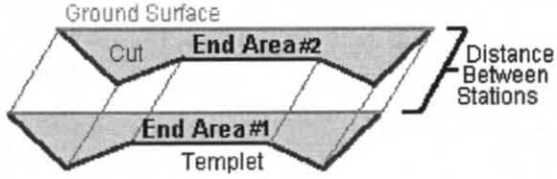
Works	Comments	Unit	Qty
Excavation	All soil and depth	m3	185.300
Backfilling	All type of material	m3	41.100
Concrete	M15, M20, M25, RCC drains	m3	10.000
Masonry	BM drains	m3	17,700
Service pipes	uPVC 110/160 mm	M	7,700
Inlet pits	Masonry chambers	No	1,400

B-Pipe Drains

Works	Comments	Unit	Qty
Excavation	All soil and depth	m3	24,600
Backfilling	All type of material	m3	19,250
Pipe drains	700/900/1200/1400 mm	M	5,200
Concrete	RCC Manhole	m3	180
Manhole	RCC	No	83
Service pipes	uPVC 110/160 mm	M	2,900
Inlet pits	Masonry chambers	No	170

Natural Drain

The reshaping volume of works of "Cut and Fill" between cross-sections shall be calculated using the Average End Area method. The Average End Area Method is not as accurate as prismodal methods, but it is as accurate as



usual field measurements warrant. The Average End Area Method is generally used by Highway Departments and Public Roads Administrations. This method is generally recommended for cut/fill calculations on roads, drains and airport projects or any project where the end areas are relatively similar.

This method takes the "cut /fill" area at one station, adds it to the cut/fill area at the next station and divides this area by two to get the average end area. Then it multiplies the average end area by the distance between the stations. Finally a unit adjustment is made in order to give a cubic volume.

$$\text{Volume} = \frac{(\text{Area of End \#1}) \times (\text{Area of End \#2})}{2} \text{ X Distance between Stations/cross-sections}$$

The detailed calculations of the quantities of the corresponding work items for preparation and earth works are presented in separate Volume 1D Appendix C3 for Natural Drains

Outfall

The detailed quantities for the calculations of the cost estimates of the Outfall of the catchments 3, 4, 5 6 and 7 are presented in the Volume 1D Appendix D4 with the Cost Estimate of the Final report. The main items of works are earthworks (excavation backfilling), concrete works (foundation, slab and walls), gabions and rip-rap.

Overflow chamber

The detailed quantities for the calculations of the Cost Estimates of the Overflow chamber are presented in the Volume 1D Appendix D5 with the Cost Estimate of the Final report. The main items of works are earthworks (excavation backfilling), concrete works (foundation, slab, wall and cover) and miscellaneous works (penstocks, handrails)

Recreational Park

The detailed quantities for the calculations of the cost estimates of the recreational park are presented in the Volume 1D with the Cost Estimates in appendix D6 of the Final report.

5.9 COSTS

5.9.1 Unit Prices

Based on the DSC experience of similar works and the market prices the list of the basic prices to be use for the calculations has been prepared. The unit prices are based on recent prices from manpower, machinery and materials. As per the quantities in the Cost estimates the unit prices are made and presented for the six main components of the drainage scheme.

The tables in the Volume 1D, Appendices A1 to A4 gives the rates used and breakdown for the calculations of the cost estimate. This Appendix includes in Appendix A1 the Parsa District rate, Appendix A2 the rates analysis for external material, Appendix A3 the break- down of rate analysis and in Appendix 5A4 the unit rate to be use in the preparation of the costs estimates of the project costs as per February 2013.

5.9.2 Costs Estimates

The tables in Appendices of Volume 1D, Appendices D1 to D7 summarize the costs estimates of each project main component

The tables hereafter shall presents the summary of the cost estimates by catchment for the proposed design system by nature of drains

- Schedule 1 Surface drains rectangular including existing drains,
- Schedule 2 Pipe drains circular
- Schedule 3 Natural drains trapezoidal
- Schedule 4 Outfall
- Schedule 5 Overflow/diversion chamber on mD1
- Schedule 6 Recreational Park to be construction above the covered MD1 in the corresponding section.

Schedule 1 – CE for rectangular drains

The cost of the calculations of the schedule 1 for rectangular drains is presented in Volume 1D Appendix D1 for each Catchment and for each item of works for which the quantities have been calculated as presented in the previous chapter. The next table gives the summary of the cost of the Schedule 1 for each catchment of the surface drains for each catchment of the drainage scheme.

Table 5- 31: Schedule 1 - Summary of cost by Catchment

Summary Surface Drains - All Catchments **NRs '000**

Catchment	Drain type	unit	Qty	Total	Cost / m
1	Catchment 3	m	6,086	201,959	33.2 NRs/m
4	Catchment 4	m	2,669.53	66,817	25.0 NRs/m
4A	Catchment 4A	m	3,847.29	100,884	26.2 NRs/m
5	Catchment 5	m	2,086.89	83,381	40.0 NRs/m
6	Catchment 6	m	5,126.85	200,060	39.0 NRs/m
7	Catchment 7	M	0.00	0	
8	Catchment 8	M	4,937.45	163,207	33.1 NRs/m
9	Catchment 9	M	11,548.24	265,569	23.0 NRs/m
10	Catchment 10	M	5,567.33	200,374	36.0 NRs/m
		Total	**41,869**	**1,282,253.9**	

The next table gives the summary of the cost of the Schedule 1 for each item of works as presented in the cost estimate of the surface drains.

Table 5- 32: Schedule 1- Summary of cost by Work's Items

Summary Surface Drains - All Catchments - 3 to 10

Part	Drain type	Total in thousand NRs
1	EARTH WORKS	217,084
2	MASONRY/CONCRETE WORKS	859,069
3	SURFACE ROAD WORKS	74,017
4	SITE ROAD INLET CHAMBER	63,290
5	EXISTING DRAIN WORKS	68,793
	Total	**1,282,253.9**

The cost estimate of the drainage of all catchments of the proposed length of 41,9km with rectangular surface drains is **'000 NRs 1,282.254.**for the work's items as presented in the previous table.

Schedule 2 – CE for pipe circular drains

The cost of the calculations of the schedule 2 for rectangular drains is presented in Volume 1D Appendix D2 for each Catchment and for each item of works for which the quantities have been calculated as presented in the previous chapter. The next table gives the summary of the cost of the Schedule 2 for each catchment of the pipe drains for each catchment 6, 7 and 8 with the related Diversion of the drainage scheme.

Table 5- 33: Schedule 2 - Summary of costs by Catchment

Summary Pipe Drains - All Catchments - 3 to 10 **NRs '000**

Catchment	Designation	unit	Qty	Total	Cost / m
6	Catchment 6 - Diversion 12	m	2,267	55,784.8	24.6 NRs/m
7	Catchment 7 - Diversion 13A	m	1,681.78	41,974.7	25.0 NRs/m
8	Catchment 8 - Diversion 13	m	1,248.00	35,247.7	28.2 NRs/m
		Total	**5,196**	**133,007.3**	

The next table gives the summary of the cost of the Schedule 2 for each item of works as presented in the cost estimate of the pipe drains.

Table 5- 34: Schedule 2- Summary of cost by Work's Items

Part	Drain type	Total	Comment
1	PIPE WORKS	114,341.9	
2	MANHOLE WORKS	13,852.9	
3	SURFACE ROAD WORKS	0.0	
4	SITE ROAD INLET CHAMBER	4,812.5	
	Total	**133,007.3**	

The cost estimate of the drainage pipes of the catchment 6, 7 and 8 of the proposed length of 5,196m with pipe drains is **'000 NRs 133,007.3**

Schedule 3 - Cost for Natural drains

The cost of the calculations of the schedule 3 for Natural drains is presented in Volume D! Appendix D3 for each Catchment and for each item of works for which the quantities have been calculated as presented in the previous chapter. The next table gives the summary of the cost of the Schedule 3 for each catchment of the natural drains for each catchment 4A, 8 and 9 of the drainage scheme.

Table 5- 35: Schedule 3 – Summary of costs by Catchments

Summary Natural Drains - Catchments 4A, 8 & 9 **NRs '000**

Catchment	Designation	unit	Qty	Total	Cost / m
4A	Catchment 4A – Shreepur	m	1,120.36	31,023.6	27.7 NRs/m
8	Catchment 8 – Nala	m	357.05	3,783.8	10.6 NRs/m
9	Catchment 9 - MD1	m	4,918.00	144,072.3	29.3 NRs/m
		Total	**6,395.41**	**178,879.6**	

The next table gives the summary of the cost of the Schedule 3 for each item of works as presented in the cost estimate of the natural drain.

Table 5- 36: Schedule 3 - Summary of cost by Work's Items

Summary Natural Drains - Catchments 4A, 8 & 9 **NRs '000**

Part	Drain type	Total	Comment
1	PREPARATION AND EARTH WORKS	29,765.3	
2	CIVIL WORKS - MASONRY/CONCRETE	136,395.7	
3	OTHERS WORKS	12,718.6	
	Total	**178,879.6**	

The cost estimate of the Natural drains of the catchment 4A, 8 and 9 of the proposed length of 6,395 m is **'000 NRs 178,879.6**

Schedule 4 - Cost estimate for Outfall

The cost of the calculations of the schedule 4 for Outfall is presented in Volume 1D Appendix D4 for each Catchment and for each item of works for which the quantities have been

calculated as presented in the previous chapter. The next table gives the summary of the cost of the Schedule 4 for each Outfall for the related to the catchment of the drainage scheme.

Table 5- 37: Schedule 4 – Summary of costs for Outfall structures

Summary Outfall - Catchments 3, 4, 5, 6 and 7 **NRs '000**

Catchment	Designation	Unit	Qty	Total	Cost / m
3	Catchment 3 - Sirsiya	No	1	1,175.4	1175.4 NRs/m
4	Catchment 4 - Sirsiya	No	1	1,367.7	1367.7 NRs/m
5	Catchment 5 - Sirsiya	No	1	1,681.6	1681.6 NRs/m
6	Catchment 6 - Singa	No	1	1,308.1	1308.1 NRs/m
7	Catchment 7 - Singa	M	1	1,066.7	1066.7 NRs/m
		Total	**5.0**	**6,599.5**	

The next table gives the summary of the cost of the Schedule 4 for each item of works as presented in the cost estimate of the Outfall structures

Table 5- 38: Schedule 4 - Summary of cost by Work's Items

Summary Outfall - Catchments 3, 4, 5, 6 & **NRs '000**

Part	Drain type	Total	Comment
1	Excavation/foundations works	1,470.3	
2	Concrete works	2,985.6	
3	Gabions/Rip Rap works	2,143.6	
	Total	**6,599.5**	

The cost estimate of the outfall structures of the 5 catchments 3, 4, 5, 6, and 7 is '000 **NRs 6,599.5**

Schedule 5 - Cost for Diversion/Overflow chamber

The cost of the calculations of the schedule 5 for Diversion/Overflow chamber (Catchment 9) is presented in Volume 1D Appendix D5 for each item of works for which the quantities have been calculated as presented in the previous chapter. The next table gives the cost of the Schedule 5 of the Diversion/overflow Chamber related to the catchment 9 of the drainage scheme.

Table 5- 39: Schedule 5 - Cost by Work's Items

Summary Overflow/Diversion Chamber - Catchment 9 **NRs '000**

Part	Drain type	Total	Comment
1	Earth works	112.8	
2	Masonry/Concrete works	3,405.6	
3	Miscellaneous works	196.4	
	Total	**3,714.7**	

The cost estimate of the outflow/Diversion chamber to be constructed in catchment 9 in MD1 is '000 **NRs 3,714.7**

Schedule 6 - Cost for Recreational Park

The cost of the calculations of the Schedule 6 for the Recreational Park (Catchment 9) is presented in Volume 1D Appendix D6 for each item of works for which the quantities have been calculated as presented in the previous chapter.

The tables hereafter give the cost estimate of the Recreational Parl to be constructed in the catchment 9 after the Campus Khetan over the MD1 and related to the Drainage scheme

Table 5- 40: Schedule 6 – Cost Recreational Park

Summary Recreational Park - Catchment 9 **NRs '000**

Part	Drain type	Total	Comment
1	GENERAL	1,650.3	
2	CIVIL WORKS - MASONRY / CONCRETE	5,037.7	
3	FINISHING WORKS	3,548.3	
4	MISCELLENIOUS WORK	3,258.1	
	Total	**13,494.4**	

The cost estimate of the recreational park in catchment 9 is '000 NRs **13, 494.4**

5.9.3 Total Costs

Cost estimates of the proposed drainage

The total costs of the main components (Schedule 1 to 6).of the proposed drainage scheme at Final Design are summarized in the following table.

Table 5- 41: Drainage Scheme – Total Estimates

Summary Drainage scheme - All Catchments - 3 to 10 **NRs '000**

Schedule	Drain type	unit	Qty	Total	Cost / m
1	Surface drains	m	41,869	1,282,253.93	30.62 NRs/m
2	Piping drains	m	5,196	133,007.27	25.60 NRs/m
3	Natural Drains	m	6,395	178,879.61	27.97 NRs/m
4	Outfall	No	6	6,599.48	1099.90 NRs/No
5	Diversion Chamber	No	1	3,714.75	-
6	Recreational Park	LS	1	13,494.41	-
		Total	**53,461**	**1,617,949.45**	

The total Cost estimates of the Drainage scheme as proposed is **NRs 1,617.95 millions** for a total length drain of 53,5km including 41.9 km of new rectangular covered drains, 5.2km of pipe storm drain, 6.4km of re-conditioning of natural drains and the cost of the construction 6 outfall, one diversion/overflow chamber and a recreational park of 0.6 ha.

The total costs are divided in area inside and outside the core Area. The core area includes the catchment 4, 4A, 5, 6, 9 and 10. The area outside the Core Area refers to the northern and Eastern area of Birgunj and refers to the diversion presented in PPTA, Diversion 4 in catchment 3, Diversion 12 in catchment 6, Diversion 13A in catchment 7 and Diversion 13 in catchment 8. The respective length and amount of each area is presented in the following table:

Table 5- 42: Drainage Scheme – Total Estimates inside/outside Core Area

Sch	Main Component	Outside Core		Inside Core		All Areas	
		Qty/m	Total	Qty/m	Total	Qty/m	Total
1	Surface Drains	16,150	565,227.6	25,719	717,026.4	41,869	1,282,253.9
2	Pipe Drains	5,196	133,007.3			5,196	133,007.3
3	Natural Drains	357	3,783.8	6,038	175,095.9	6,395	178,879.6
4	Outfall	-	3,550.2	-	3,049.3	-	6,599.5
5	Overflow	-	0.0	-	3,714.7	-	3,714.7
6	Park	-	0.0	-	13,494.4	-	13,494.4
All	Total	**21,703**	**705,568.8**	**31,758**	**912,380.6**	**53,461**	**1,617,949.4**
	%	41%	44%	59%	56%		

Note: Some Catchment outside the Core area includes lines located in schedule 1 are in the core area.

The length of drain to be constructed inside the core Area is 31.8km and 21.8km outside the core area for a respective cost of '000 NRs **912,380.6 [56%] and 705,568.8 [44%].**

5.9.4 Bill of Quantity

Bill 2 – Civil Works total amount

The format of the BOQ for the tender documents is prepared from the works items of the Cost Estimates. According to the Nepalese standards the BOQ will include all basic quantities and therefore some of the items included in the CE will be break up in individual basic work items such as concrete, formwork reinforcement, plastering. Other item expressed in m2 shall be transformed in m3 as per standard practice. In addition an identical description will apply in the description of the items as they unit rates will apply uniformly to the four components of the Tender i.e. STP, Sewerage, Drainage and Road.

The Final BOQ for the tender document is presented in Volume 1D Cost Estimate and BOQ as annex to the report. The table hereafter presents the Bill 2 "Civil Works" of the final cost the BOQ including the four component of the Tender document and the Bill No 2B related to the Sewerage Scheme as described in the present Final Report.

Table 5- 43: Bill 2 Civil Works (NRs)

No	Component	Spec's	Total Cost mNRs
2A	Sewerage Treatment Plant	-	83.383
2B	Sewerage	15,216 m	365.218
2C	Drainage	53,461 m	1,617.949
2D	Road	11,306 m	429.144
-	**Total Bill 2 – Civil Works**		**2,495.695**

Bill 2 – Sewerage and drainage Cost

The table hereafter presents the Bill 2 "Civil Works" of the final Cost Estimate for Sewerage and Drainage as included in the BOQ of the Tender document. This refers to the Bills No 2B and 2C

respectively for the Sewerage and the Drainage Scheme as described in the present Final Report.

Table 5- 44 : Sewerage and drainage Cost

No	Component	unit	Length	Total Cost mNRs
2B	Sewerage	m	15,216	365.218
2C	Drainage	m	53,461	1,617.95
-	**Total Bill 2B & C**	**m**	**68,677**	**1,983.17**

5.10 SEWERAGE DESIGN DRAWINGS (IN SEPARATE VOLUME 1E)

The design drawings related to the proposed drainage scheme are included in a separate Volume 1E. The volume includes the following drawings related to the present sewerage scheme:

- 1-General drawing
- 2-Layout drawings
- 3-Long sections, plan view and cross sections drawing
- 4-Standards drawings

6. SURFACE REINSTATEMENT

6.1. GENERAL

All surface restoration shall be done by the Contractor whether it is within the limits of the works or not, if such surface has been destroyed, damaged or in any way disturbed by the Contractor's forces or by anyone employed by the Contractor in the carrying out of this Contract. The surface restoration shall be carried out over all areas of trenching and excavation or any surface that has been damaged destroyed or in any way disturbed by the Contractor's forces or by anyone employed by the Contractor during the performance of this Contract.

The cost of all such permanent surface restoration shall be included in the unit prices tendered for the installation of sewers and appurtenances. Within the Municipality there is an estimated total of 280 km of road network with 115 Km black toped road (41%), 83 Km of gravelled road (20%) and 82 Km of earthen road (20%). During site survey, some concrete narrow streets have also been noticed as well as large two lane roads.

6.2. RESTORATION OF PAVEMENT

Surface restoration shall comply with the following:

General

If the Contractor does not propose to install the permanent pavement immediately after his works (Blacktop), he shall install a temporary surface which shall be composed of ten (10) cm (compacted depth) of approved granular material of maximum size 25mm, compacted to not less than 95% of the optimum dry density as determined by Modified AASHTO Test or the BS 1377 (Test 13).

The Contractor shall be required to maintain the temporary surface in functional condition and to control dust or mud or as directed by the Engineer until the work for the permanent restoration commences.

However if, in the Engineer's opinion, before the trenches are repaved, the streets are not maintained properly to inhibit dust and mud and to provide a hard wearing level surface with the minimum inconvenience to traffic and adjacent owners, the Engineer may require the Contractor to discontinue the execution of any works until the Contractor installs at his own expense a temporary asphalt surface along the trenches which shall be removed before the final restoration. However, it is the Contractor's obligation to install the permanent pavement

within one month from the time of installation of the respective sewers. When the Contractor is ready to install the permanent pavement he shall act as follows.

- Removal of the backfill material, unless it conforms with the Specifications to a depth of forty five (45) cm from the road surface and compaction to the required degree of the disturbed layer of soil.
- Supply, placing and compaction to the required degree with the required moisture content in layers of fifteen (15) cm thick of appropriate backfill material to complete a total compacted layer of 30cm.
- Supply and placing of crusher run base course of the appropriate thickness to bring surface to the underside of the surfacing material. This crusher run base course material shall be as specified in the Standard and shall be compacted to not less than 95% of the optimum dry density as determined by Modified AASHTO Test or the BS 1377 (Test 13). The crusher run base course material shall be compacted in layers not exceeding 100mm.

Bituminous Paving - Blacktop

All materials and methods of placing of bituminous materials including aggregates, tack coats and fillers shall conform to the requirements. The base and sub-base layers with a total thickness of 35 cm loose depth shall be compacted to not less than 95% of the optimum dry density as determined by Modified AASHTO Test or the BS 1377 (Test 13).

Restoration where existing Road Surface is not Paved

Existing unpaved roads shall be resurfaced using approved material in place of the crusher run base and asphaltic paving courses specified for paved roads. It shall be installed in layers with a maximum thickness of 100mm loose depth, and each shall be compacted to not less than 95% of the optimum dry density as determined by Modified AASHTO Test or the BS 1377 (Test 13). The finished surface shall be sprinkled with water as necessary to obtain an even, stable surface equal to the existing surface, in the opinion of the Engineer.

Restoration of Sidewalks, Curbs, Driveways and Other existing Features

All sidewalks, curbs, driveways, gardens, walls, fences and other existing features disturbed, damaged or destroyed by the Contractor during his operations shall be restored by him to at least their original condition by him. All sidewalks, curbs and driveways which have to be restored under this Contract shall be installed on a base of sand and gravel as specified in the Specifications which shall be compacted to not less that 95% of the optimum dry density as determined by the Modified AASHTO Test or the BS 1377 (Test 13).

Maintenance

Except where it has been established by the Engineer that the Contractor's work is not responsible for any failure, any subsidence of restored surfaces occurring within the Period of Maintenance shall be repaired or replaced by the Contractor. He shall maintain all finished surfaces to the satisfaction of the Engineer.

6.3. STANDARD ROADS LAYERS

For each respective type of roads the reinstatement shall include the following material and layers as shown in the figure hereafter.

Table 6- 1: Road Course Thickness

A - Blacktop - Total finish layer 40cm	Wearing course	5.0 cm	
	Base course	15.0 cm	
	Sub-base	20.0 cm	
B – Gravel Road - Total finish layer 15cm	Sub-base	15.0 cm	
C - Narrow concrete lane – total finish layer 25 cm	Concrete M20	10.0 cm	
	Sub-base	15.0 cm	

The permitted tolerance of course thickness, i.e. the total compacted thickness of any layers of the surfacing material at any point shall not be less than 5 mm of the course thickness shown on drawings.

6.4. INVENTORY OF ROAD AND SURFACE PAVEMENT

The table hereafter gives the details characteristics of the surface road/nature and widths as well as presence of pavement/side walk. The first table is made for the main collectors SW1 SW2, SW3 and SW5 and the second table for all the branches lines to the main collector.

Table 6- 2: Road surface inventory – Sewerage Line

A-Main collectors

	Name of the Road	Node No.		Road Width (m)	Pavement	Material
		From	To			
SW1		N36	N35	4.6	Y	Gravel
		N35	N34	5.3	Y	Gravel
		N34	N33A	4.6	Y	Gravel
		N33A	N31	4.0	N	Black Top
2	Shreepure Road	N31	4	3.8	N	Black Top
3	Ranighat Road	4	5	5.1	Y	Black Top
		5	6	5.5	Y	Black Top
		6	7A	6.9	Y	Black Top
		7A	7	8.1	Y	Black Top
		7	8	5.6	Y	Black Top
		8	9	6.8	Y	Black Top
		9	9A	5.4	Y	Black Top
		9A	10	4.0	N	Black Top
		10	11	5.6	Y	Black Top
4	Ghadiharwa Road	11	12	3.9	N	Black Top
5	Ghadiharwa Road	12	13	5.4	Y	Black Top
		13	14	5.2	Y	Black Top
6	Bhajuratna Road	14	14A	6.1	Y	Black Top
		14A	15	5.1	Y	Black Top
		15	15A	4.7	Y	Black Top
		15A	15B	5.1	Y	Black Top
		15B	15C	4.8	Y	Black Top
		15C	16	4.7	Y	Black Top

	Name of the Road	Node No.		Road Width (m)	Pavement	Material
		From	To			
		16	16A	4.7	Y	Black Top
		16A	16B	4.8	Y	Black Top
		16B	16C	3.8	N	Black Top
		16C	17	4.2	N	Black Top
7	Pani Tanki Road	17	18	6.6	Y	Black Top
8	Hadji Ali Road	18	19	4.3	N	Black Top
		19	20	3.0	N	Black Top
		20	21	-		Earthen
9	Pulchowk (River Bank)	21	22	-		Earthen
		22	23	-		Earthen
		23	23B	-		Earthen
		23B	24	-		Earthen
10	Pulchowk (River Bank)	24	25	-		Earthen
		25	STP	13.28	Y	Earthen
SW3	Tribhuvan Rajpath	1	2	9.1	Y	Black Top
		2	3	10.5	Y	Black Top
		3	4A	8.0	Y	Black Top
		4A	4	8.0	Y	Black Top
		4	5	8.7	Y	Black Top
		5	6A	8.0	Y	Black Top
		6A	6	7.7	Y	Black Top
		6	7	7.6	Y	Black Top
		7	7A	7.8	Y	Black Top
		7A	8	8.6	Y	Black Top

	Name of the Road	Node No.		Road Width (m)	Pavement	Material
		From	To			
		8	9	4.4	N	Black Top
2	Tax Office Chowk to Pulchowk	9	10	3.6	N	Black Top
		10	11	3.0	N	Black Top
		11	12	3.8	N	Black Top
		12	N 23	5.2	Y	Black Top
SW4	Road No. 3	1	2	2.7	N	Black Top
		2	3	2.9	N	Black Top
		3	4	3.0	N	Black Top
		4	4A	2.7	N	Black Top
		4A	5	3.5	N	Black Top
		5	6	4.9	Y	Black Top
		6	7	4.5	N	Black Top
		7	SW5/8	5.9	Y	Black Top
SW5	Ghantaghar Chowk to Birta Bazar Chowk	1	2	5.2	Y	Gravelled
		2	3	4.1	N	Black Top
		3	4	3.2	N	Black Top
		4	5	4.6	Y	Black Top
		5	6	4.9	Y	Black Top
		6	8	5.0	Y	Black Top
		8	8A	7.6	Y	Black Top
		8A	9	6.2	Y	Black Top
		9	10	3.6	N	Black Top
2	Birta Bazar Chowk to Tribhuvan Rajpath	10	SW3/8	4.6	Y	Black Top

B-Branches

	Name of the Road	Node No.		Road Width (m)	Pavement	Material
		From	To			
SW9/1		8	7	4.0	N	Gravelled
2		7	SW1/19	2.5	N	Gravelled
SW10		11	SW1/17	5.9	Y	Black Top
SW12A	Drain	38	SW1/14A		N	
SW12A 1	Drain	37	SW1/14A		N	
SW12B	Drain	40	SW1/15A		N	
SW12B 1	Drain	39	SW1/15A		N	
SW12C	Drain	41	SW1/15B		N	
SW12C 1	Drain	42	SW1/15B		N	
SW12D	Drain	43	SW1/15C		N	
SW12D 1	Drain	44	SW1/15C		N	
SW11A	Drain	45	SW1/16A		N	
SW11A	Drain	46	SW1/16A		N	
SW11B	Drain	47	SW1/16B			
SW11B 1	Drain	48	SW1/16B			
SW11C	Drain	49	SW1/16C			
SW11C 1	Drain	46	SW1/16C			
SW13	Ghadiharwa Road	22	23	6.6	Y	Black Top
2	Ghadiharwa Road	23	SW1/14	7.2	Y	Black Top
SW14	Ashok Batika Road	28	27	6.1	Y	Black Top
2	Ashok Batika	27	26	6.2	Y	Black Top

	Name of the Road	Node No.		Road Width (m)	Pavement	Material
		From	To			
	Road					
3	Ashok Batika Road	26	SW1/13	7.1	Y	Black Top
SW15		21	SW1/9A	4.0	N	Black Top
SW16		29	SW1/9	4.5	N	Black Top
SW17		20	SW1/8	5.4	Y	Black Top
SW18		19	SW1/7A	3.9	N	Black Top
SW19		30A	30	6.4	Y	Black Top
2		30	SW1/6	5.5	Y	Black Top
SW20	Shreepur Road	32	SW1/31	6.4	Y	Black Top
SW21		33B	33	4.6	Y	Black Top
2		33	SW1/31	2.1	N	Black Top
SW22		35A	SW1/35	3.8	N	Black Top
SW23		3	SW1/4	4.7	Y	Black Top
SW24		1	2	3.4	N	Black Top
2		2	SW1/4	2.0	N	Black Top
SW3A		4B	SW3/4A	3.4	N	Black Top
SW3B		5A	SW3/5	3.8	N	Black Top
SW3C		6B	SW3/6A	3.4	N	Black Top
SW29	Loharpatti Road	12	16	2.0	N	Black Top
		16	SW5/6	3.6	N	Black Top
SW30		15A	15	3.0	N	Black Top
2		15	SW4/5	2.5	N	Black Top
SW31		14	SW4/4A	2.7	N	Black Top
SW32		17	SW4/3	3.0	N	Black Top
SW27	Birta Link Road	10	SW5/10	3.9	N	Black Top

	Name of the Road	Node No.		Road Width (m)	Pavement	Material
		From	To			
SW28		13A	13	3.1	N	Black Top
2	Jail Road	13	SW5/8A	2.8	N	Black Top
SW33		3	SW3/9	8.3	Y	Black Top

The detailed characteristics of the surface road/nature for the drainage drains have been noted in the model for the calculations of the Drainage in Volume 1D appendix C, C1 to C3 for the main components of the drainage scheme

7. OPERATION & MAINTENANCE OF SEWERS SYSTEM

7.1. INTRODUCTION

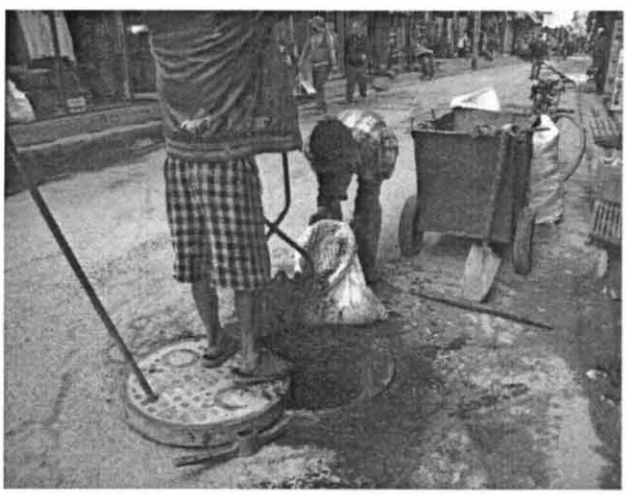
No storm system will continue to operate satisfactorily if maintenance, in particular drain cleaning, is routinely neglected. There is no point in providing a new drain scheme if analysis shows that flooding is caused by a failure to maintain an existing drain of the same or similar capacity to that which is proposed. Where problems arise from poor operation and maintenance, the focus should be on improving O&M unless it can clearly be shown that providing new facilities will contribute to solving those O&M problems. Major points to be considered are preventive maintenance and maintenance/rehabilitation.

Maintenance also helps to protect the capital investment and ensures an effective and economical expenditure in operating and maintenance of a sewerage facility. Besides, it is essential to build up cordial relations with the public, whose support is essential for success of any facility.

7.2. GENERAL CONCEPT

Sewerage

Maintenance of a sewerage system consists of optimum use of labor, equipment and materials to keep the system in a good functional condition for collection and transportation of wastewater to treatment plant. In case of treatment plant the maintenance comprises such operations, which are well-planned, systematic program of maintaining the machinery by taking such steps to prevent breakdown well in advance before it causes major breakdown. The maintenance of any system as such can be classified as (a) preventive, (b) corrective.



Preventive maintenance is required for all components of the project, including sewer network and appurtenances and treatment plants. It is necessary to carry out preventive or routine maintenance to avoid situations like clogged sewer line, overflowing manholes, structural failure of system or failure of function of STP. The preventive maintenance is always more economical and ensures reliability in operation of the assets created and

emergency repairs would become very rare if preventive maintenance is carried out regularly.

Sewer network requires regular maintenance in order to maintain proper hydraulic conditions. In Asian condition, wastewater from households is often not only the source causing sewerage flows, there is a tendency to connect roof water drain to the connection manholes which contribute to surcharge condition of sewers during rainfalls.

Drainage

The Operation and Maintenance (O&M) for drainage is similar to the O&M presented in the previous section 5 for sewerage as far as equipments and personnel are concerned. The main difference are the type and length of drains, the presence of natural channel and the more specific operations procedures related to preventive maintenance as the frequency of inspection and cleaning will be more frequent especially at the start of the rainy season and on the importance of the drain, main diversion channels/pipes and natural drains, secondary and tertiary drains

7.3. PREVENTIVE MAINTENANCE OF SYSTEM

General

Preventive maintenance as the name suggests are carried out to prevent breakdown of sewer systems if it is done on regular basis and in a systematic manner, it prevents clogging of service lines, overflowing of manholes, backflow of sewage in to a house. It also prevents structural failure of sewer system. The need of emergency maintenance may not arise if carried out in a planned manner. The success preventive maintenance depends upon three elements.

- Manpower
- Equipments
- Schedule of maintenance

The entire sewerage system or service lines are divided into sections and each section or service line is put under a gang which normally consists of a supervisor and skilled sewer men. The area for one gang will depend upon size of sewer, its depth, number and spacing of manholes and whether mechanical sewer machines are being used.

7.4. PREVENTIVE MAINTENANCE PROGRAM

For the proper functioning of the Storm drainage system it is essential to have an appropriate maintenance program or **Standard Operation Procedures. S**tandard operating procedure (SOP) specifies responsibilities and procedures for inspecting and maintaining the streams,

ditches, storage basins and manmade drainage conveyances within the defined jurisdiction. The program must include inspection, enforcement, cleaning and repair. The frequency of inspection and cleaning will be dependent on the season of the year with more frequent inspection and cleaning at the start of the rainy season and on the importance of the drain. An example for maintenance program could be:

Inspection

Routine inspections shall consist of walking the entire length of the drainage, documenting obstructions, trash, debris or any other issues that may cause flooding including the condition of any manmade structures.

Open brick drains-monthly in general; weekly in market areas.

Covered brick drains-monthly with drains opened in February.

Brick linings drains-monthly.

All drains following first heavy rainfall in year.

Cleaning

Open brick drains-as required.

Covered brick drains-in February when opened

Brick linings drains and culverts- January to February prior to rains. All drains-as revealed by inspection.

The inspections will also show where repairs are required and where encroachment into the drain and deliberate blocking of the drain is taking place. Appropriate action to enforce the regulations must be initiated immediately. The cleaning of permanently closed brick drains and small culverts is difficult and time consuming. New drains should have removable covers to facilitate cleaning.

Whereas, the responsibility of cleaning and conservancy of drains fall under the conservancy section under health department, operation and maintenance of drains of the Municipality involve the services in the following areas.

- Conservancy (Cleaning of drains)
- Mosquito killing
- Solid waste management
- Structural maintenance of drains

It is essential that the Municipality should develop a routine preventive maintenance program

for the Storm drainage system. The structural improvements to be taken up under the project will provide a sustainable benefit. A failure to develop the capacity and methods related to preventative maintenance program will entirely eliminate the benefits of the program in the long run.

Though the needs and methods must ultimately be identified by the personnel responsible for the maintenance, it is suggested that the following guidelines should be followed for initial development of the staffing and equipment for a preventive maintenance program:

- drain should be cleaned once per month, but not less frequently than once per three month;
- task objective for 1 cleaner/sweeper should be 50m of primary / secondary drains, per day;
- adequate equipment should be provided for efficient operations of cleaning crews, including wheel barrows and miscellaneous hand tools for each drain cleaner, 3 ton dump truck for waste transport and disposal.

Based on the length of drains and its importance, standard drain cleaning crews will be defined to carry out the routine preventive maintenance operation required to keep the system in good operating condition.

7.5. DRAIN MAINTENANCE & REHABILITATION

Storm drainage rehabilitation costs involves determination of total cost related to development, operation, maintenance and rehabilitation costs of existing and new drains of the City. There are four types of maintenance issues:

- Trash: manmade objects, such as garbage shopping carts, tires, lumber, furniture and appliances. Animal carcasses are also considered to be trash.
- Minor problem: vegetation growth, tree limbs, and other "naturally "occurring debris. Sedimentation in a retention basin is also included.
- Obstruction: fallen tree, culvert damage, large appliance, etc., that by itself, obstructs the flow of the ditch, inlet or outlet.

Structural Issues: bridge or culvert repair or replacement, bank stabilization, dredging, or other major project.

7.6. SPECIAL EQUIPMENTS

The maintenance of sewerage system requires a number of special equipments and devices notable among them are sewer jetting machines and suction units.

Sewer Jetting Machine

Sewer jetting machines are high velocity sewer cleaners. The make use of high velocity water jets to remove and dislodge obstructions, soluble grease, grit and other materials from sewerage system. It combines the functions of a Roding machine and gully emptier machine. It consists of high pressure hydraulic pump generally capable of delivering water at variable pressure up to about 80 kg/cm² as per standards through a flexible hose to a sewer cleaning zone. The high pressure water coming out of the holes with a very high velocity breaks up and dislodges the obstructions and flushes the materials down the sewer.

The entire equipment is usually mounted on truck chassis. The truck shall consist of one tank for fresh water only.

Suction cum Jetting Machine

Suction units creates vacuum for siphoning of mud, slurry, grit and other materials from sewerage system. The vacuum created is such as to siphon the materials from the deep manholes. The unit will be vehicle mounted. To achieve economy in operation of sewer cleaning, it is normal to have a combined unit of jetting and suction machine to perform both the function.

Suction Machine for Cleaning of Sewer Lines/Septic Tanks

Septic tanks are constructed for onsite disposal and treatment of excreta. A septic tank is a combined sedimentation and digestion tank where the sewage is held for one or two days. During this period, the suspended solids settle down to the bottom. Further anaerobic digestion of settled solids and liquid takes place resulting in a reasonable reduction in the volume of sludge and biodegradable organic matter. The effluent of septic tanks requires secondary treatment.

The desludging of septic tanks by manual means is not advisable. Therefore best option for desludging of septic tanks is by vehicle mounted suction machines. Normally individual's households size their septic tanks so that desludging is required after three years.

Therefore for effective maintenance of sewer lines and regular cleaning of septic tanks, sewer jetting machine, suction and jetting machine and suction machine for septic tanks cleaning are essential equipments.

The main purpose is identification of requirement of equipments after assessing the use of existing facility of sewer cleaning equipments maintained by concerned Municipal Corporation.

Maintenance Body:

Organization required for maintenance of any such facility will depend on the size and life of system provided. In case of sewer lines, the prime effort will be towards maintenance of free and unobstructed flow. Sewer cleaning works involve special equipments such as pumping sets, bucket machines for de-silting, suction units for blockage removal etc. Besides above, sewer cleaning works is hazardous due to presence of gases.

Safety equipments and precautions at various stages of works are therefore essential requirement for maintenance. Maintenance works of sewers also involves rehabilitation /sewer renovations.

Availability of proper maps of the system showing manholes, their invert levels, sizes etc., maintenance of proper data of complaints and their nature is also an essential element for solving the problem. The de-silting is achieved by Winch Bucket Machines generally and used for regular interval cleaning but choked and blocked sewer may by be cleaned with suction cum jetting machines and jetting machines.

7.7. OPERATION & MAINTENANCE STAFF

The field as well as supervisory staff will be required for regular preventive maintenance of sewerage system. Trained staff will be required for operation of Roding and winch bucket machines and jetting/suction machines Staff in adequate strength will be required for operation and maintenance of different units of SPS and treatment plants.

The staffing pattern can be planned as per guidelines so that the sewage treatment plant as well as entire sewerage system including pumping station & STP can be operated and maintained properly.

7.8. COSTS FOR O&M

Most of the operation costs related to drains involve for carrying out activities in the field of conservancy, mosquito killing and collection and disposal of solid wastes. Major portion of operation cost is covered as establishment cost. Maintenance expenses relate to maintenance

of garbage trolleys, office transports and drains.

Currently the operation and maintenance cost is partly met from the revenue generated from conservancy rates and the deficit amount is subsidized from the holding tax of the Municipality or from Government subsidence.

It is expected that the City will need additional expenditure to maintain the new drains constructed and rehabilitate the old drains, after completion of the first phase work. It is observed that the cost of operation & maintenance of the Storm drainage system amounts to minimum of 5% to maximum of 10% of the civil cost of the drains which gradually increasing with age of the drain & increase of population and thereby increase of quantity of solid waste.

Plant & Equipment

The main special vehicles/machinery that can be owned by the client are the combination suction truck, drain cleaning machine (or sewer TV vehicle), camera inspection unit, dewatering suction pumps, portable submersible sewage pumps and diesel generator sets

The tentative list and costs for equipment and machineries proposed for the maintenance of the proposed system Drainage/Sewerage is given below.

Table 7- 1: Plant & Equipment

No.	Description of Works	Unit	Qty	Rate (NRs.)	Amount
1	Labour intensive tools according to the NBSM (1 set comprises followings : Wheel barrow (150 ltr capacity) fabricated from 2mm thick m s sheet, enamel colored, with pneumatic tyre - 1 No Shovel 1.5kg - 1No., Bucket 15 ltr - 1 No., Iron Pan (Karahi) - 1 No., Spade - 1No., Trowel(Karni) -1 No., Pick - 1 No.	Set	20	10,000	200,000.00
2	Safety tools as accordance to the NBSM (helmet, safety jacket belt, gloves, boots, safety rope)	Set	15	5,000	75,000.00
3	Tractor with trolley/trailer **(Spec No 6.12)**	No.	2	1,100,000	2,200,000.00
4	Truck mounted jetting cum suction machine with 6000 Lit. or more **(Spec No 6.3)**	No.	1	1,500,000	1,500,000.00

No.	Description of Works	Unit	Qty	Rate (NRs.)	Amount
5	Truck mounted suction cleaning with 4000 Lit. or more **(Spec No 6.2)**	No.	1	750,000	750,000.00
6	Pavement cutter **(Spec No 6.5)**	No.	1	350,000	350,000.00
7	Pickup jeep **(Spec No 6.11)**	No.	1	2,500,000	2,500,000.00
8	Four door, five seat, 2500 CC or more capacity Vehicle Four wheel drive all complete as per specification	No.	1	3,000,000	3,000,000.00
9	100 cc or more capacity, two seat motorcycle with helmet all complete as per specification	No.	3	350,000	1,050,000.00
10	Drain camera equipment **(Spec No 6.7)**	No.	1	1,005,000	1,005,000.00
11	Trash Water potable Pumps 3" or 80mm (suction and delivery diameter) petrol engine, 9HP delivery volume 1300 litre/minute	No.	2	500,000	1,000,000.00
12	Winch, tripod, bucket for sewer cleaning	Set	1	250,000	250,000.00
13	Portable Air Compressor 185 CFM, engine 45HP, air pressure 7 bar, two outlets and 2 concrete breaker hammer including spare tools, hose and fittings.	Set	1	300,000	300,000.00
14	Manhole cover lifting hook, & tripod	Set	1	250,000	250,000.00
15	Bamboos 8 to 10m long & Nylon Rope	Set	1	50,000	50,000.00
16	Workshop tool equipment & machineries **(Spec No 6.12 Equipment and Tools for Workshop)**	Job	1	500,000	500,000.00
	Total Amount				**14,980,000.00**

The reference to the specifications is noted for major items of equipments and machineries. The proposed amount for the procurement of maintenance equipment is estimated to be **NRs 14,980,000.00**. The characteristics of the equipments shall be review and finalized at final design stage.

Staff

The staff to be employed for maintaining the proposed system including the STP is given in the table hereafter: The tentative repartition of activity is noted in the last two columns of the table:

Table 7- 2: Proposed staff

ID	Position	No	unit	Qty	Cast	STP	Sewer
1	TL/Sewerage Engineer >5 yrs exp	1	Month	12	960,000	x	x
2	Civil Engineer (> 2 yrs Exp)	1	Month	12	480,000	x	x
3	Overseer/Junior Engineer	2	Month	12	840,000	x	x
4	Chemist	1	Month	12	420,000	x	
5	Office Secretary/Manager	1	Month	12	240,000	x	x
6	Lab boy	1	Month	12	180,000	x	
7	Office Assistant	3	Month	12	430,000	x	x
8	Chemicals and tools etc.	1	Month	12	240,000	x	
10	Seasonal Labour	1	Day	240	72,000	x	x
9	Minor servicing	1	Month	12	120,000	x	x
			Total		**3,982,000**	**-**	**-**

The maintenance team should use Health and Safety equipment such as Personal Protective, as Monitors, Tripod, Escape Set (especially for work in confined space) etc as panned to be purchased as per point 1 and 2 of the list of Equipments and Machineries presented in table 7.1 above .

Running Costs for O&M

The running costs for the operation and maintenance of the proposed system including the STP and the sewers lines are given in the table hereafter: The tentative repartition of activity is noted in the last two columns of the table:

Table 7- 3: Total Costs for O&M including Staff and Operating expenses

ID	Position	No	unit	Qty	Cast	STP	Sewer
1	Electricity Bill/cost (1400*9*30)	1	Month	12	4,500,000	X	
2	Fuel for Generator(	1	Month	12	5,500,000	X	x
3	Telephone	1	Month	12	10,000	X	
4	Transportation car/jeep rent	1	Month	12	720,000	x	X
5	Transportation (2 Wheelers)	2	Month	12	288,000	x	X
			Total		**11,018,000**	**-**	**-**

The total amount for O&M of the STP and Sewers is estimated to be **NRs 15,015,000.00** or a monthly cost of **NRs 1,250,000.00.**

8. TENTATIVE CONSTRUCTION SCHEDULE

The tentative schedule of implementation of the drainage and sewerage scheme as presented at the present stage of Final Design can be found in the following page. The schedule shows the main component of works related to the development of the network as well as the road construction, the implementation of the environmental park and the procurement of maintenance equipments for the network.

With a final completion by end of 2016 the provisional acceptance of all works has be made by end of 2015 given little bit more than two years says 26 months in total for the implementation of all projects activities.

The main direction adopted for the scheduling of the activities is the following:

1. Identification of works in core area including the construction of the sewerage and drainage network. In those areas the prioritization of the works shall be made from downstream to upstream. The following drainage catchments are 9, 8, 5 and 4/4A. One rod project in catchment 8/diversion 13 is related to this area.

2. Identification of works outside the core area with drainage network, the prioritization shall follow the project needs such as the construction of the access roads to the land fill and the second by-pass. The drainage catchments are 3/diversion 4, 6/diversion 12, 7/diversion 13A and 10. The catchments 6 and 8 have to be coordinated with road works [second by-pass] as the catchment 7 with the access road to the landfill.

In order to control the implementation of the project during its period, it is proposed to fix some project milestone:

- By end 2014 the completion of the southern part of the catchment 9 with its reshaping of the MD1 downstream of the recreational park including all the sewerage system of the area

- By mid-2015 the completion of the recreational park and all roads works with related drainage works

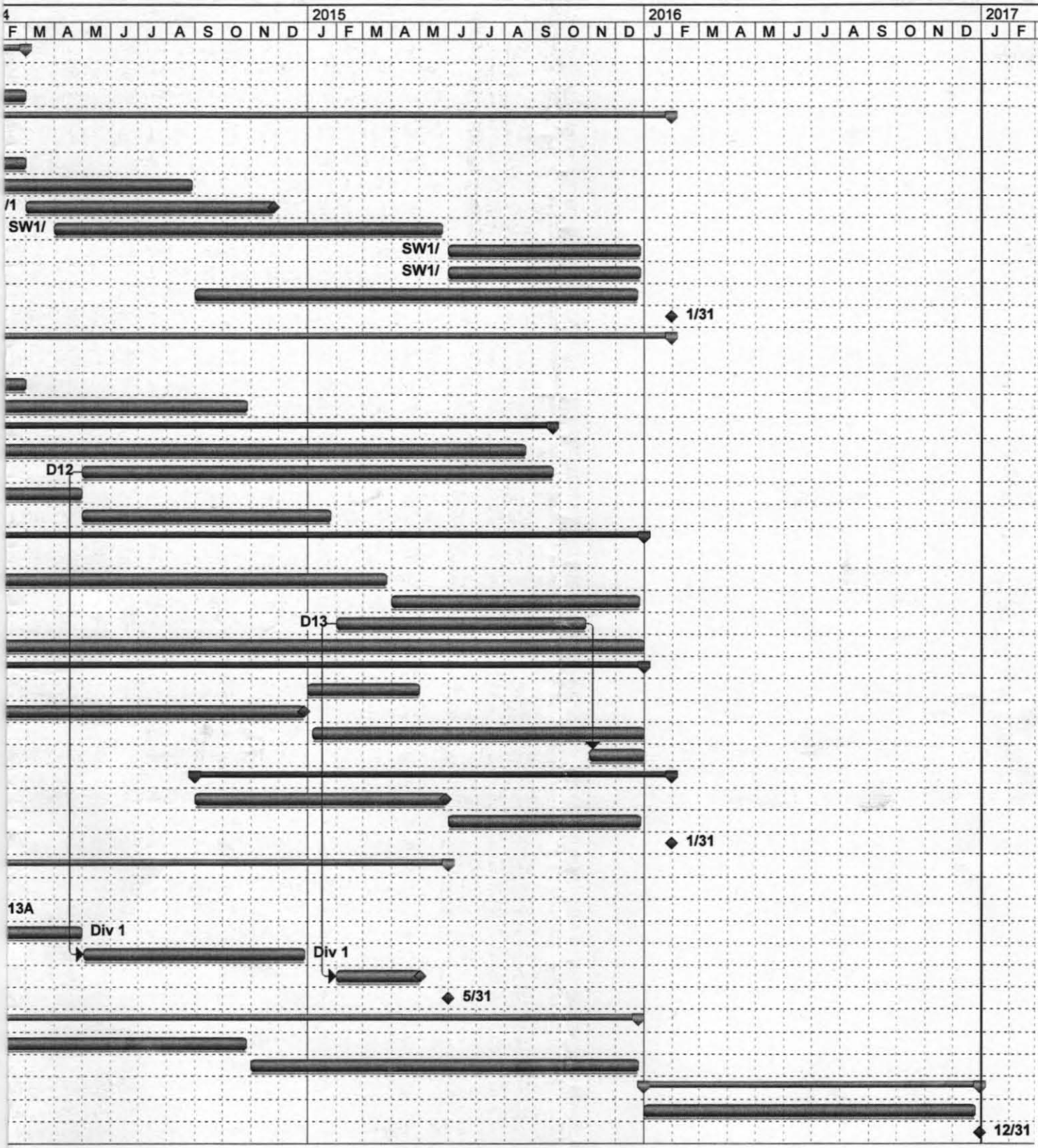
Figure 8-1:Tentative Implementation Sche STII

ID	S.No.	Task Name		Duration	Start	Finish
1	[1]	**Implementation Sewerage Network**		**4 mons?**	**Fri 11/1/13**	**Fri 2/28/14**
2	1.1	Start date		0 mons	Fri 11/1/13	Fri 11/1/13
3	1.2	Mobilization		4 mons?	Fri 11/1/13	Fri 2/28/14
4	[2]	**Sewerage Network - Pipes Collectors & Branches/Manholes/House Connections**		**27.37 mons?**	**Fri 11/1/13**	**Sun 1/31/16**
5	2.1	Shop drawings	15.2 km	4 mons?	Fri 11/1/13	Fri 2/28/14
6	2.2	Procurement pipe	15.2 km	8 mons	Wed 1/1/14	Thu 8/28/14
7	2.3	1-SW1 / southern lines to STP	2.6 km	9 mons	Sat 3/1/14	Tue 11/25/14
8	2.4	2-SW1 - SW3 / Catch 9	6.3 km	14 mons	Tue 4/1/14	Mon 5/25/15
9	2.5	3-SW1 / Catch 5	3.0 km	7 mons	Mon 6/1/15	Sun 12/27/15
10	2.6	4-SW1 / Catch 4 & 4A	3.4 km	7 mons	Mon 6/1/15	Sun 12/27/15
11	2.8	House connections	6.100 No	16 mons	Mon 9/1/14	Thu 12/24/15
12	2.9	Provisional acceptance		0 mons	Sun 1/31/16	Sun 1/31/16
13	[3]	**Implementation Drainage Network - Drains/Outfall/Chamber/Pipes**		**27.37 mons?**	**Fri 11/1/13**	**Sun 1/31/16**
14	3.1	Shop drawings		4 mons?	Fri 11/1/13	Fri 2/28/14
15	3.2	Material/Testing/Procurement		10 mons	Wed 1/1/14	Mon 10/27/14
16	**3.3**	**Surface Drains Outside Core Area**		**21 mons?**	**Wed 1/1/14**	**Tue 9/22/15**
17	3.3.1	Catchment 3 / Diversion 4	8.7 km	20 mons	Wed 1/1/14	Sun 8/23/15
18	3.3.2	Catchment 6 / Diversion 12	9.4 km	17 mons	Thu 5/1/14	Tue 9/22/15
19	3.3.3	Catchment 7 / Access Landfill	1.6 km	4 mons?	Wed 1/1/14	Wed 4/30/14
20	3.3.4	Catchment 10	5.6 km	9 mons	Thu 5/1/14	Sun 1/25/15
21	**3.4**	**Surface Drains inside Core area in Coordination with Sewerage Construction**		**24.33 mons**	**Wed 1/1/14**	**Thu 12/31/15**
22	3.4.1	Catchment 4 & 4A	6.3 km	15 mons	Wed 1/1/14	Thu 3/26/15
23	3.4.2	Catchment 5 / Overflow	2.1 km	9 mons	Wed 4/1/15	Sat 12/26/15
24	3.4.3	Catchment 8 / Diversion 13	7.7 km	9 mons	Sun 2/1/15	Wed 10/28/15
25	3.4.4	Catchment 9	11.6 km	24 mons	Sat 1/11/14	Thu 12/31/15
26	**3.5**	**Natural Drains**		**23.3 mons?**	**Sat 2/1/14**	**Thu 12/31/15**
27	3.5.1	Shripur	1.4 km	4 mons?	Thu 1/1/15	Thu 4/30/15
28	3.5.2	MD1 / Downstream Park	3.0 km	11 mons	Sat 2/1/14	Sat 12/27/14
29	3.5.3	MD1 / Upstream Park	1.5 km	12 mons	Tue 1/6/15	Thu 12/31/15
30	3.5.4	Cathment 8 / Outfall	0.3 km	2 mons	Mon 11/2/15	Thu 12/31/15
31	**3.6**	**Environmental Park**		**17.23 mons**	**Mon 9/1/14**	**Sun 1/31/16**
32	3.6.1	Earthworks and Civil Works	0.3 km	9 mons	Mon 9/1/14	Thu 5/28/15
33	3.6.2	Finishing Works		7 mons	Mon 6/1/15	Sun 12/27/15
34	3.6.3	Provisional Acceptance		0 mons	Sun 1/31/16	Sun 1/31/16
35	[4]	**Implementation Road**		**19.23 mons?**	**Fri 11/1/13**	**Sun 5/31/15**
36	4.1	Start date		0 mons	Fri 11/1/13	Fri 11/1/13
37	4.2	Mobilization		2 mons	Sat 11/2/13	Tue 12/31/13
38	4.3	Access to Landfill / Catch 7	1.6 km	4 mons?	Wed 1/1/14	Wed 4/30/14
39	4.4	2nd By-pass Diversion 12	2.3 km	8 mons	Sat 5/3/14	Sun 12/28/14
40	4.5	2nd By-pass Diversion 13	1.6 km	3 mons?	Sun 2/1/15	Fri 5/1/15
41	4.6	Provisional Acceptance		0 mons	Sun 5/31/15	Sun 5/31/15
42	[5]	**Equipments**		**26.17 mons**	**Fri 11/1/13**	**Fri 12/25/15**
43	5.1	Procurement		12 mons	Fri 11/1/13	Sun 10/26/14
44	5.2	Delivery		14 mons	Sat 11/1/14	Fri 12/25/15
45	[6]	**DNP**		**12.17 mons**	**Fri 1/1/16**	**Sat 12/31/16**
46	6.1	Defects Notification Period		12 mons	Fri 1/1/16	Sun 12/25/16
47	6.2	Final Acceptance		0 mons	Sat 12/31/16	Sat 12/31/16

Project: Implementation Schedule - Sewerage & Drainage Network
Date: Tue 9/10/13

Task
Split
Progress

Final Design - Sewerage and Drainage Network - Birgunj



e	◆	External Tasks	
y		External Milestone	◆
Summary		Deadline	⇩

9. TENDER DOCUMENT AND BUDGET

9.1. BIDDING DOCUMENTS

As part of the contractual obligations of the Consultant a set of tender documents need to be submitted at a chronological period defined in ToR. The Consultant shall prepare Tender Documents for Sewerage and Drainage, Sewerage Treatment Plant (STP) and Road in one single package. The Tender shall be single stage with two envelopes for procurements and shall include the following documents:

Volume I

PART I	**BIDDING PROCEDURES**	
	Section 1 Instructions to Bidders	ITB
	Section 2 Bid Data Sheet	BDS
	Section 3 Evaluation and Qualification Criteria	EQC
	Section 4 Bidding Forms	BDF
	Section 5 Eligible Countries	ELC
PART II	**REQUIREMENTS**	
	Section 6 Employer's Requirements	ERQ
PART III	**CONDITIONS OF CONTRACT AND CONTRACT FORMS**	
	Section 7 General Conditions of Contract	GCC
	Section 8 Particular Conditions of contract	PCC
	Section 9 Contract Forms	COF

9.2. BILL OF QUANTITIES (BOQ)

The BOQ generated from the respective Cost Estimates shall be included in the Volume II of the Tender documents in Volume II

Volume II

PART I	**BIDDING PROCEDURES**	
	Section 4 A Bidding Forms – Bill of Quantities (Estimates)	-
	Section 4 B Bidding Forms – Bill of Quantities	BDF

The BOQ with the estimates is included in the Volume 1D: Appendix F of the present report. The total amount and Budget are presented hereafter in the next chapter of this report.

9.3. TECHNICAL SPECIFICATIONS (TS)

The technical specifications shall be included in the Volume III of the Tender documents.

Volume III

PART I	REQUIREMENTS	
	Section 6A Employer's Requirements – Technical Specifications	ERQ

9.4. DRAWINGS

The technical specifications shall be included in the Volume IV of the tender documents.

Volume IV

PART II	REQUIREMENTS	
	Section 6B Employer's Requirements – Drawings	ERQ

Only a selection of typical details necessary for the understanding of the project shall be included in the tender documents.

The drawings will consist of general drawings, layouts drawings and typical drawings: (drains, pipes, manholes, service and inlet pits, house connection). The specific drawings, includes the general layout plans, longitudinal profiles, cross sections for both the sanitary and storm drainage networks.

9.5. PHYSICAL INFORMATION

Furthermore if required the Consultant will produce a specific volume containing factual information data regarding the geology, topography and underground utilities of the areas defined in the contract.

10. BUDGET - LOAN

10.1. BOQ COSTS

The complete cost estimate of the Contract Package includes Sewerage and Drainage, Sewerage Treatment Plant (STP) and Road project components.

The following table present the total amount of the component including O&M, Provisional sums and Day Works:

Table 10- 1: BOQ - Total Cost

All Bill	Civil Works	Amount NRs
Bill 1	Preliminary and General Works	10,825,000.00
Bill 2	Civil Works	2,495,695,000.00
Bill 3	Electro-Mechanical Works	22,876,000.00
Bill 4	Provisional items and sums	20,833,252.00
Bill 5	O&M Equipments & Machineries	14,980,000.00
Bill 6	Laboratory Equipment	7,414,000.00
Bill 7	O&M of Wastewater Treatment Plant and Sewerage System	15,000,000.00
Bill 8	Day Works	993,000.00
	Total Amount	**2,588,616,252.00**
	Price Contingencies 5%	129,431,000.00
	Physical Contingencies 5%	129,431,000.00
	Sub-Total	**2,847,478,000.00**
	VAT 13%	370,172,000.00
	Grand Total	**3,217,650,000.00**

10.2. BUDGET

During the discussion in July 2013 between the Parties it was agreed that the rate of exchange for the calculation of the budget amount in NRs shall be taken to 96.00. Therefore the total available Budget v/s the BOQ amount is presented for comparison in the following table:

Table 10- 2: Budget v/s BOQ - Total Cost

Sewerage and Drainage, STP, and Road	MUSD	Rate*	MNRs
Package 1	**Budget**		**Amount**
Budget at exchange rate	33.87	95.00	3,217.650
Present BOQ	-	-	3,217.650

*Note *: Agreed conversion exchange rate*

DSC's reply to Comments on the Draft Final Report on Birgunj Drainage Works

Report/Drawings

No	Comment from PCO/	DSC's reply
1	Please look at the drawing "Cross-section of outfall 03" Line 3L1: The alignment of drainage line should be at the edges, not away from the edges at a certain distance towards the middle. Such proposal violates the planning bylaws adopted by Birgunj Sub Metropolitan City Office and thus, cannot be agreed. The consultants are requested to shift the location toward the edges.	The DSC proposal in his initial drawing was taking into account the existing conditions as a construction of a new drain on the edge is not practically feasible before the road works are completed and the appropriate road backfilling made. Furthermore the location of the inlet pit to collect the run-off of the future road will incompatible with the location of the inlet pit required for the existing conditions The location in the edge as required will create construction difficulties backfill, additional costs and inadequate run-off collection of the existing roads. It would be better to postpone the execution of the lines interfering with the future road especially if the location of the drain is incompatible with the existing conditions. But as per the comment made, the position of the drain will be shifted at the edges of the road according to the right of way of the respective road.
2	Refer drawing of "Overflow Structure": In the report it is nowhere mentioned about the overflow structure. Please add a paragraph explaining why it is needed and how it will function.	A description of the need and the function of the overflow chamber is given in the report in paragraph 6.6 Outfall 5 p57 under heading "New Diversion –Overflow Drain".
3	Please refer Table 5-6 "Design Criteria": In the table it has been mentioned 0.1% as the minimum slope, whereas the consultants have adopted a minimum slope of 0.05% (refer Line 9L, sheet 3 of 11). Also, in the same table the maximum slope has been mentioned as 10%. What does it mean? A 10% slope is very big figure for a drainage system.	In the table 5-6, DSC gives a parameter as General design Criteria. Exceptionally the Line 9L in a location has very low gradient such as 0.05% which is the natural gradient of the drain. The bottom of the drain can't be modified. Therefore the Drain slope has been preserved as far as possible where the self cleaning velocity is maintained with the proposal of larger section.

No	Comment from PCO/	DSC's reply
		The maximum slope of 10% is certainly very big and does not need to be mentioned in the Table.
4	The design criteria should also cover spacing of rain inlet chambers. It is missing.	The spacing of the rain inlet is mentioned in the Table 5-6 p37 and noted as "Gullies". But for the final report the word "Gullies" will be replaced by the word "Rain Inlet".
5	It is not clear how the consultants have calculated rainfall intensity and what the values are. The report does not say anything about the Rainfall Intensity Duration Curve, results of Gumbell's Equation and calculation of time of concentration. Please explain, because it is the governing factor in the calculation of storm water discharge.	In the draft report, the section "Hydrology" just gives the general idea about the hydrology of the Birgunj area. The detail hydrological calculation which includes the calculation of Rainfall Intensity Duration Curve, results of Gumbell's Equation and calculation of time of concentration has been provided in Hydrology Report which was missing in Draft Final Report. The detail report on Hydrological study will be submitted with the Final Report as Volume 1A. .
6	Refer Table 6 – 1: Where are the details of Outfall 1 and 2? The figures given in the table is crossed ones and therefore, there should be other figures, which are missing.	The outfall 1 and 2 has been removed from the study of the present draft Design. The corresponding figures shall be removed from the table 6-1
7	Please refer drawing no 5 of 11, Line 9L1: There is something wrong in the write-ups for the existing ground level. As we have understood, the figures mentioned in the drawing should be the existing bed level of MD1. Otherwise there will be a difference of only 99 mm between the invert level and ground level, which is not acceptable.	Agreed. In the L-section of natural drain (i.e. Trapezoidal drain) the given values of ground level are the level of existing bed. So to avoid all misinterpretation, the legend in the L-section of natural drain will be written as Existing Bed Level.
8	Refer the drawings of outfalls: As no calculations have been provided by the consultants it is hard to know, whether the structure provided by the consultants is adequate or not. The comments are mainly in reference to the sizes gabion boxes and length of launching aprons. Also, a cut-off wall is missing in all the drawings.	The DSC will prepare calculations for the Outfall and revises the corresponding drawings as required.
9	Please do not mix up M20 and M25. Though drainage structures are water retaining structures, they are considered structures with reduced risks, not like bridges and dams and therefore, M-20 is enough for drainage structures.	Agreed; All the RCC drainage structures will be of M20 except the road crossing culvert, Overflow structure and Toe wall of outfall structure which will be of M25.

No	Comment from PCO/	DSC's reply
10	Please refer standard drawings: Top bars are missing in all x-sections. Also, please consider using only flat brick soling as a base course. Regarding steel in base slab of brick drain, please check the overall cost and if there is space, please leave them. Otherwise, please remove them as uplift pressure will have little impact on them.	Agreed, the drawings shall be revised to show top bars in the drain cover slab. As per the cost, granular material filling found to be cheaper than flat brick soiling; So DSC will use Granular Material instead of Flat Brick Soiling. All the reinforcement on the base slab of brick drain will be removed and RCC will be of M20.
11	Please refer "Standard Drawings" and drawing 4 of 14: Is it really required to provide a RCC trapezoidal section? If not, stone lining sections will be much better.	The RCC in the trapezoidal section are reinforced beam to be constructed in every 4 m.
12	Please refer the same drawing: Please remove steel in toppings over brick masonry. Concreting is more than enough.	The toping beam seems to be required as in many places the masonry wall works as retaining wall and needs to be reinforced / supported.
13	Please refer "Standard Drawings" and drawing 7 of 14: There is mistake in the titles.	Agreed, mistakes will be corrected.
14	Please refer the same drawing: Steel is not required in the base slabs of such a small structure for the following reasons: a) 150 mm thick M-20 concrete can resist upward pressure and b) they will be at shallow depths.	Agreed; the base slab of the rain inlet shall be M20 without reinforcement. The drawing shall be revised and the BOQ up-dated accordingly
15	Drawing No. 8 and 9 are irrelevant, and thus should be removed.	As the two drawings refer to pipe drain, those two drawings are required
16	Cost estimate has been done on ad hoc basis (lump sum basis). A detailed estimate in the same format as of BoQ should be carried out. Also, care should be taken that the estimate remains within the budget.	The corresponding cost estimate will be submitted with final design.
17	Please refer the rate analysis part: There are still the names STWWSP and Bardighat WSP. Please erase them.	Agreed, the improper reference will be removed.

YMX 09-07-2013

DSC's reply to Comments on the Draft Final Report on Birgunj Sewerage Works

Report

No	Comment from PCO/	DSC's reply
1	Please look at the cover page. It should be "sewerage system"	Agreed, Correction will be made accordingly.
2	What is the meaning of the last sentence written on page 3. (The densification of the lateral in core shall be constructed.....)	As per 4.2.1 Design Concepts the various parts of the sewerage systems differentiate between main collectors, branch sewers and lateral sewers [figure 4.2 illustrates the definitions]. The DSC mainly designs main collectors and branch sewers, but due to budget constraint only the lateral collection pipes have been designed in Aadarshnagar area. The densification of lateral in other areas is not part of the present collection system and shall be constructed later
3	Please refer the first sentence on page 8: Please clarify what this sentence means? "Population projection by the consultants is approved by Department"	The Population projection has been carried out by the DSC. The calculated population projections are based on the parameters jointly agreed during discussions between DSC and PCO/PMSC and prepared by the Urban Planner.
4	Refer last sentence on page 9: It is not clear what the consultants wanted to say.	The DSC wanted to highlight that subsidence is generally limited to area where underground excavations were carried out.
5	Refer paragraph "Sewerage and Sanitation". The total figure about the coverage by sanitation comes to be only 98%. Where is the remaining 2%?	The DSC corrected the figure which are the following: 51% modern toilets, 24% ordinary toilets 25% no toilets
6	There is some confusion regarding the diameter and types of pipe on page 18. Please refer the paragraph "Minimum Size of Sewer"	The table 4.2 gives the pipe diameter i.e. the nominal diameter. The flow for a 200 mm should be corrected, and read 28.3 l/s. In the paragraph "Minimum Size of Sewer", in the last line the ND is to be read 150 mm and not 160 mm. The outside diameter of a pipe is related to its type.
7	Refer design formula: Manning's formula is okay. But how the consultants have derived the formula: $V= (1/n) (3.968 \times 10^{-3} \times D^{3/2} \times s^{1/2})$ for circular condition? Please check your design using this formula; it gives the values other than given in your design table.	The design Formula used is the Manning Equation for SI units: $\mathbf{V} = (\mathbf{1.0/n})(\mathbf{R}^{2/3})(\mathbf{S}^{1/2})$ where: V = velocity water flow rate passing through the stretch of channel in m/s for S.I. units **n** = Manning roughness coefficient (empirical constant), dimensionless, **R** = hydraulic radius in m for S.I units **S** = bottom slope of channel, m/m (dimensionless),

No	Comment from PCO/	DSC's reply
		The flow rate **Q** passing through the stretch of channel in m^3/s for S.I. units is as follows : **Q = V x A** where **A** = cross-sectional area of flow perpendicular to the flow direction, m^2 for S.I. The DSC highlighted that Q_{full} and V_{full} the formula can be readily calculated from the Manning equation for a circular pipe flowing full, and the formula become: $\mathbf{V} = (\mathbf{1.0/n})\ (\mathbf{3.968}\ 10^{-3}\ \mathbf{D}^{2/3})(\mathbf{S}^{1/2})$, $\mathbf{Q} = (\mathbf{1.0/n})\ (\mathbf{3.118}\ 10^{-6}\ \mathbf{D}^{8/3})(\mathbf{S}^{1/2})$, This is because the hydraulic radius for a circular pipe flowing full is simply D/4. (D = pipe diameter in mm) For **V**(m/s), R is replaced by D/4 : $\mathbf{R}^{2/3} = (10^{-3}\ D/4)^{2/3} = (10^{-3}/4)^{2/3}\ D^{2/3} = 10^{-3\ x\ 2/3}\ x\ (1/4)^{2/3}\ D^{2/3} =$ **3.968 x 10^{-3} x $D^{2/3}$** For **Q** (m3/s), V is multiplied by $A = \Pi/4\ x\ (D\ 10^{-3})^2$, and the factor $\mathbf{R}^{2/3}$ becomes: $\mathbf{R}^{2/3} = \mathbf{3.968}\ 10^{-3}\ D^{2/3}\ \Pi/4\ x\ (D\ 10^{-3})^2 = 3.968\ x\ \Pi/4\ x\ 10^{-9}\ x\ D^{8/3} =$ **3.117 x 10^{-9} x $D^{8/3}$** In general calculation are not made full flow, and the use of the formula is indicative as for a circular conduit the peak flow occurs at 93 percent of the height of the pipe, and the average velocity flowing one-half full is the same as gravity full flow. Gravity full flow condition is usually assumed for purposes of storm drain design Software calculations are made for partially full-flow Note that the computed diameter by the Software for sewerage scheme must be increased in size to a larger nominal dimension in order to carry the design discharge without creating pressure flow with a ratio of depth of flow to diameter d/D of 80% maximum.

No	Comment from PCO/	DSC's reply
8	One meter cover is more than sufficient. 1.2 meter is high.	Agreed, this requirement will be in the specifications
9	Proposed RCC bedding for HDPE pipes in no circumstance will be required. However, concrete bedding could be provisionally proposed.	In Table 4-5 b) HDPE is a combination of PCC and Arch (concrete blocks) on the top every 3 m for pipe2-4m. The RCC bedding with 0.4% steel is provided only for the RCC pipe laid below 5m and is below 2% of the total length of sewerage.
10	Refer paragraph "Manhole Cover Levels": SFRC manholes are expensive and not produced in the country. Instead, quality CI products matching Nepalese Standards are produced in the country. They are durable, less expensive and easily replaceable. Therefore, preference should be given for cast iron manhole (CI) covers: "heavy duty" type on all the motorable roads and "medium duty" type in lanes and on footpaths.	Agreed; the DSC will make the modification in the drawings and BOQ with the 2 following options -Heavy duty for motorable roads -Medium duty for lanes and footpath
11	Please refer Table 4-8: Some SAARC countries like India and Bangladesh have per capita water demand (not water supply rate) more than 80 lpcd.	The PCO 's comment is noted
12	Refer the same table: PEHD should be changed to HDPE.	Agreed, accordingly the designation will be HDPE in all documents [drawings, report and BOQ]
13	It is not clear what the consultants want to say through the last sentence given on page 38 (Gravity mains.....)	The DSC refers to the topography of the area and the natural gradient of the ground is used as possible for the layout of the gravity mains
14	The use of the software "EPA SWMM" for hydraulic modeling is good, but the consultants should not finalize the design only being based on this software. There should be cross-checks of the outputs through other means for verifications.	It is not clearly expressed in 4.3.4, but the DSC has carried out the modeling using both software (1) SWMM [main collectors] and (2) Soft well [main collectors and branches] for Draft design. But for Final design, DSC used both model for the total sewerage line. The number of nodes and sections, sized with respective software are indicated in 4.3.4. Cross check of output has been made including pipe size, gradient, velocity, water depth etc.

YMX 09-07-2013

Drawings

No	Comment from PCO/	DSC's reply
1	Please refer L-profiles and check figures given as ground levels. There are mistakes.	The DSC will check the:L-profiles and correct the corresponding mistakes
2	Please refer precast reinforced cement arch: HDPE pipes are subjected to deflection and therefore, we need some sorts of weight on them to put them in lines and levels. But 2 meter spacing is too much. It is more than enough, if there are 3 blocks for 6 meter long section: 2 at joints and one in the middle. In this way, the spacing becomes 3 m.	Agreed, the spacing of the concrete blocks shall be increase to 3 m
3	It is understood that base slabs of manholes are reinforced for possible upward pressures. Bur they are not like water tanks where any leakage through cracks at the bottom empties the tank. It has become common practice in Nepal not to reinforce base slabs of brick manholes with the following reasons: a) to speed up construction works, b) it is assumed that there will be constant flow through manholes to counter upward pressure and c) it will reduce the cost. Therefore, consultants are requested to avoid reinforcement in the base slab of brick manholes.	Agreed, no reinforcement will be planned in the base slab of the masonry manhole
4	The type of concrete for all the manholes should be limited to only M-20.	Agreed
5	Please refer the drawings of for all the types of manholes: The consultants have given two options for the base; granular bedding or flat brick soling. In our opinion bricks are easily available in Terai in comparison to granular material (pebbles) and therefore, request is made to accordingly change in the drawings.	After investigation on availability and cost, it is recommended that the base for all type of manholes are GRB [granular bedding]; the documents shall be corrected accordingly
6	Refer house connections: Encasement of pipes will be required only in the locations where the cover is less than 1 meter.	Agreed; for cover less than 1m, pipe encasement shall be proposed for uPVC pipe for house connection and/or between service pits

YMX 09-07-2013