Palestine Polytechnic University

College of Engineering and Technology
Civil & Architecture Engineering Department

Project Title

Design Of Stormwater Drainage System For Nuba Town

Project Team

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Hebron – Palestine

2016

Design Of Stormwater Drainage System For Nuba Town

BY

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A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
BACHELOR OF ENGINEERING
IN
CIVIL & ARCHITECTURAL ENGINEERING DEPARTMENT

Project Supervisor

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CIVIL &ARCHITECTURAL ENGINEERING DEPARTMENT COLLEGE OF ENGINEERING AND TECHNOLOGY PALESTINE POLYTECHNIC UNIVERSITY

HEBRON- WEST BANK
PALESTINE
2016

CERTIFICATION

Palestine Polytechnic University

Hebron- Palestine

The Senior Project Entitled:

Design Of Stormwater Drainage System For Nuba Town

Prepared By:

Noureddin Meqlad   Mohammad Hantouli

In accordance with the recommendations of the project supervisor, and the acceptance of all examining committee members, this project has been submitted to the Department of Civil and Architectural Engineering in the College of Engineering and Technology in partial fulfillment of the requirements of the department for the degree of Bachelor of Science in Engineering.

Project Supervisor   **Department Chairman**

إهــداء

إلى منارة العلم والامام المصطفى إلى الأمي الذي علم العالمين إلى سيد الخلق إلى رسولنا الكريم سيدنا محمد صلى الله عليه وسلم.

إلى شهدائنا الأبرار الذين جعلوا من أجسادهم جسراً لفكرة الحق العابرة.

إلى الينبوع الذي لا يمل العطاء إلى من حاكت سعادتي بخيوط منسوجة من قلبها إلى والدتي العزيزة.

إلى من سعى وشقى لأنعم بالراحة والهناء الذي لم يبخل بشيء من أجل دفعي في طريق النجاح إلى الذي علمني أن أرتقي سلم الحياة بحكمة وصبر إلى والدي العزيز.

إلى من حبهم يجري في عروقي ويلهج بذكراهم فؤادي إلى أخواتي وأخواني إلى من سرنا ونحن سوياً نشق الطريق معاً نحو النجاح والإبداع إلى من تكاتفنا يداً بيد ونحن نقطف زهرة العلم إلى أصدقائي وزملائي.

إلى من علمونا حروفاً من ذهب وكلمات من درر وعبارت من أسمى وأجلى عبارات في العلم إلى من صاغوا لنا علمهم حروفاً ومن فكرهم منارة تنير لنا سيرة العلم والنجاح إلى أساتذتنا الكرام .

نهديهم جميعاً هذا العمل المتواضع

فريق العمل

ACKNOWLEDGEMENT

We would like to express our thanks and gratitude to Allah, the Most Beneficent, the most Merciful who granted us the ability and willing to start and complete this project. We pray to his greatness to inspire us the right path to his content and to enable us to continue the work started in this project to the benefits of our country.

We wish to express our deep and sincere thanks and gratitude to Palestine Polytechnic University, the Department of Civil & Architectural Engineering, College of Engineering & Technology. We wish to express our thanks to Eng.Samah Al-Jabari, for a valuable help, encouragement, supervision and guidance in solving the problems that we faced from time to time during this project.

We can find no words to express our sincere, appreciation and gratitude to our parents, sisters and brothers, for their endless support and encouragement, we are deeply indebted to you and we hope that we may someday reciprocate it in some way.

Work Team

<u>ABSTRACT</u>

Design Of Storm Waterdrainage System For Nuba Town

By :

Noureddin Meqlad Mohammad Hantouli

Supervisor:

Eng. Samah Al-Jabari

Drainage as mean of disposal till recently has been largely a neglected a sect in the West Bank now. There is no storm water drainage system at present in the Nuba town. The storm water accumulates on the main streets as a result of heavy precipitation (running water).

At the same time, the accelerated development and grow of Nuba town has led to change in the hydrological and geomorphological features. All of the areas of Nuba town do not have a natural drainage outlet. Heavy rain fall causes storm water to collect in low areas and flood streets and walk way. Rabid growth has decreased the open area available for percolation and rain water and has greatly increased the runoff to low lying areas.

In view of this prevailing condition, the drainage system in Nuba town would have a new characteristic and development of new water drainage system is very necessary to drain excuse water from streets. This study is conducted to design a storm drainage system for the center of Nuba town.

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CHAPTER ONE
"INTRODUCTION"

1.1 General

Stormwater is water that originates during precipitation rains, or it may also water resulting from the melting of snow, Stormwater is of concern for two main issues one related to the volume and timing of runoff water (flooding), the other related to potential contaminants that the water is carrying.

At the present time, Stormwater is a resource and ever growing in importance as the world's human population demand exceeds the availability of readily available water, Techniques of stormwater harvesting with point source water management and purification can potentially make urban environments self-sustaining in terms of water.

like other countries , Palestine needs a storm water drainage networks , Nubba one of Town in Palestine have no a storm water drainage networks , because what has been mentioned , design of storm water drainage system study for Nuba city have been conducted. Data must be developed on topography, geology, hydrology climate, ecological elements and social and economic conditions. Topographic maps with existing and proposed streets provide the most important information for preliminary flow routing.

1.2 Problem Definition

Water drainage is very important due to water accumulation on the streets as a result of heavy precipitation, population growth, and the development and extension of West Bank cities.

Nuba town is located in a semi arid region with rainfall generally limited to autumn and winter months. In the past, the open area of the city easily observed most of this rainfall and provided the primary source for recharging the ground water aquifer. All of the areas of Nuba town do not have a natural drainage outlet, heavy rainfall causes storm water to collect in low areas and flood streets and walk ways.

Rapid growth has decreased the open areas available for percolation of rain water and has greatly increased the runoff to flow laying areas. In view of this condition, design of storm water drainage system in Nuba Town becomes very essential.

1.3 Objectives of the Project

This Project "Design a storm water drainage System for Nuba town ", which include the following:-

1. Determine the sub catchments and catchments of the study area with the help of aerial photogrammetric map and Geographical information system (GIS).
2. Design of storm water drainage system of the city.
3. Prepare all of the tables and drawing needs to implement the drainage system.
4. Prepare A Bill of Quantities.

1.4 Methodology

1- Many site visits to Nuba town and cooperation with Nuba Municipality to make sufficient system.

2- All needed maps and the previous studies that contain different information about Nuba town were obtained.

3- The amount of rain fall in the last years, the rainfall rate, and the maximum quantities were obtained.

4- The different layouts of the purposed storm water collection system were completed.

5- The necessary calculations for the quantity of storm water.

6- The necessary calculations for design of the storm water drainage system were completed.

7- Tables, Maps, Drawings and bill of quantities were completed.

8- Writing the report.

1.5 Phase of the Project

The Project will consist of the four phases as shown in Table (1.1).

Table (1.1): Phases of the Project with Their Expected Duration

Title	Duration						
	02/16	03/16	04/16	05/16	06/16	07/16	08/16
Data collection and survey							
Preparing layout for storm water collection system and calculate the amount of storm water							
Design of storm water collection system							
Writing the report and preparing maps							

1.5.1 First Phase: - Data collection and Survey

In this phase, available data and information were collected from different sources. Moreover, many site visits to both town and municipality were done. This phase includes the following tasks:-

1- Collecting of aerial and topographical maps for all areas.
2- Collecting of metrological data (temperature, rainfall … etc) from different sources.

1.5.2 Second Phase:-Preparing Layout for StormWater Collection System and calculate The Amount of StormWater

In this phase layout was prepared and put in its final shape and then quantities of stormwater will determine. This phase includes the following tasks:

1- Draw the layout of stormwater collection system and check it more than one time to make sure that is correctly , later compare layout with the real situation in Nuba town then make adjustment and draw the final layout , this step is the most important one .

2- Evaluation of the contour maps and matching it with actual ground levels in the town.
3- Determination of the stormwater quantities.

1.5.3 Third Phase: - Design of Stormwater collection system

In this phase the necessary calculations needed for the design of main trunks was completed, this phase includes the following tasks:

1- Establish a system layout, which includes the areas that are going to be served, existing streets, roads, topography … etc
2- Establish the catchments and sub-catchments areas and routes of the sewers.
3- Establish the design criteria and conducting the needed sewer diameter calculations.
4- Preparing needed different drawings for the designed sewers.

1.5.4 Fourth Phase: - Writing the report and preparing

After finishing the design calculations of the main trunks the project team was prepared the specification drawing, bill of quantities preliminary maps. Final report prepared and submitted to the Department of Civil and Architectural Engineering at Palestine Polytechnic University.

1.6 Organization of the Project

The study report has been prepared in accordance with the objectives and of work.
The report consists of six chapters.

- The first chapter entitled "Introduction" outlines the problem, project objectives, and phases of the project.
- Chapter two entitled "Project Area" which deals with the metrological data geographic data, rainfall, temperature, water supply.
- Chapter three entitled "Design Criteria" which deals with the storm water runoff hydraulic consideration, design of storm water sewers.
- Chapter four entitled "Analysis and Design" which deals with the layout, design computations, storm water drainage system and profiles of drainage channels.

- Chapter five entitled "Bill of quantities" which deals with the quantities needed to complete the design system.
- Chapter six entitled "Conclusions" which deals with the conclusions of the study.

CHAPTER TWO
"PROJECT AREA"

2.1 General

In this chapter, the basic data of Nuba Town will be briefly discussed. The location, topography, and climate will be described. The water supply and rainfall quantity will be briefly presented.

2.2 Project Area

Nuba is a town in Hebron Governorate, located 12 km northwest Hebron city, in the south of the West Bank. The town is located within the southern Palestinian mountains, upon an east to west sloping plain. It is bordered by Halhul to the east, Kharas to the north, Beit Ula to the south and the Green Line to the west. (See Fig (2.1) and the Arial Photo for Nuba Town in Fig(2.2)).

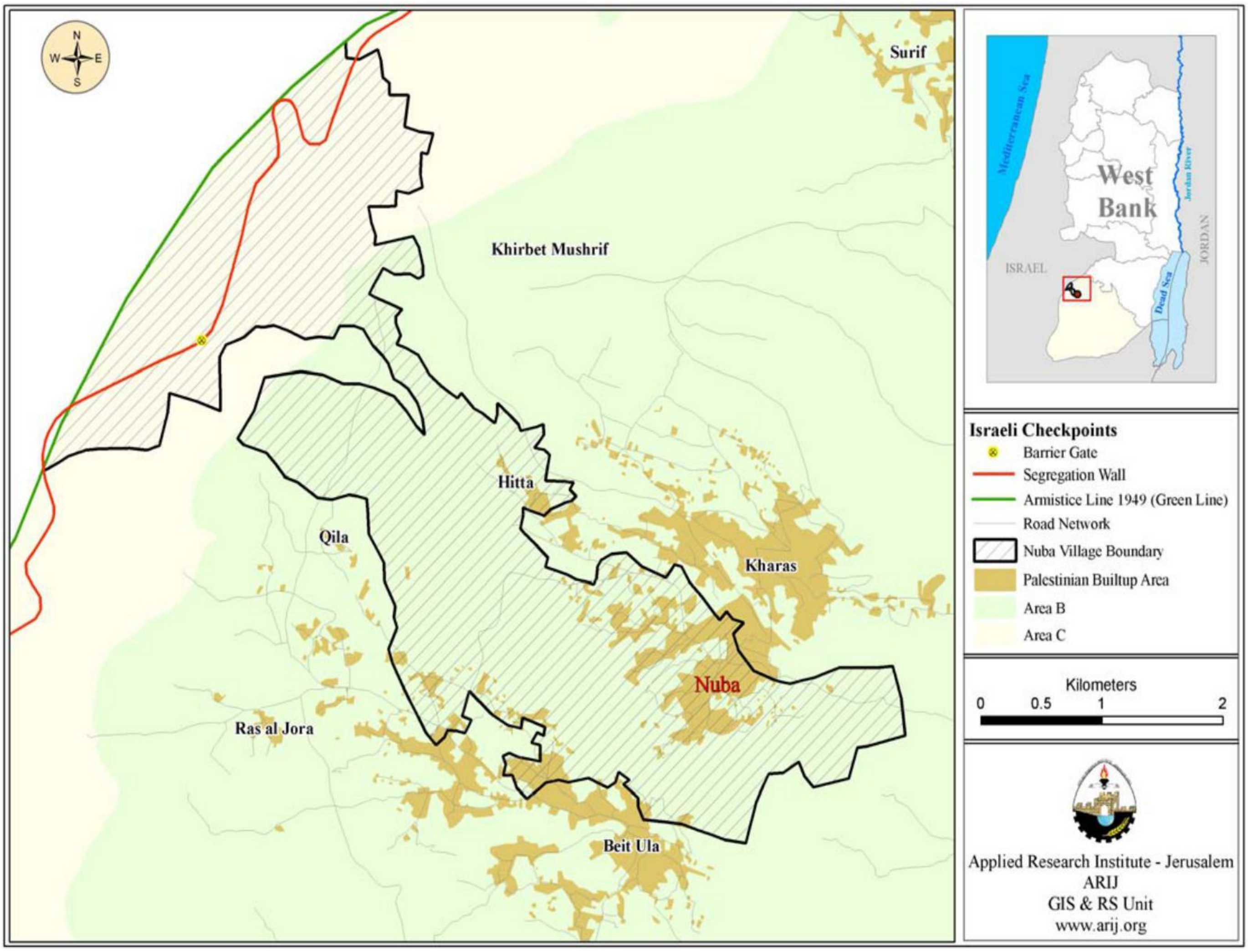


Fig (2.1): Nuba Town location and borders

The elevations ranging from (300-700) meters above sea level. The highest point in the whole Nuba town is actually at the east part of the town to the east of Halhul city and the lowest point which in the west part Fig(2.3) That show the Topographic map for Nuba town, see Fig(2.4) that show Flow direction ,and see Fig(2.5) that show Flow accumulation in Nuba town.

-History

Nuba is an old village that dates back to the Canaanite Period, deriving its name from the word "Nabo", which means 'height'. During the Islamic Expansion, Umar Ibn Al Khattab designated the village as a religious site. An engraved in stone in the village, dating to the period of Islamic Expansion, mentions Nuba and the adjacent villages as Islamic waqf. See Fig(2.6).

Fig (2.6): Nuba town

-Religious and Archaeological Sites

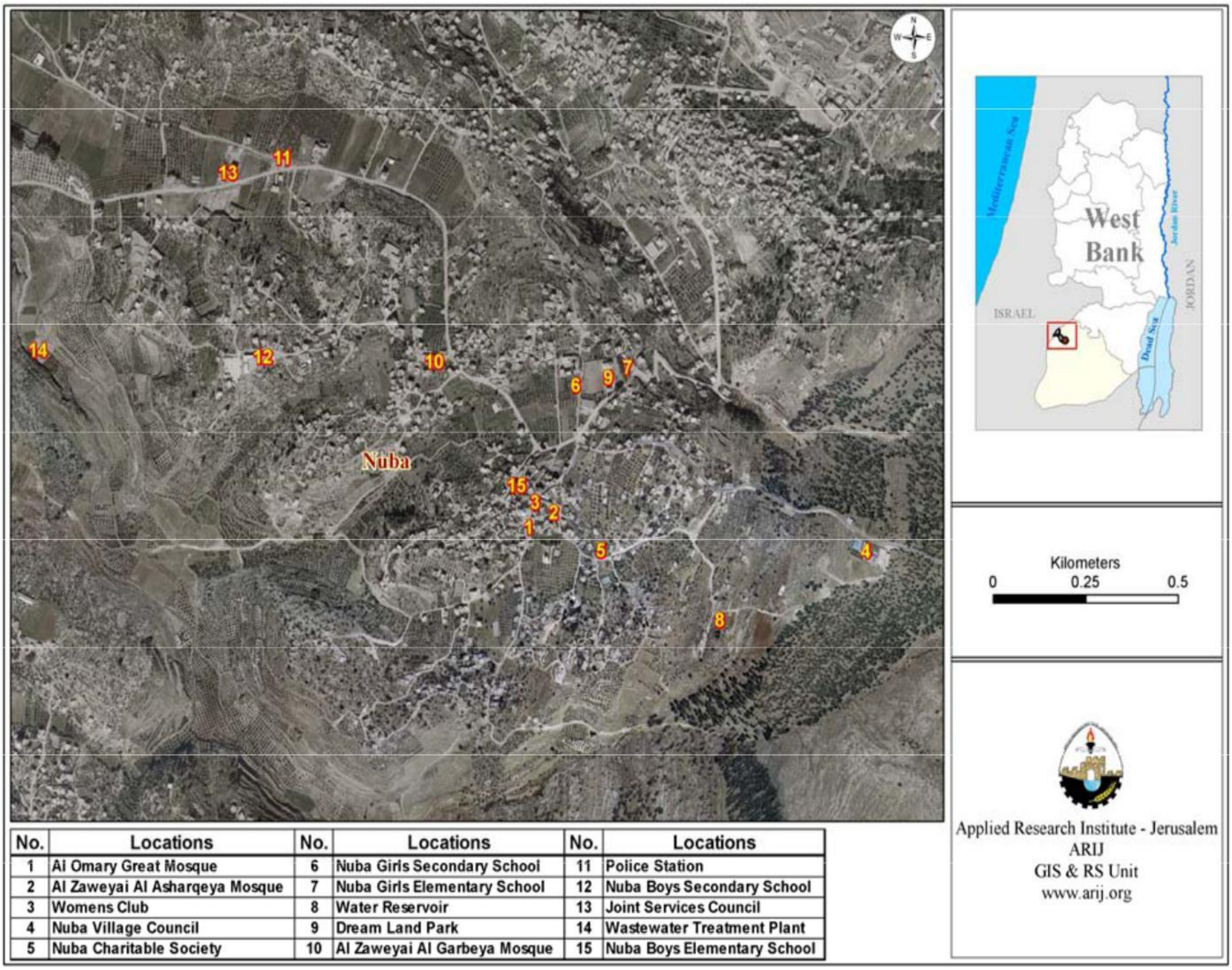
Nuba's importance as a religious site derives from the presence of Al Omary Mosque, which includes the engraved script by Umar Ibn al Khattab, assigning the village as a holy site related to Al Aqsa Mosque in Jerusalem. The village also contains four places of religious commemoration: Sheikh Isma'il Shrine, Abu Raghif Shrine, Sheikh Jarrah Shrine and Sheikh Youssef Shrine.Other religious places in the village include Al Zawiyah Ash Sharqiyah Mosque, Al Zaweiyah Al Gharbiyah Mosque, Al Baq'ah Mosque and Al Shuhada Mosque.

Nuba has also gained a general historical and archeological importance. There are a number of historical and archeological sites in Nuba, for example, several ancient wells, in addition to many water springs.Be'ir el Maleh is a well with a 25 m underground tunnel that reaches a water spring, which people use to heal skin diseases.Be'ir Al Qaws, named for the arrows that are engraved on the stone edges, is another ancient well that provides a continuous discharge of groundwater.

Other historically significant water springs in the village include Be'ir Al Suweida and Be'ir Khalal. There are also three ancient ruined sites in the village:

- **Khirbet Hitta** is an area of 30 donums, populated with Bedouins, located in western Nuba, and about 1 km away from the village center. The site has many archeological caves, ruins, and old drawings and inscriptions.
- **Khirbet Al Ahmar** is an area of 20 donums, located northern Nuba. It is populated and has many archeological caves.
- **Khirbet Baten Al Asfar** is an area of 15 donums to the south of Nuba. The site has many ancient ruins related to the Roman and Canaanite periods.

Although there are many archeological and historical sites in the village, none is currently utilized for recreational or tourist use see Fig(2.7) that show the main location of Nuba town.



No.	Locations	No.	Locations	No.	Locations
1	Al Omary Great Mosque	6	Nuba Girls Secondary School	11	Police Station
2	Al Zaweyai Al Asharqeya Mosque	7	Nuba Girls Elementary School	12	Nuba Boys Secondary School
3	Womens Club	8	Water Reservoir	13	Joint Services Council
4	Nuba Village Council	9	Dream Land Park	14	Wastewater Treatment Plant
5	Nuba Charitable Society	10	Al Zaweyai Al Garbeya Mosque	15	Nuba Boys Elementary School

Fig (2.7): Main Locations Of Nuba Town

2.3 Infrastructure and Natural resources

1.**Water Services**

Nuba has been connected to the water network since 1975; almost 90% of the housing units are connected. The domestic water supply per capita is 81.0 (L/day), and currently, the Palestinian Water Authority (PWA) is the main provider for water resources. Cisterns are alternative resources to water networks. The village also owns a water reservoir with a 500 cubic meter capacity. The main problem that faces water services in the village is that the network is old and needs reconstruction.

2. Sewage Disposal Facilities

Nuba Municipality had constructed a new sewage network in 2005. The new network covered less than 50% of the village housing units, and the rest rely on cesspits.

2.4 Population

Prediction of the future population of Nuba is very difficult due to the lack of reliable historic data, and the political uncertainties, which will greatly influence future social and economic development. At the same time, the available data on past population growth do not constitute a reliable basis for projecting the future population growth in Nuba. The base for the forecast is the 2011 population for Nuba obtained from Palestine Central Of Bureau Statistics (PCBS) was 4872 inhabitants.

2.5 Land Use

The overall area of the town is distributed among the following:

1. The Old Town: The old town is famous for its old buildings, two stories high, and it's old Passageways.

2. Built up Area: It is about 18.4% of total area of Nuba Town. Residential buildings are scattered all over the town of Nuba. There is no apparent system for organizing residential distribution or establishing a clear distinction between land uses.

3. Public Properties: It is about 1.8% of total area of Nuba Town. There is four schools The municipal building and the police station, With an area equal 54 donums.

4. Roads: It is about 6.3% of total area of Nuba Town. There are about 40 km internal roads in Nuba town, 20 km are paved and in a good condition, 5 km are paved but in a bad condition and 15 km are not paved at all.

5. Agricultural Area: It is about 56.1% of total area of Nuba Town.

See table (2.1) that show The overall area of Nuba town .

Table (2.1): Land Use in Nuba Town

Total Area donum	Forest Area donum	Agriculture Area Donum	Built up Area donum	Road Area donum	Empty Area donum
3080	**202**	**1728**	**566**	**194**	**390**

There are about 5 donums of greenhouses. Most agricultural activities in Nuba are dependent on rain, but farmers also use the water network and the storage cisterns for further irrigation. The main crops cultivated in the village include olives, grapes, field crops and vegetables. Table 2.2 shows the different types of rain-fed and irrigated open cultivated vegetables in the village of Nuba. The rain-fed fruity vegetables are the most cultivated with an area of about 117 donums. The most common vegetables cultivated within this area are gumbo and squash (See table2.2), and see Fig(2.8) that show the land use for Nuba town.

Fruity Vegetables		Leafy vegetable		Green Legumes		Bulbs		Other vegetables		Total area	
Rf	Irr	Rf	Irr	Rf	Irr	Rf	Irr	Rf	Irr	Rf	Irr
117	12	5	12	15	3	0	6	0	20	137	53

Table2.2: Total area of rain fed and irrigated open cultivated vegetables in Nuba Town

Rf: Rain-fed, Irr: Irrigated

2.6 Meteorological Data

The hydrology of region depends primarily on its climate, and secondarily on its topography. Climate is largely depends on geographical position of the earth surface, and temperature. These factors are affecting evaporation. So this study will include needed data about these factors, since they play big role in the determination of rainfall.

2.6.1 Rainfall: The amount annual rainfall in Nuba Town between 300 - 500mm. Rainfall occurs between September and May, while it stop raining in the summer season from June to August, see(table2.3) that slow the amount of rainfall in 2014/2015 and (table2.4)) that show the amount of rainfall in 2015/2016.

Table (2.3): The amount of rainfall in Nuba town in 2014/2015

Day	Date	Quantity (mm)
Monday	17/11/2014	5
Saturday	22/11/2014	7
Monday	24/11/2014	9
Tuesday	25/11/2014	4
Wednesday	26/11/2014	31
Thursday	27/11/2014	30
Saturday	29/11/2014	9
Sunday	21/12/2014	9
Tuesday	23/12/2014	11
Sunday	04/01/2015	15
Monday	05/01/2015	3
Wednesday	07/01/2015	42
Friday	09/01/2015	37
Sunday	11/01/2015	25
Thursday	15/01/2015	1
Saturday	17/01/2015	22
Monday	16/02/2015	19
Thursday	19/02/2015	15
Sunday	22/02/2015	56
Thursday	12/03/2015	7
Sunday	12/04/2015	37
Thursday	16/04/2015	25
SUM		419

Table(2.4):The amount of rainfall in Nuba town in 2015/2016

Day	Date	Quantity (mm)
Sunday	01/11/2015	34
Tuesday	10/11/2015	17
Thursday	03/12/2015	12
Monday	14/12/2015	18
Thursday	31/12/2015	15
Saturday	09/01/2016	25
Sunday	24/01/2016	16
Monday	25/01/2016	41
Wednesday	27/01/2016	35
Sunday	07/02/2016	27
Monday	08/02/2016	14
Wednesday	17/02/2016	7
Tuesday	23/02/2016	50
SUM		311

2.6.2 Temperature: The temperature is characterized by considerable variation between summer and winter times. The average annual temperature is 20.5˚ C, The following minimum and maximum values were shown.

1.Wenter:

- The mean maximum temperature: 20° C

-The mean minimum temperature: 10° C

2.Summer:

- The mean maximum temperature: 28° C

-The mean minimum temperature: 25° C

CHAPTER THREE
"DESIGN CRITERIA"

3.1 General

Rapid effective removal of storm runoff was a luxury not found in many cities in the early nineteenth century. Today, the modern city dweller has come to think of this as an essential service. Urban drainage facilities have progressed from crude ditches and stepping stones to the present intricate coordinates systems of curbs, gutters, inlets, and underground conveyance. The design must consider meteorological factors, geomorphological factors, and the economic value of the land, as well as human value considerations such as aesthetic and public safety aspects of the design. The design of storm water detention basins should also consider the possible effects of inadequate maintenance of the facility.

3.2 StormWater Runoff

Stormwater runoff is that portion of precipitation which flows over the ground surface during and a short time after a storm. The dependence parameters that controlled the quantity of the stormwater which carried by a storm or combined sewer are the surface of the drainage area (ha), the intensity of the rainfall (l/s.ha), and runoff coefficient C dimensionless (the condition of the surface). There are many methods and formulas to determine the storm flow.

3.2.1 Rational Method

The rational method has probably been the most popular method for designing storm systems. It has been applied all over the world and runoff is related to rainfall intensity by the formula.

$$Q = C.i.A \qquad (3.1)$$

Where Q = peak runoff rate (l/sec).

C = runoff coefficient, which is actually the ratio of the peak runoff rate to the average rainfall for a period known as the time of concentration.

i = average rainfall intensity, mm/min, for period equal to the time of concentration.

A= drainage area (ha).

For small catchments areas, it continues to be a reasonable method, provided that it is used properly and that results and design concepts are assessed for reasonableness. This procedure is suitable for small systems where the establishment of a computer model is not warranted. The steps in the rational method calculation procedure are summarized below:

1- The drainage area is first subdivided into sub-areas with homogeneous land use according to the existing or planned development.

2- For each sub-area, estimate the runoff coefficient *C* and the corresponding area *A*.

3- The layout of the drainage system is then drawn according to the topography, the existing or planned streets and roads and local design practices.

4- Inlet points are then defined according to the detail of design considerations. For main drains, for example, the outlets of the earlier mentioned homogeneous sub-areas should serve as the inlet nodes. On the other hand in very detailed calculations, all the inlet points should be defined according to local design practices.

5- After the inlet points have been chosen, the designer must specify the drainage sub-area for each inlet point A and the corresponding mean runoff coefficient *C*. If the sub-area for a given inlet has non-homogeneous land use, a weighted coefficient may be estimated.

6- The runoff calculations are then done by means of the general rational method equations for each inlet point, proceeding from the upper parts of the watershed to the final outlet. The peak runoff, which is calculated at each point, is then used to determine the size of the downstream trunk drain using a hydraulic formula for pipes flowing full.

7- After the preliminary minor system is designed and checked for its interaction with the major system, reviews are made of alternatives, hydrological assumptions are verified, new computations are made, and final data obtained on street grades and elevations. The engineer then should proceed with final hydraulic design of the system.

3.2.2 Runoff Coefficient, C

Runoff coefficient is a function of infiltration capacity, interception by vegetation, depression storage, and evapotranspiration. It is requires greatest exercise of judgment by engineer and assumed constant, actually variable with time. It is desirable to develop composite runoff coefficient (weighted average) for each drainage area as:

$$C=\frac{\sum C_i A_i}{\sum A_i} \qquad (3.2)$$

Where Ai = i_{th} area.

Ci = i_{th} runoff coefficient.

The range of coefficients with respect to general character of the area is given in the following
tables (Table 3.1 and Table 3.2).

Table (3.1): The Range of Coefficient with Respect to General Character of the Area

Description of Area	Runoff Coefficients
Business	
Down town Neighborhood	0.70 to 0.95 0.50 to 0.70
Residential	
Single-Family Multi-unit, detached Multi-unit, attached	0.30 to 0.50 0.40 to 0.60 0.60 to 0.75
Residential (suburban)	0.25 to 0.40
Apartment	0.50 to 0.70
Industrial	
Light Heavy	0.50 to 0.80 0.60 to 0.90
Parks, Cemeteries	0.10 to 0.25
Playground	0.20 to 0.35
Railroad yard	0.20 to 0.35
Unimproved	0.10 to 0.30

Table (3.2): The Range of Coefficient With Respect to Surface Type of the Area

Character of Surface	Runoff Coefficients
Pavement	
Asphalt and concrete Brick	0.70 to 0.95 0.70 to 0.85
Lawns, Sandy soil	
Flat, 2 percent Average,2to7percent Steep, 7 percent	0.05 to 0.10 0.10 to 0.15 0.15 to 0.20
Roofs	0.75 to 0.95
Lawns, Heavy soil	
Flat, 2 percent Average,2 to 7percent Steep, 7 percent	0.13 to 0.17 0.18 to 0.22 0.25 to 0.35

3.2.3 Rainfall Intensity (i)

In determining rainfall intensity for use in rational formula it must be recognized that the shorter the duration, the greater the expected average intensity will be. The critical duration of rainfall will be that which produces maximum runoff and this will be that which is sufficient to produce flow from the entire drainage area. Shorter periods will provide lower flows since the total area is not involved and longer periods will produce lower average intensities. The storm sewer designer thus requires some relationship between duration and expected intensity. Intensities vary from place to another and curves or equations are specified for the areas for which they were developed.

The rainfall intensity depends on many factors through which we can do our calculations; we can list these factors as follow:

1- Average frequency of occurrence of storm (n) or (f).

Average frequency of occurrence is the frequency with which a given event is equaled or exceeded on the average, once in a period of years. Probability of occurrence, which is the reciprocal of frequency, (n) is preferred by sum engineers. Thus, if the frequency of a rain once a 5-year (f=5), then probability of occurrence n=0.20. Selection of storm design rain frequency based on cost-benefit analysis or experience. There is range of frequency of often used:

a. Residential area: f = 2 to 10 years (5 year most common).
b. Commercial and high value districts: f = 10 to 50 (15 year common).
c. Flood protection: f = 50 year.

2- Intensity: duration and frequency characteristics of rainfall. Basic data derived from gage measurement of rainfall (Point rainfall) over a long period can be used to obtain a rainfall height diagram that show the relation between the height of rain (mm) and time (min). The slope of the curve or rain height per unit time is defined as rain intensity:

$$i = (\Delta \text{ height of rain / time}) \left[\frac{mm}{\min}\right]$$

The rain intensity in litter per second. Hectare is equal:

$$i\left(\frac{l}{s.ha}\right) = 166.7i \left[\frac{mm}{\min}\right]$$

In order to drive intensity-duration-frequency curves long-term observation of rainfall is needed. Analysis of such observation is given in any text in sanitary engineering.

3- Time of Concentration: The time of concentration is the time required for the runoff to become established and flow from the most remote part (in time) of the drainage area to the point under design.

$$t_c = t_i + t_f \tag{3.3}$$

Where t_c: time of concentration.
t_i: inlet time.
t_f: flow time.

$$\text{Time of flow in storm, } t_f = \frac{\text{Length of pipe line (L)}}{\text{Velocity of flow (v)}} \tag{3.4}$$

Inlet time (t_i): is the time required for water to flow over ground surface and along gutters to drainage inlet. Inlet time is function of rainfall intensity, surface slope, surface roughness, flow distance, and infiltration capacity and depression storage.

3.2.4 Catchments Area, A

Most of the catchments are partly developed with residential facilities. The catchments are moderately flat with rural, residential and commercial land uses. The rural areas are located at the downstream end of the catchments.

3.3 Hydraulic Consideration

3.3.1 Introduction

Wastewater systems and (storm water) are usually designed as close channels except where lift stations are required to overcome topographic barriers. The hydraulic problems associated with these flows are complicated in some cases by the quality of the fluid, the highly variable nature of the flows, and the fact that an unconfined or free surface exists. The driving force for open channel flow and sewer flow is gravity. For the hydraulic calculations of sewers, it is usually assumed uniform flow in which the velocity of flow is constant, and steady flow condition in which the rate discharge at any point of a sewer remains constant (Metcalf,1982).

3.3.2 Hydraulic Design Equations

In principle all closed channel flow formulas can be used in hydraulic design of sewer pipes. The following are the most important formulas:

1. Chezy's formula:

$$V = C\sqrt{RS} \qquad (3.5)$$

Where V: the velocity of flow (m/s).

C: the Chezy coefficient; $C = \frac{100\sqrt{R}}{m+\sqrt{R}}$, where m = 0.35 for concrete pipe or 0.25 for vitrified clay pipe

R: the hydraulic radius (m)

S: the slope of the sewer pipe (m/m).

2. Darcy-Weisbach formula: It is not widely used in wastewater collection design and evaluation because a trial and error solution is required to determine pipe size for a given flow and head loss, since the friction factor is based on the relative roughness which involves the pipe diameter, making it complicated. Darcy-Weisbach formula states that

$$H = \lambda \frac{L \times V^2}{D \times 2g} \qquad (3.6)$$

Where H: the pressure head loss

L: the length of pipe (m).

D: the diameter of pipe (m).

λ : the dimensionless friction factor generally varying between 0.02 to 0.075.

3. The Manning formula: Manning's formula, though generally used for gravity conduits like closed channel, it is also applicable to turbulent flow in pressure conduits and yields good results, provided the roughness coefficient n is accurately estimated. Velocity, according to Manning's equation is given by:

$$V = \frac{1}{n} R^{2/3} S^{1/2} \qquad (3.7)$$

Where n: the Manning's roughness coefficient [1/n (k_{str}) = 75 $m/s^{1/3}$].

R: the hydraulic radius = area /wetted perimeter (R= A/P).

- For circular pipe flowing full, R=D/4.
- For open channel flowing full, R=A/P.

The Manning's roughness coefficient depends on the material and age of the conduit. Commonly used values of n for different materials are given in Table (3.3).

Table (3.3): Common Values of Roughness Coefficient Used In the Manning Equation

Material	Commonly Used Values of n
Concrete	0.013 and 0.015
Vitrified clay	0.013 and 0.015
Cast iron	0.013 and 0.015
Brick	0.015 and 0.017
Corrugated metal pipe	0.022 and 0.025
Asbestos cement	0.013 and 0.015
Earthen channels	0.025 and 0.003

3.3.3 Hydraulics of Partially Filled Section

The filling rate of a sewer is an important consideration, as sewers are seldom running full, so storm water sewers designed for 40% or 50% running full, that is means only 40 % to 50 % of the pipe capacity should be utilized to carry the peak flow.

Partially filled sewers are calculated by using partial flow diagram and tables indicating the relation between water depth, velocity of flow and rate flow .The hydraulic characteristics are similar as for closed channels, but the velocity of flow is reduced by increased air friction in the pipe with increasing water level, particularly near the top of the pipe. The velocity of flow and the flow rate are reduced at filling rates between 60% and 100%; the water level in the pipe is unstable at filling rates above 90% or 95%.

3.4 Storm Water Sewers Design

Designing a community storm system is not a simple task. It requires considerable experience and a great deal of information to make proper decisions concerning the layout, sizing, and construction of a storm network that is efficient and cost-effective. The design engineer needs to generally undertake the following tasks (Qasim, 1985, Peavy, 1985):

1. Define the service area.
2. Conduct preliminary investigations.
3. Develop preliminary layout plan and profile.
4. Selection of design parameters.
5. Review construction considerations.

6. Conduct field investigation and complete design and final profiles.
7. Prepare contract drawing and specifications.

3.4.1 Service area

Service area is defined as the total area that will eventually be served by the drainage system... It is important that the design engineers and project team become familiar with the surface area of the proposed project.

3.4.2 Preliminary Investigation

The design engineer must conduct the preliminary investigations to develop a layout plan of the drainage system. Site visits and contacts with the city and local planning agencies and state officials should be made to determine the land use plans, zoning regulations, and probable future changes that may affect both the developed and undeveloped land. Data must be developed on topography, geology, hydrology, climate, ecological elements, and social and economic conditions. Topographic maps with existing and proposed streets and other utility lines provide the most important information for preliminary flow routing.

If reliable topographic maps are not available, field investigations must be conducted to prepare the contours, place bench marks, locate building, utility lines, drainage ditches, low and high areas, stream, and the like. All these factors influence the sewer layout.

3.4.3 Layout Plan:

Proper storm sewer layout plan and profiles must be completed before design flows can be established. The following is a list of basic rules that must be followed in developing a sewer plan and profile.

1. Select the site for disposal of the storm water at the end of the network, generally the lowest elevation of the entire drainage area.
2. The preliminary layout of storm sewers is made from the topographic maps. In general, sewers are located on streets, or on available right-of-way; and sloped in the same direction as the slope of the natural ground surface.
3. The trunk storm sewers are commonly located in valleys. Each line is started from the

intercepting sewer and extended uphill until the edge of the drainage area is reached, and further extension is not possible without working downhill.

4. Main storm sewers are started from the trunk line and extended uphill intercepting the laterals.
5. Preliminary layout and routing of storm sewage flow is done by considering several feasible alternatives. In each alternative, factors such as total length of storm sewers, and cost of construction of laying deeper lines versus cost of construction, operation, and maintenance of lift station, should be evaluated to arrive at a cost- effective drainage system.
6. After the preliminary storm sewer layout plan is prepared, the street profiles are drawn. These profiles should show the street elevations, existing storm sewer lines, and manholes and inlets. These profiles are used to design the proposed lines.

Finally, these layout plans and profiles are revised after the field investigations and storm sewer designs are complete.

3.4.4 Selection of Design Parameters

Many design factors must be investigated before storm sewer design can be completed. Factors such as design period; peak, average, and minimum flow; storm sewer slopes and minimum velocities; design equations …etc. are all important in developing storm sewer design. Many of the factors are briefly discussed below.

1. **Design Flow Rate:** Storm water sewers should be designed to carry the largest storm that occurred in the period of design; commonly it is 25 years because of consideration of the cost and the frequently factors.

2. **Minimum Size:** As mentioned earlier, the minimum storm sewer size recommended is 250 to 300 mm for closed system, and for open channel depend on the type of profile that selected.

3. **Minimum and Maximum Velocities:** In storm water sewers, solids tend to settle under low-velocity conditions. Self-cleaning velocities must be developed regularly to flush out the solids. Most countries specify minimum velocity in the sewers under low flow

conditions. The minimum allowable velocity is 0.75 m/s, and 0.9 m/s is desirable. This way the lines will be flushed out at least once or twice a day. The maximum velocities for storm water system are between 4 to 5 m/s. The maximum velocity is limited to prevent the erosion of sewer inverts.

4. **Slope:** For closed system minimum slopes determined from minimum velocities, for minimum velocity 0.9 m/s, the slopes are shown in Table 2.4.

Table (3.4): Minimum Recommended Slopes of Storm Sewer (n = 0.015)

Pipe Diameter (D)		Slope (min)	Slope (max) =1/D
mm	**inch**	**mm**	**cm**
250	10	0.00735	0.04
300	12	0.00576	0.033
450	18	0.00336	0.0222
600	24	0.00229	0.0167

Note: for a velocity of 0.75m/s the slopes shown above should be multiplied by1.56.

Maximum slopes determined from maximum velocities, 0.9/D (cm) can be used as a guide.

5. **Depth:** The depth of storm sewers when using closed system is generally just enough to receive flow but not less than 1 m below the ground surface. Depth depends on the water table, lowest point to be served, topography, and the freeze depth. But for the open channel it is at the ground surface.

6. **Appurtenances:** Storm Sewer appurtenances include manholes, inlets, outlets and outfall, and others. Appropriate storm sewer appurtenances must be selected in design of storm water sewers.

7. **Design Equations and Procedures**: Storm water sewers are mostly designed to flow partially full. Once the peak, average, and minimum flow estimates and made general layout and topographic features for each line are established, the design engineer begins to size the sewers. Design equations proposed by Manning, Chezy, Gangullet, Kutter, and Scobey have been used for designing sewers and drains. The Manning equation, however, has received most widespread application. This equation is expressed below:

$$V=\frac{1}{n}R^{2/3}S^{1/2} \quad (3.7)$$

And as mentioned earlier, the runoff flow is calculated using the following formula:

$$Q=C.i.A \quad (3.1)$$

Various types of monographs have been developed for solution of problems involving sewers flowing full. Monographs based on Manning's equation for circular pipe flowing full and variable n values are provided in Figure 2.1. Hydraulic elements of circular pipes under partially-full flow conditions are provided in Figure 2.2. It may be noted that the value of n decreases with the depth of flows Figure 2.1. However, in most designs n is assumed constant for all flow depths. Also, it is a common practice to use d, v, and q notations for depth of flow, velocity, and discharge under partial flow condition while D, V, Q notations for diameter, velocity, and discharge for sewer flowing full. Use of equations 2.1 and 2.7 and Figures 2.1 and 2.2, one can design the drainage system.

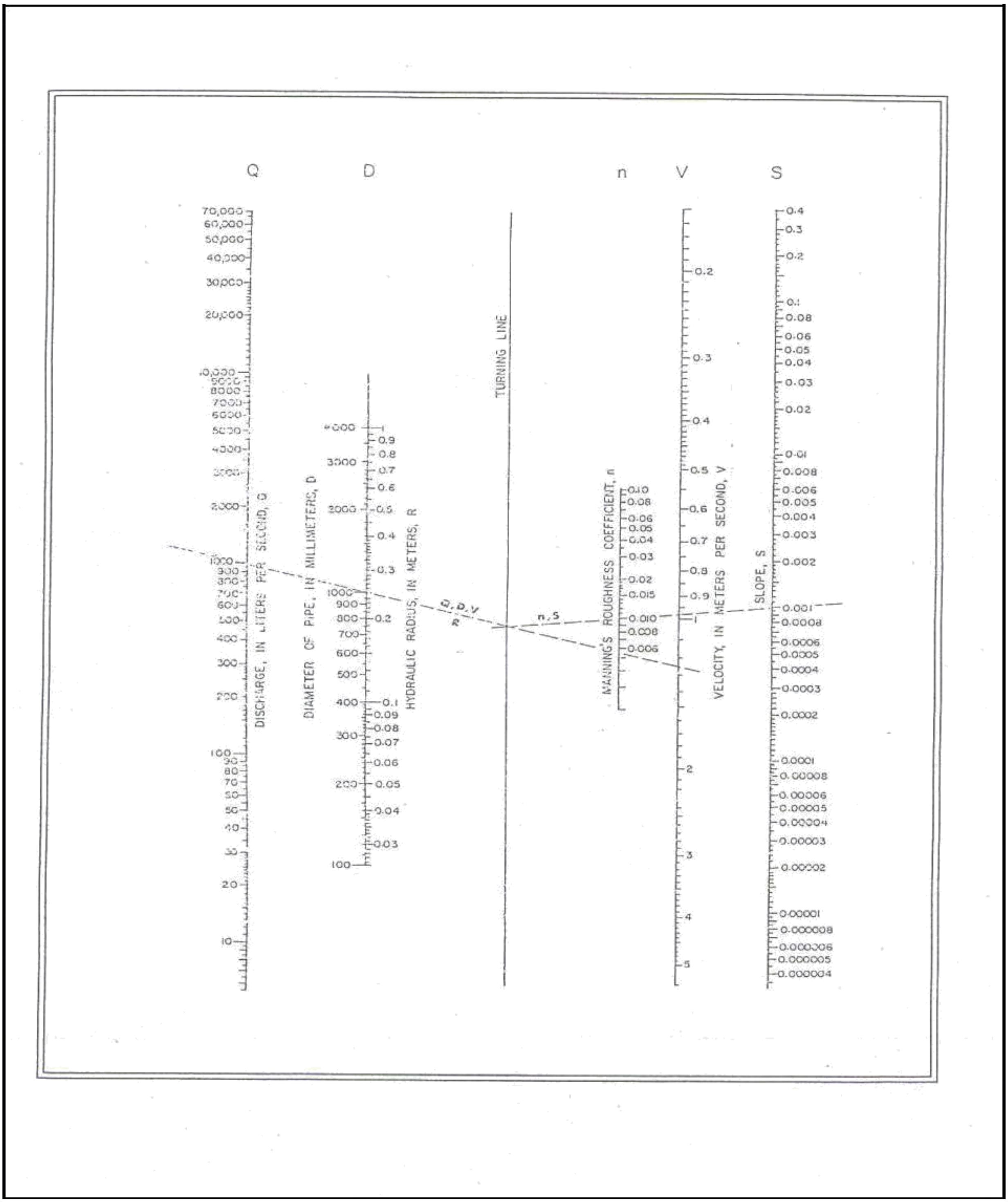
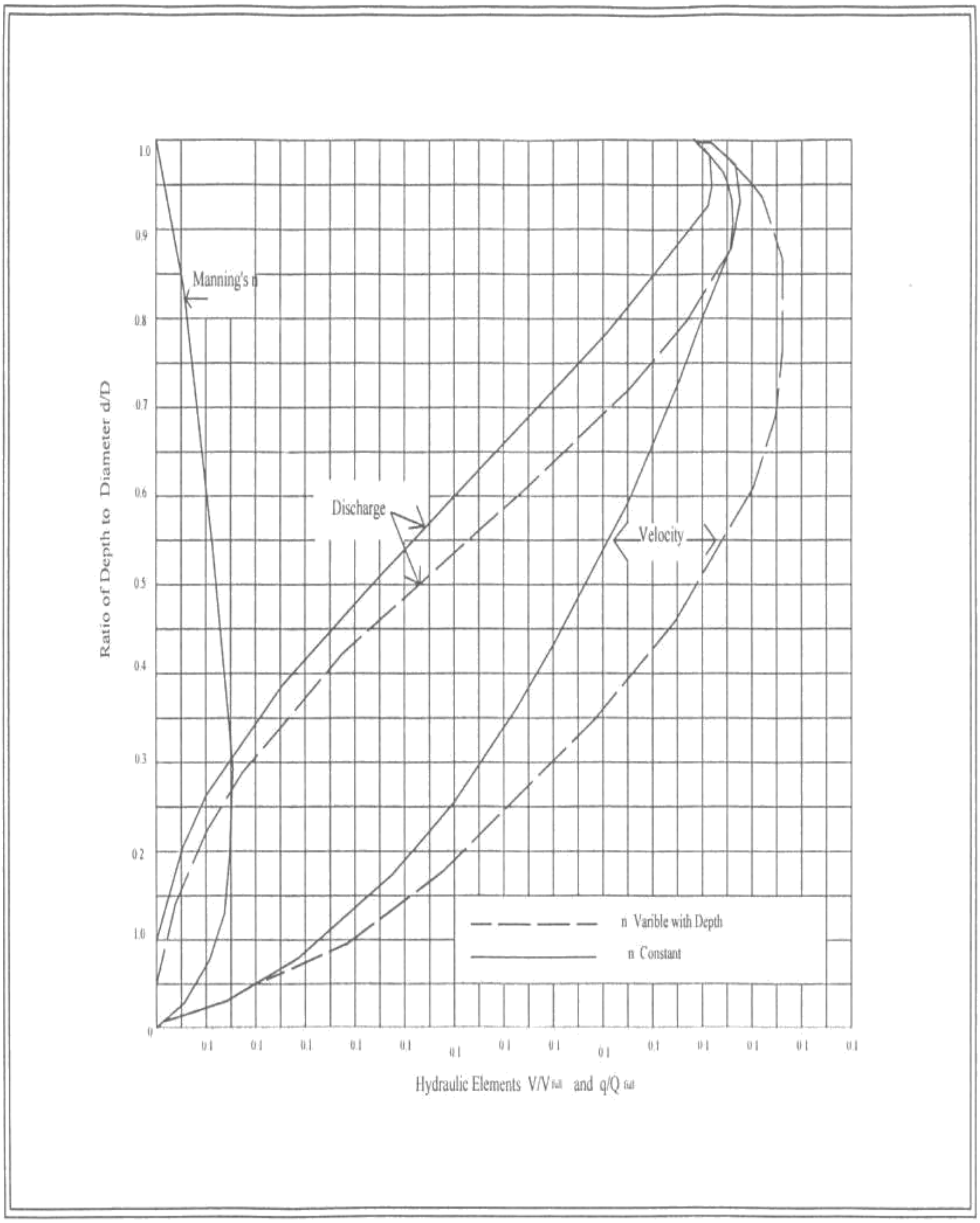


Figure 3.1: Diagram for Solution of the Manning Formula



Fig, 3.2: Hydraulic Properties of Circular Sewer

3.4.5 Design Computations

After the preliminary sewer layout plan is prepared, the design computations are accomplished. Design computations for sewers are repetitious and therefore, are best performed in a tabular format.

3.4.6 Preparation of maps and profile

It is important that the detailed drawings be prepared and specifications completed before the bid can be requested. The contract drawings should show (1) surface features, (2) depth and character of material to be excavated, (3) the existing structures that are likely to be encountered, and (4) the details of sewer and appurtenances to be constructed.

The specifications should be prepared by writing clearly and completely all work requirements and conditions affecting the contracts. As an example, technical specifications should cover items such as site preparation, excavation and backfill, concrete work, sewer materials and pipe lying, and acceptance tests (Qasim, 1985).

3.5 Summary

In this chapter, municipal storm water drainage systems in general have been described. The method of calculating the storm water runoff has been presented. The flow equations of sewer pipes and channels have been brought out. Finally the design and construction of community storm water drainage system has been briefly discussed.

CHAPTER FOUR

"ANALYSIS AND DESIGN"

4.1 General

In this project, design of stormwater drainage system for Nuba Town is made, and develop a future plans for construction of the drainage system, corresponding to the vision of Nuba municipality about their future plan, in order to reduce the problem causes by missing this important part.

In this section, the layout of the system established is presented, and the estimation of quantity of storm water procedures and tables are given along the drawings of layout, also the design calculation, drawing will shown in this chapter.

4.2 Layout of the System

The first step in designing a storm water drainage system is to establish an overall system layout that includes a plan of the area, showing roads, streets, buildings, other utilities, topography.

In suggesting the layout of storm water drainage system for the Nuba, the following basic steps were followed:

1. Obtain a topographic map of the area to be served.
2. Visit the location.
3. Locate the catchment of the site and determine the area of this catchment.
4. Sketch in pipe system to serve the area.
5. Pipes are located so that the main sterrts can be easly served.
6. Sewer layout is followed natural drainage ways so as to minimize.
7. Establish preliminary pipe diameter that can drain the required water runoff.
8. Revise the layout so as to optimize flow-carrying capacity at minimum cost.

Note that: To determine the catchment area and to determine the flow direction we must use maps prepared in Ch2, these maps are topographic map, Flow accumulation, and use Contour map (Fig 4.1) in this chapter.

The final layout of stormwater drainage system for Nuba town is illustrated in the (Fig 4.2) and (Fig 4.3).

4.3 Quantity of StormWater

After preparing the layout of stormwater drainage system the quality of stormwater that the system must carry it will be calculated using the data collected about the area.

Example:

Design a gravity flow stormwater drainage pipe for the area of Nuba town use line main A,B,C as an example this is line shown in (Fig 4.4) , (Fig 4.5) and (Fig 4.6). Assume that the following design criteria have been developed and adopted based on an analysis of local conditions and codes.

1. For weighted Runoff coefficient (C) uses 0.6
2. For Inlet time (t_i) use 7 minutes
3. For Concentration time (t_c) use equations:

$$t_c = t_i + t_f \tag{3.3}$$

4. For Runoff rate depending on the formula:

$$Q = C.i.A \tag{3.1}$$

5. For Rainfall intensity use (Fig 4.7).

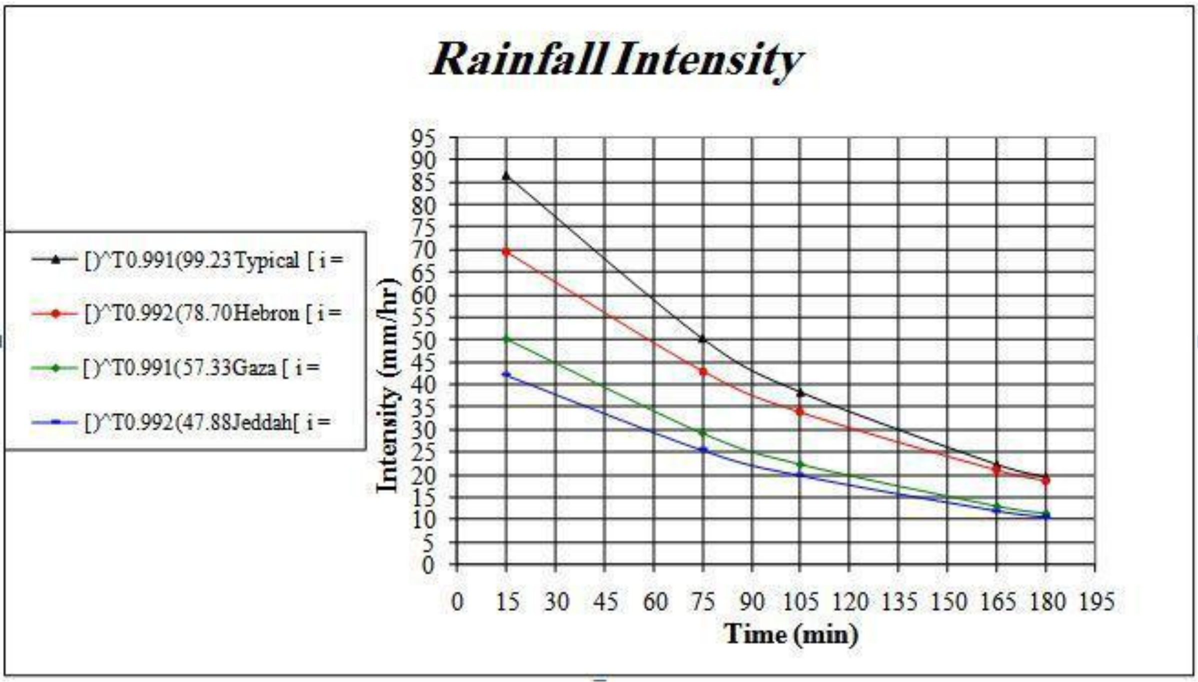


Fig (4.7): The Rainfall Intensity-Duration Curve For Several Areas

Solution:

a. Layout the storm water sewer. Draw a line to represent the proposed sewer.

b. Locate and number the upper and lower points of the line A , B and C.

c. The necessary computations for the storm water sewer presented in the table(4.1) for line A ,table (4.2) for line B and table (4.3) for line C. The data in the table are calculated as follow:

1. The entries in columns 1 through 6 are used to identify the point locations, their numbers and the length between them.

2. The entries in columns 7 used to identify the sewer area; column 7 shows the partial sewered area in hectare.

3. The entries in columns 8 through 14 are used to calculate the design flow. Runoff coefficient (C) is entered in column 8. The partial sewered area in hectare is multiplied by runoff coefficient (C) and the result is given in column 9. The cumulative multiplication of the sewered area in hectare is multiplied by runoff coefficient (C) are given in column 10. The concentration time is shown in column 11 and rainfall intensity (L/s.ha) is shown in column 12. Column 14 shows the quantity of storm water separately between two inlets.

Table (4.1) Computation Table for Line A

StormWater Design Computations

Line A

NUMBER	LOCATION			LENGTH	LENGTH COMULATIVE	AREA of Street	C FACTOR Street	C.A STREET	SUM(AC) COMULATIVE	Tc	(i)	Q	Qi
	LINE NAME	UPPER MH. NO.	LOWER MH. NO.	(m)	(m)	(ha)		(ha)	(ha)	(min)	(l/s.ha)	(l/s)	(l/s)
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	A P1	1	2	115	115	4.761	0.600	2.856	2.856	9.130	73.135	125.341	125.341
2	A P2	2	3	120	235	3.209	0.600	1.925	4.782	11.352	71.842	206.112	80.772
3	A P3	3	4	30	265	0.476	0.600	0.286	5.067	11.907	71.522	217.458	11.346
4	A P4	4	5	50	315	0.512	0.600	0.307	5.375	12.833	70.992	228.932	11.474
5	A P5	5	6	40	355	0.362	0.600	0.217	5.592	13.574	70.571	236.773	7.841
6	A P6	6	7	95	450	0.805	0.600	0.483	6.075	15.333	69.580	253.626	16.852
7	A P7	7	8	55	505	0.5408	0.600	0.324	6.400	16.352	69.014	264.995	11.370
8	A P8	8	9	140	645	1.4501	0.600	0.870	7.270	18.944	67.591	294.819	29.824
9	A P9	9	10	80	725	2.447	0.600	1.468	8.738	20.426	66.792	350.165	55.346
10	A P10	10	11	80	805	2.277	0.600	1.366	10.104	21.907	66.002	400.126	49.961
11	A P11	11	12	100	905	2.251	0.600	1.351	11.454	23.759	65.027	446.911	46.785
12	A P12	12	13	50	955	1.269	0.600	0.762	12.216	24.685	64.545	473.096	26.185
13	A P13	13	14	60	1015	1.400	0.600	0.840	13.056	25.796	63.972	501.123	28.027
14	A P14	14	15	50	1065	0.770	0.600	0.462	13.518	26.722	63.498	515.011	13.888
15	A P15	15	16	40	1105	0.633	0.600	0.380	13.897	27.463	63.121	526.329	11.318
16	A P16	16	17	108	1213	2.102	0.600	1.261	15.158	29.463	62.115	564.936	38.607
17	A P17	17	18	52	1265	0.869	0.600	0.521	15.680	30.426	61.637	579.859	14.923
18	A P18	18	19	55	1320	1.191	0.600	0.715	16.394	31.444	61.134	601.356	21.496
19	A P19	19	20	50	1370	1.020	0.600	0.612	17.006	32.370	60.681	619.180	17.824
20	A P20	20	21	45	1415	0.842	0.600	0.505	17.512	33.204	60.277	633.323	14.143
21	A P21	21	22	100	1515	2.761	0.600	1.657	19.168	35.056	59.387	683.000	49.677
22	A P22	22	23	50	1565	0.987	0.600	0.592	19.760	35.981	58.947	698.880	15.880
23	A P23	23	24	30	1595	0.665	0.600	0.399	20.159	36.537	58.684	709.826	10.946
24	A P24	24	25	60	1655	1.207	0.600	0.724	20.883	37.648	58.163	728.783	18.958
25	A P25	25	26	35	1690	0.531	0.600	0.319	21.202	38.296	57.861	736.060	7.276
26	A P26	26	27	65	1755	1.046	0.600	0.627	21.829	39.500	57.304	750.550	14.490
27	A P27	27	28	55	1810	0.313	0.600	0.188	22.017	40.519	56.837	750.847	0.297
28	A P28	28	29	40	1850	0.255	0.600	0.153	22.170	41.259	56.500	751.576	0.729
29	A P29	29	30	68	1918	0.602	0.600	0.361	22.531	42.519	55.931	756.126	4.550

Table (4.2) Computation Table for Line B

StormWater Design Computations													
Line B													
NUMBER	LOCATION			LENGTH	LENGTH COMULATIVE	AREA of Street	C FACTOR Street	C.A STREET	SUM(AC) COMULATIVE	Tc	(i)	Q	Qi
	LINE NAME	UPPER MH. NO.	LOWER MH. NO.	(m)	(m)	(ha)		(ha)	(ha)	(min)	(l/s.ha)	(l/s)	(l/s)
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	B P1	1	2	115	115.000	1.631	0.600	0.979	0.979	9.130	73.135	42.940	42.940
2	B P2	2	3	40	155.000	9.4450	0.600	5.667	6.646	9.870	72.702	289.885	246.945
3	B P3	3	4	138.73	293.730	5.2078	0.600	3.125	9.770	12.439	71.217	417.482	127.597
4	B P4	4	5	30.366	324.096	1.5055	0.600	0.903	10.674	13.002	70.896	454.024	36.543
5	B P5	5	6	32.17	356.266	0.5598	0.600	0.336	11.009	13.598	70.557	466.076	12.052
6	B P6	6	7	38.89	395.156	1.9199	0.600	1.152	12.161	14.318	70.150	511.873	45.797
7	B P7	7	8	30	425.156	1.2081	0.600	0.725	12.886	14.873	69.838	539.968	28.095
8	B P8	8	9	33.08	458.236	0.1227	0.600	0.074	12.960	15.486	69.495	540.387	0.419
9	B P9	9	10	80.07	538.306	0.26	0.600	0.156	13.116	16.969	68.672	540.417	0.030
10	B P10	10	11	108	646.306	1.3759	0.600	0.826	13.941	18.969	67.578	565.278	76.493
11	B P11	11	12	65	711.306	0.719	0.600	0.431	14.373	20.172	66.928	577.163	11.885
12	B P12	12	13	65	776.306	0.932	0.600	0.559	14.932	21.376	66.284	593.849	16.686
13	B P13	13	14	95	871.306	1.2867	0.600	0.772	15.704	23.135	65.354	615.789	21.940
14	B P14	14	15	78	949.306	0.8356	0.600	0.501	16.205	24.580	64.600	628.119	12.330
15	B P15	15	16	46	995.306	0.48	0.600	0.288	16.493	25.432	64.160	634.923	6.804
16	B P16	16	17	58	1053.306	0.3714	0.600	0.223	16.716	26.506	63.608	637.973	3.051

Table (4.3) Computation Table for Line C

StormWater Design Computations

Line C

NUMBER	LOCATION: LINE NAME	LOCATION: UPPER MH. NO.	LOCATION: LOWER MH. NO.	LENGTH (m)	LENGTH COMULATIVE (m)	AREA of Street (ha)	C FACTOR Street	C.A STREET (ha)	SUM(AC) COMULATIVE (ha)	Tc (min)	(i) (l/s.ha)	Q (l/s)	Qi (l/s)
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	B P1	1	2	79	79.000	0.5132	0.600	0.308	0.308	8.463	73.528	13.584	13.584
2	B P2	2	3	40	119.000	0.2038	0.600	0.122	0.430	9.204	73.092	18.866	5.282
3	B P3	3	4	40	159.000	0.2157	0.600	0.129	0.560	9.944	72.658	24.397	5.530
4	B P4	4	5	45	204.000	0.2032	0.600	0.122	0.682	10.778	72.174	29.514	5.117
5	B P5	5	6	38	242.000	0.1227	0.600	0.074	0.755	11.481	71.767	32.517	3.004
6	B P6	6	7	37	279.000	0.2898	0.600	0.174	0.929	12.167	71.373	39.785	7.268
7	B P7	7	8	70	349.000	0.4821	0.600	0.289	1.218	13.463	70.634	51.632	11.847

4.4 Storm CAD Program Works:

a. Open Storm CAD, select file → import →DXF Background to import the DXF file, Fig (4.8) below shows this step.

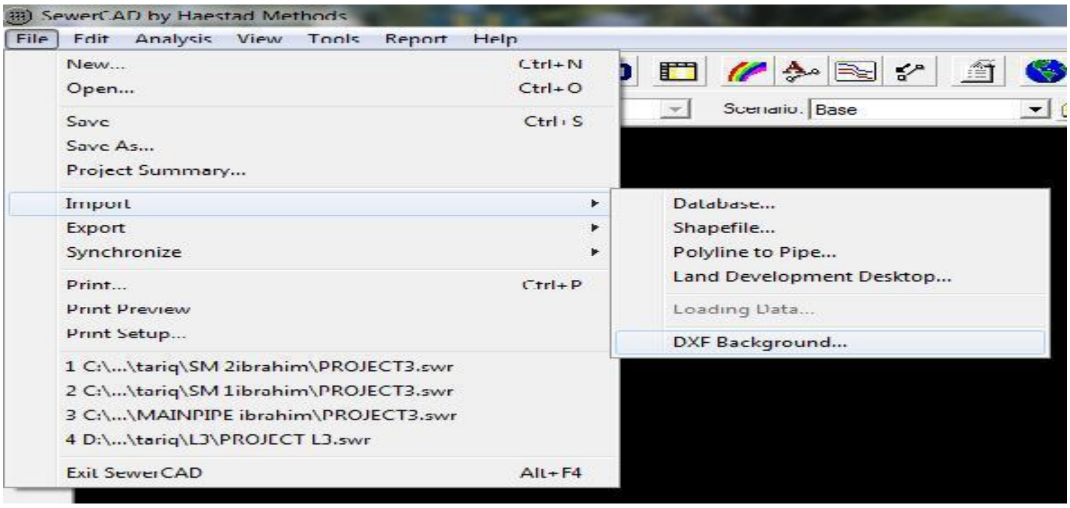


Fig (4.8)

b. Specify file location is then press open, Fig (4.9) below shows this step. And Fig (4.10) shows main line C.

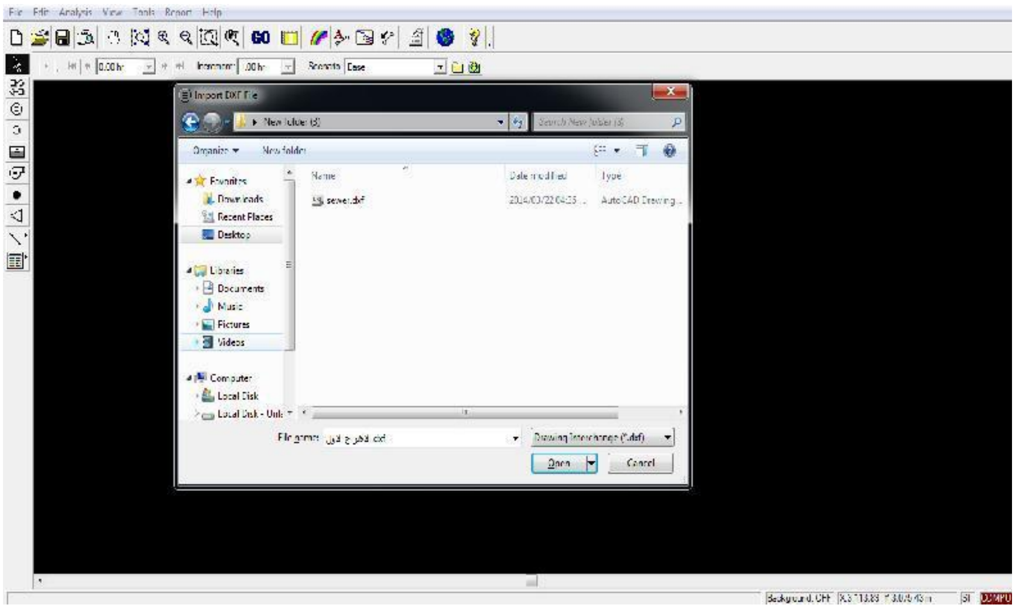


Fig (4.9)

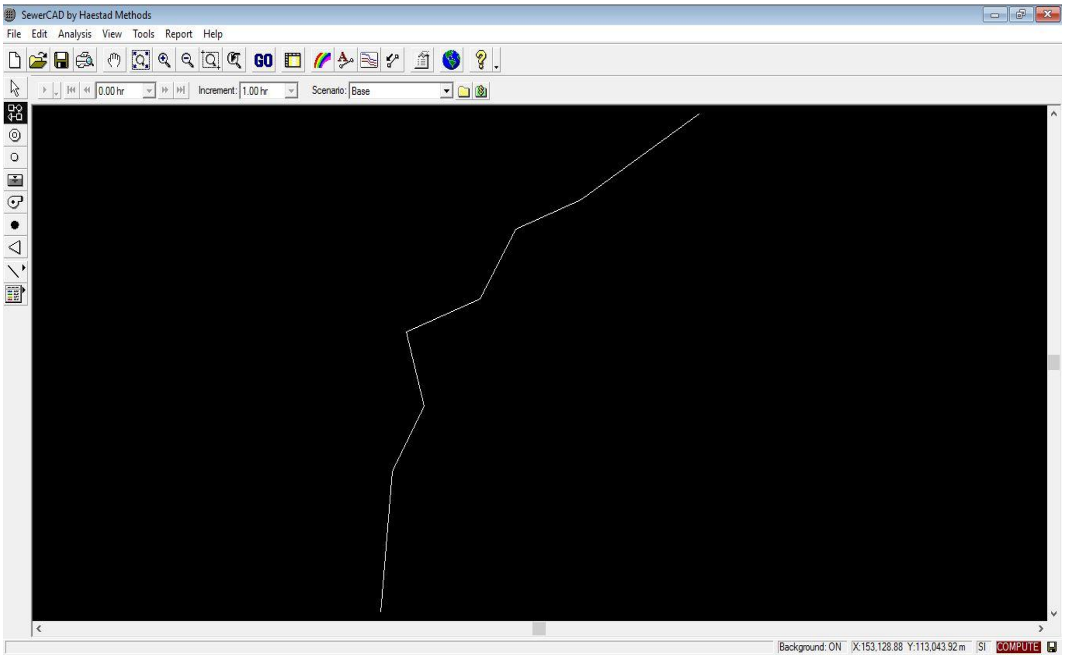


Fig (4.10)

c. Press pipe icon, a massage will appear tell you to create a project see Fig (4.11).

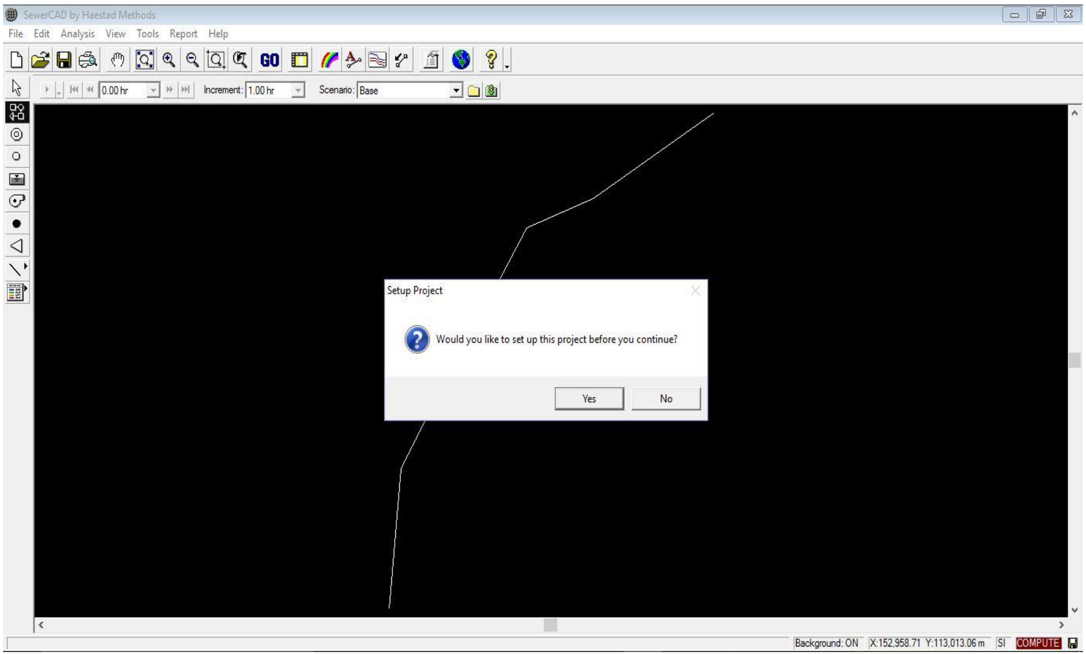


Fig (4.11)

d. Press yes and define the project then press next twice, then select finish, the Fig (4.12) below show this step.

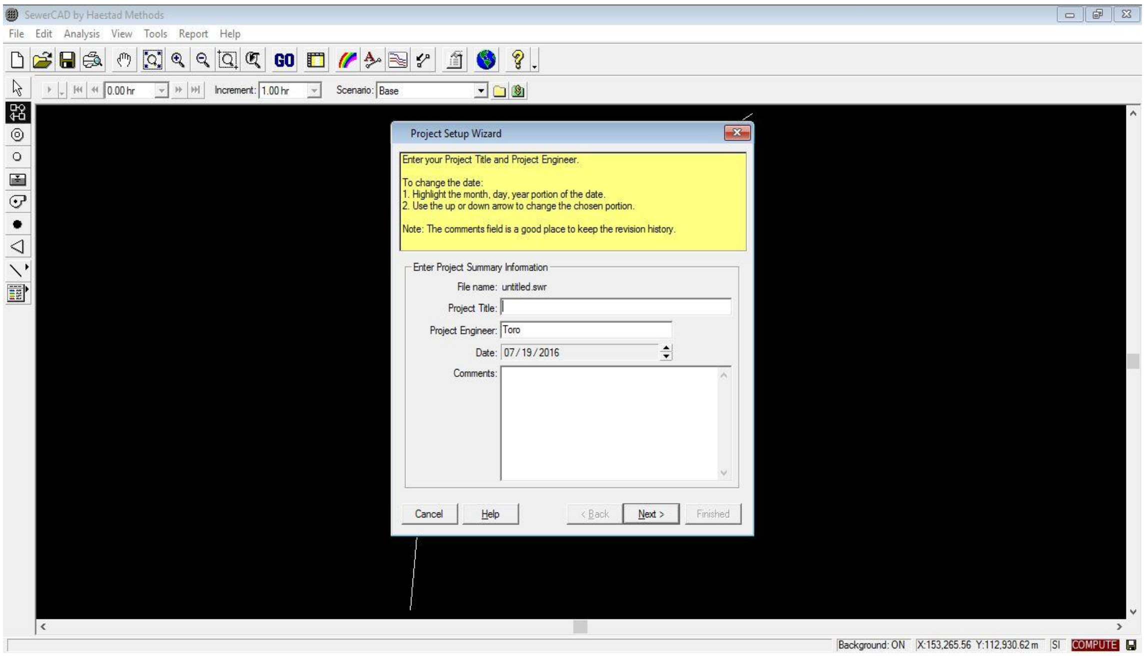


Fig (4.12)

e. Press pipe icon and connect between inlets, Fig (4.13) below shows the step.

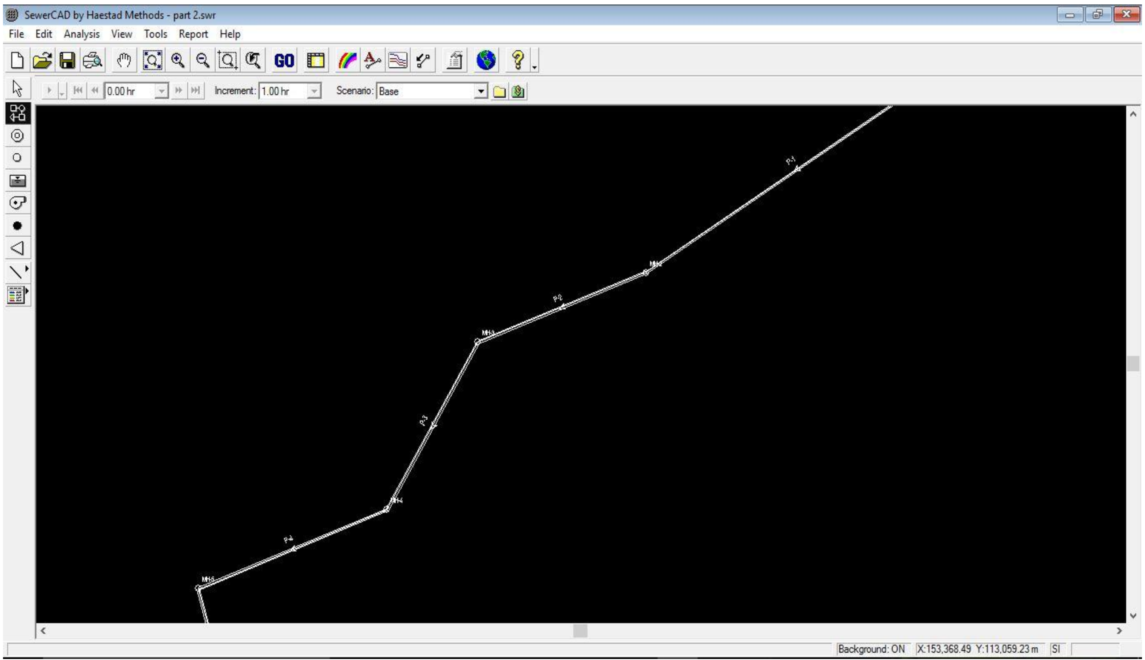


Fig (4.13)

f. After you connect between all inlets, press on the out let icon and click on the last inlet, then press yes to replace the inlet with outlet, the Fig (4.14) below shows the step.

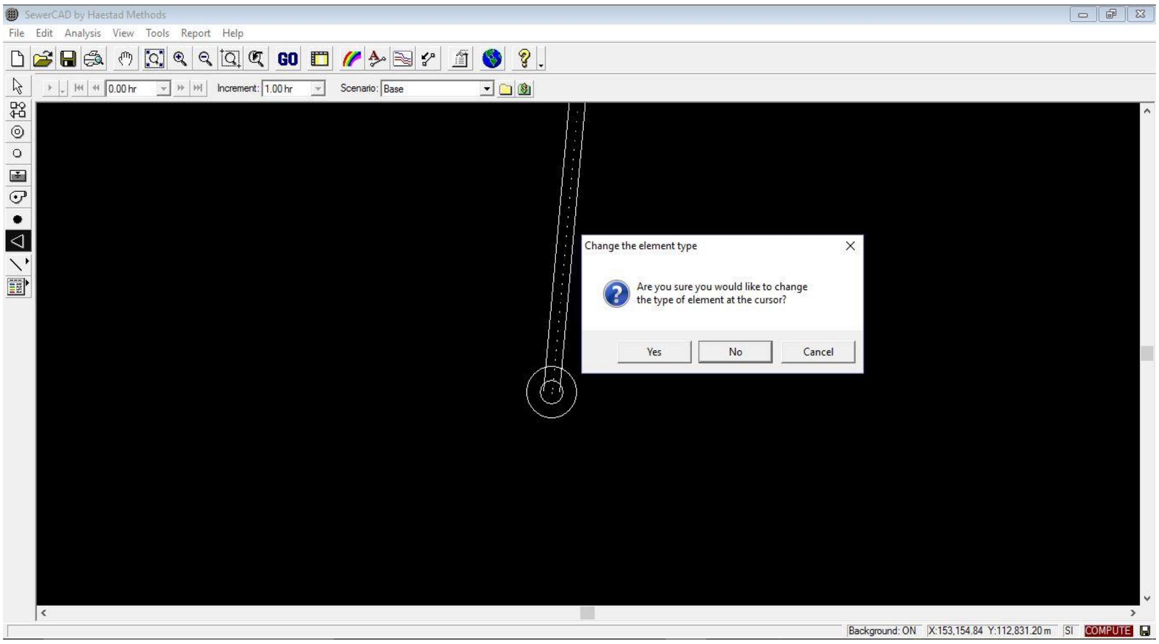


Fig (4.14)

g. Save your project, then select analysis → alternatives → physical properties → edit, then start editing gravity pipe, see Fig (4.15).

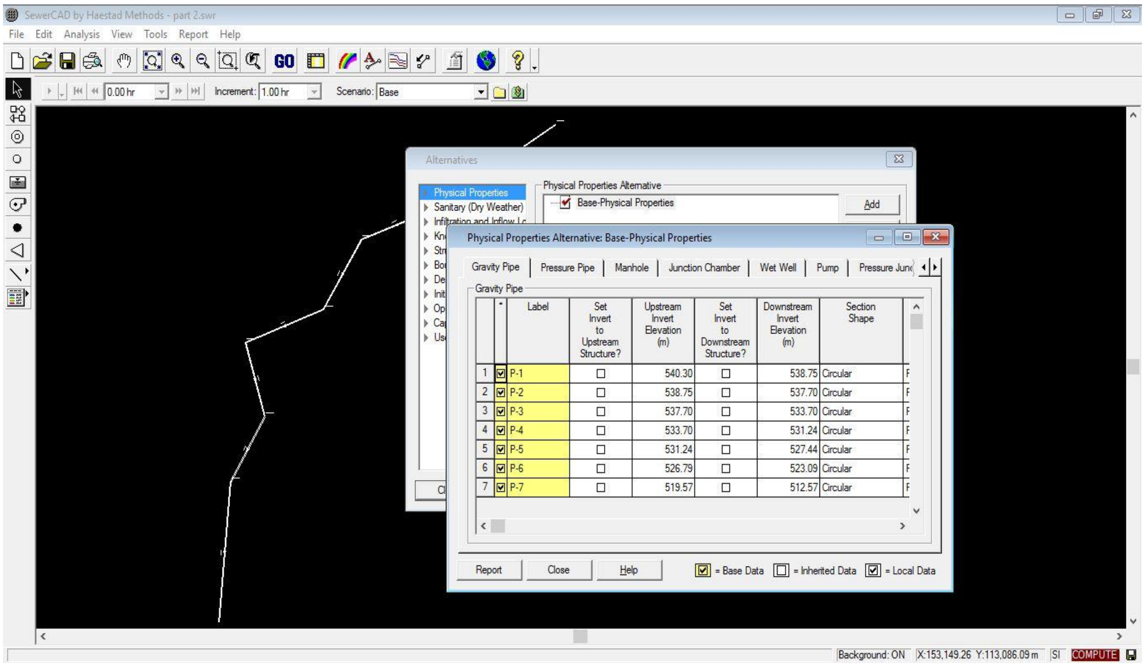


Fig (4.15)

h. Select inlet to enter the ground elevations of inlets, then select out let to enter its elevation. Then press close. Fig (4.16) below shows the step.

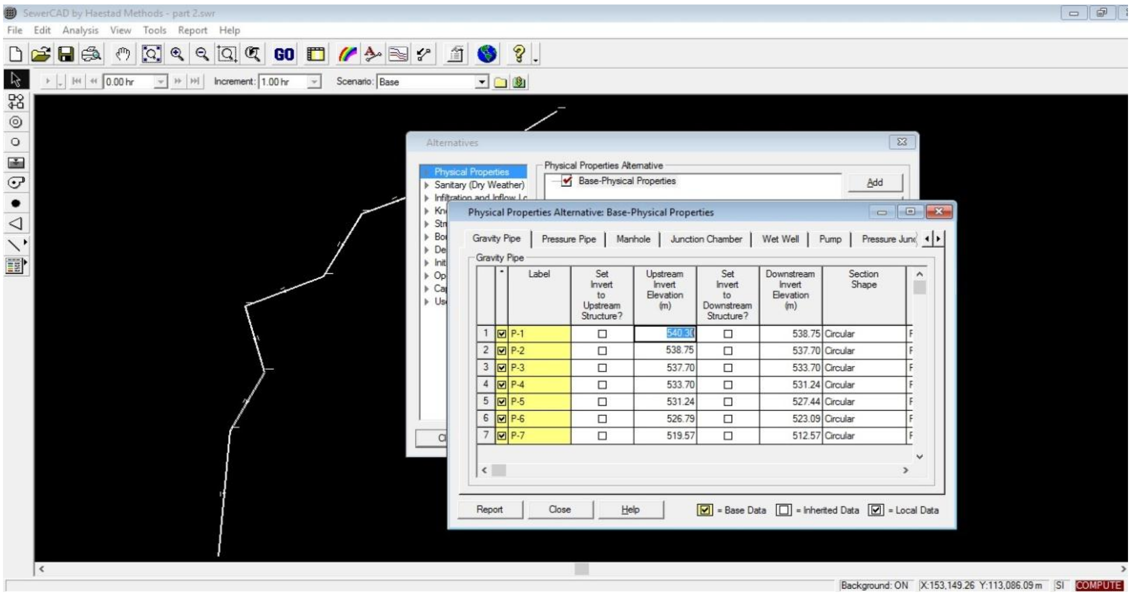


Fig (4.16)

i. Select sanitary (dry weather) → edit → manhole to select the type of load and to enter the load for each inlet, Fig (4.17) below shows the step.

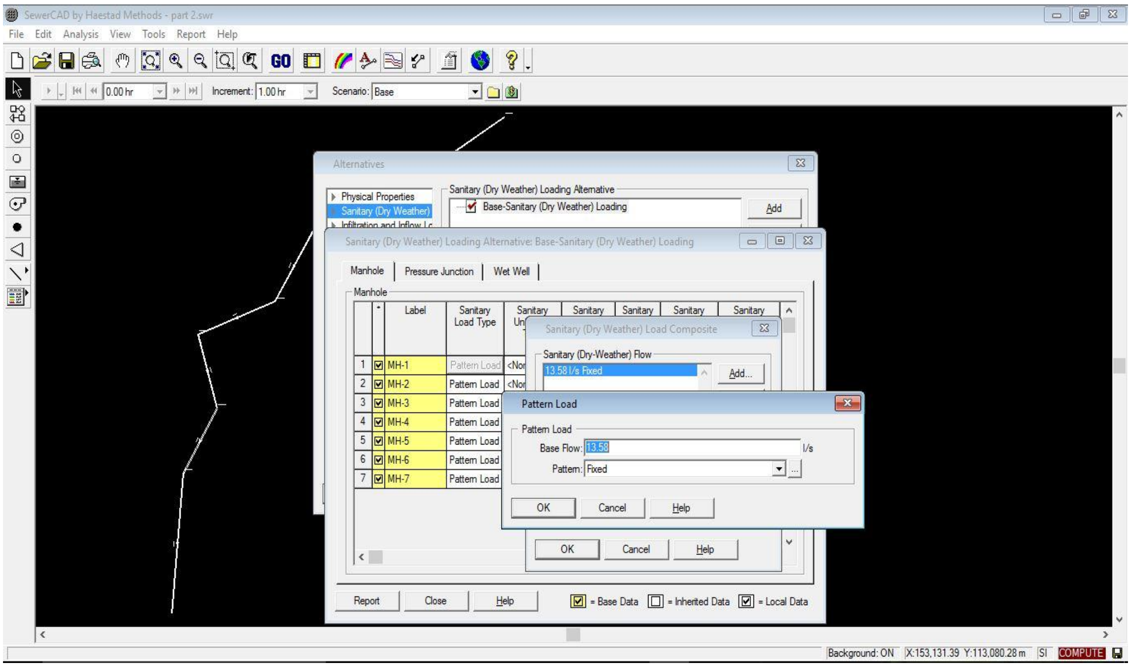


Fig (4.17)

j. After doing this for each inlet press close, then select design constrains → edit to enter the design specifications, Fig(4.18) below shows the step.

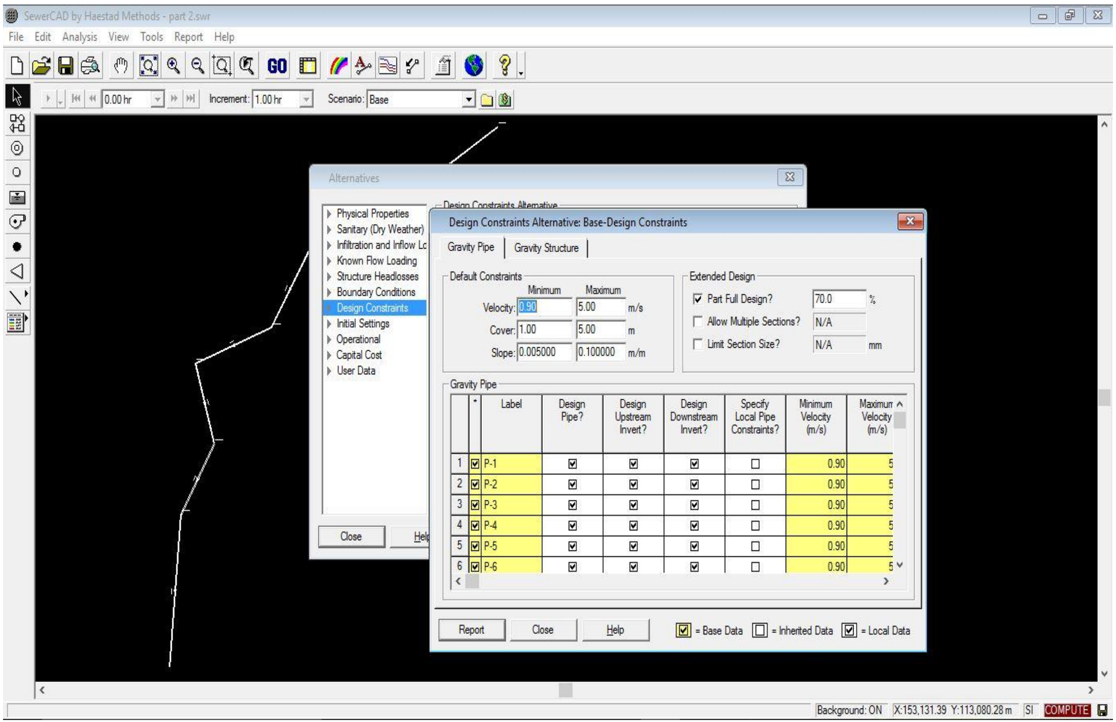


Fig (4.18)

k. Last step press save, press GO button to start design then press on GO, Fig (4.19) below shows the step.

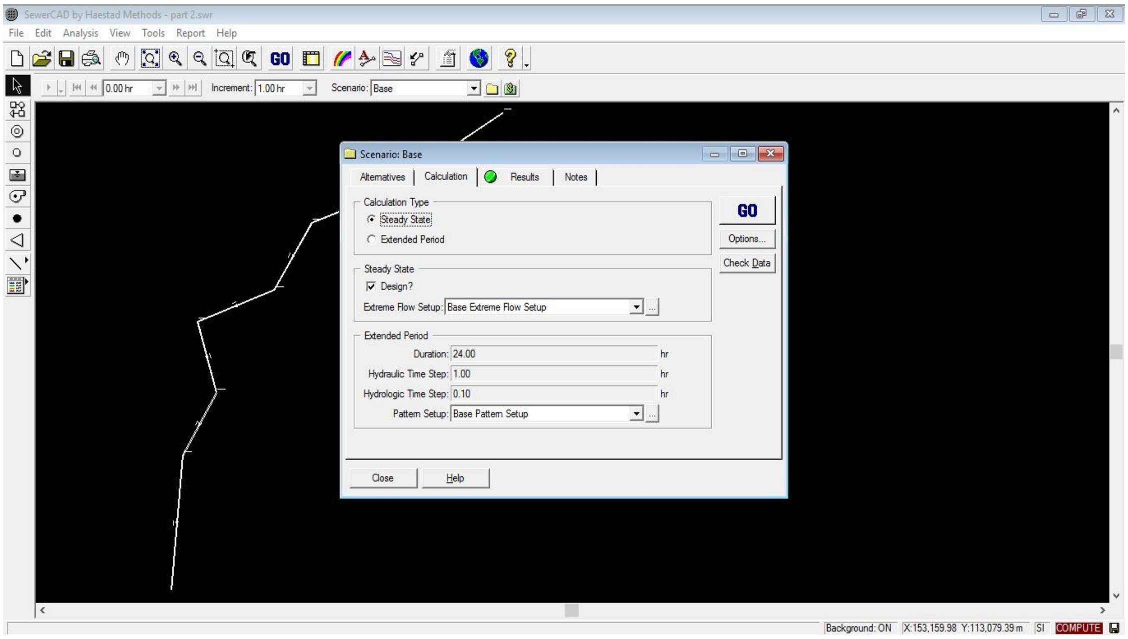


Fig (4.19)

NOTE: If you have green light that mean there is no problems in the design work, but if you have yellow or red light that's mean there is problem, read the massages and fix these problems.

m. After finishing design work we need to show the pipe line profile and the profile, gravity pipe report and manhole report. Press profile button to make the profile see Fig (4.20), here we should put the scale of the profile. The profiles for this project are attached in appendix C. We can get the required tables by pressing tabular report button see Fig (4.21), and then choose gravity pipe report and manhole report. The required reports for this project are attached in appendix C.

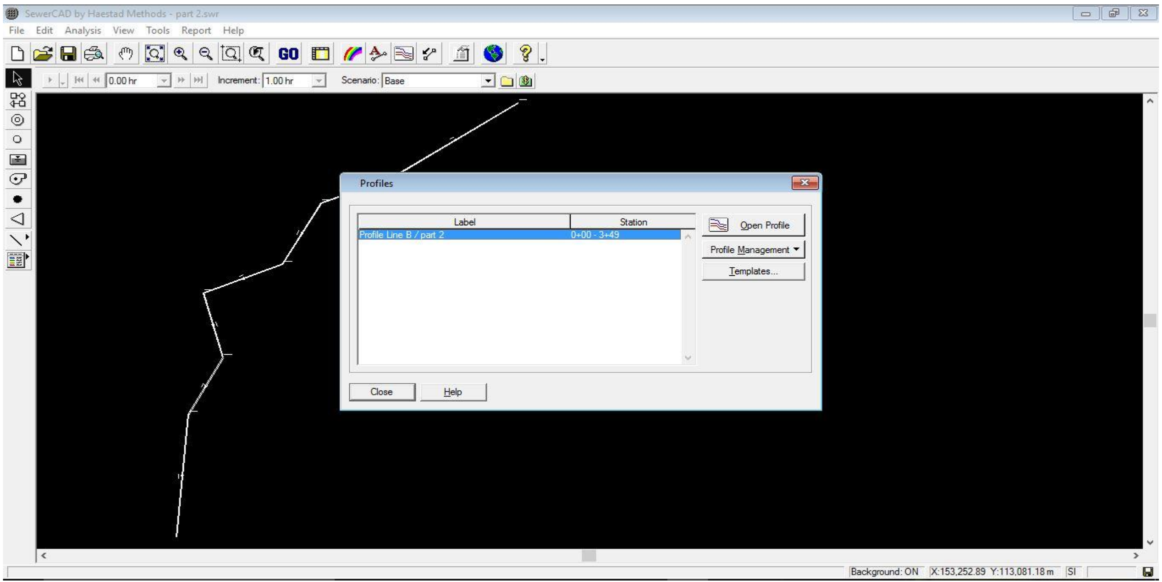


Fig (4.20)

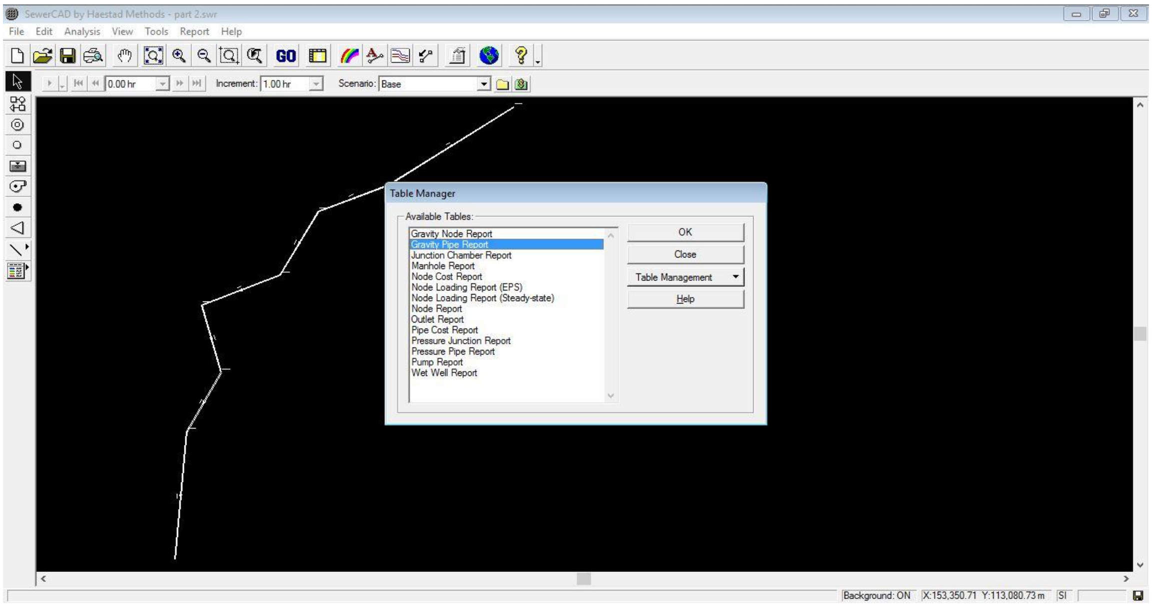


Fig (4.21)

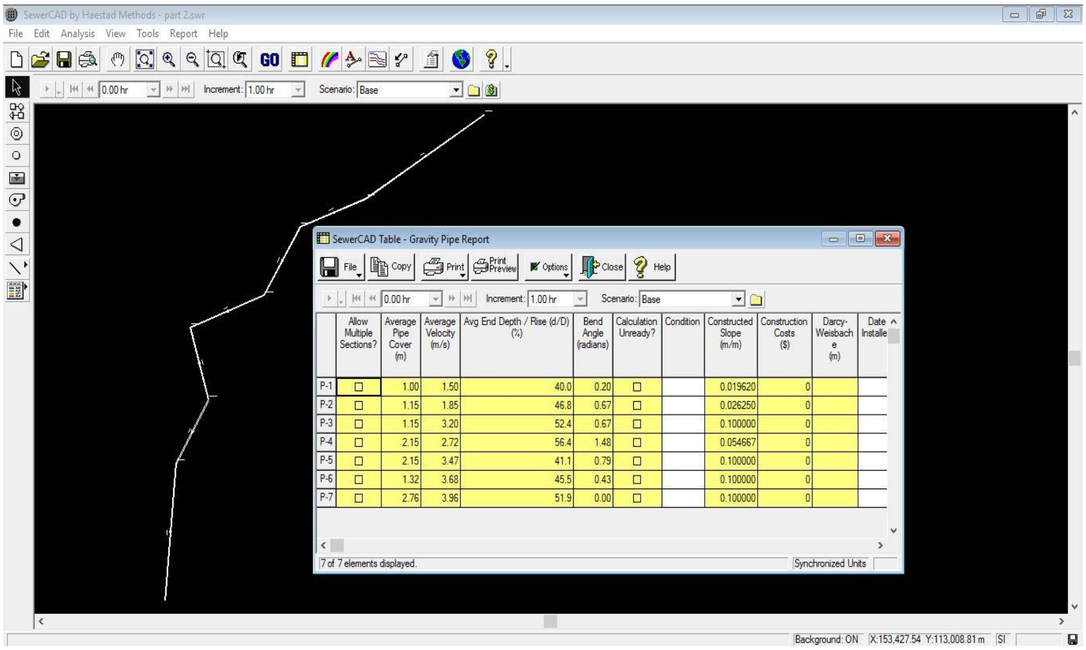


Fig (4.22) Example of Storm Water Table

The following tables are calculated by the software Storm CAD, they shows the following data:

1- Manhole report table, contain :
   - Label.
   - Ground elevation.
   - Rim elevation.
   - Sump elevation.
   - Manhole diameter.
   - Manhole depth.

2- Pipe report table, contain:
   - Label.
   - Upstream Manhole.
   - Downstream Manhole.
   - Length.
   - Total flow.
   - Section shape.
   - Average velocity.

- Average pipe cover.
- Slope.

Table (4.2) showing an example on storm water design report.

All profiles for all lines with sufficient data prepared by the software Storm CAD, this is shown in Fig (4.23).

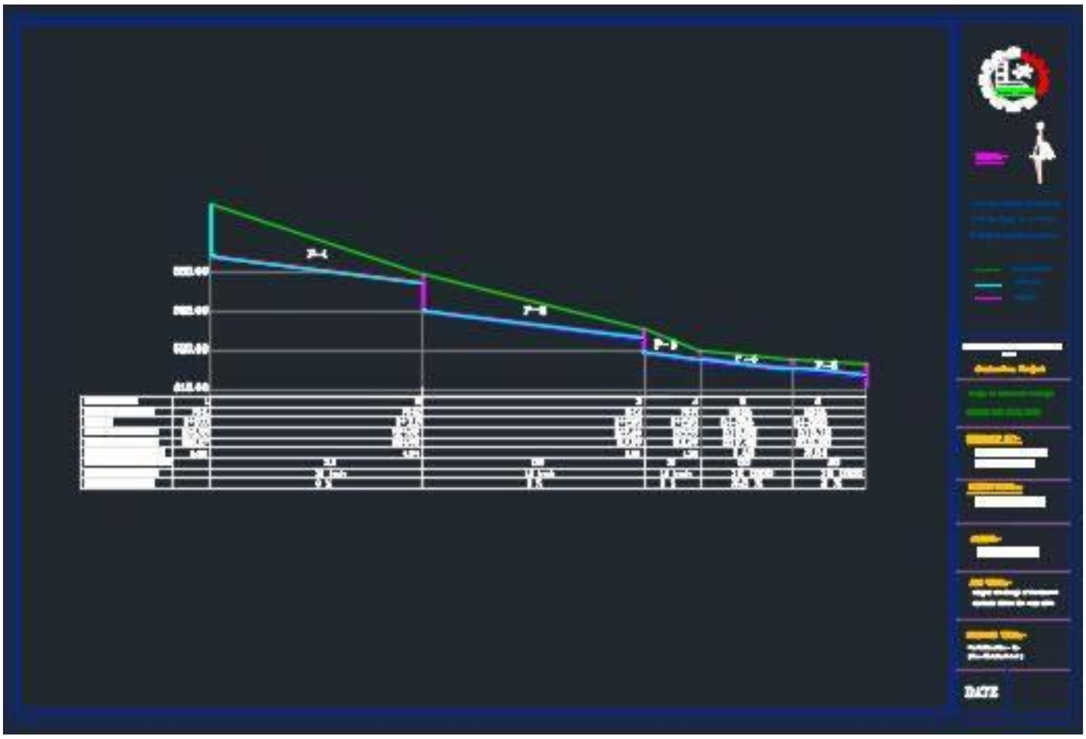


Fig (4.23) Example of storm water profile

Table(4.4) Storm Water Design Report For main Line C

Manhole Report					
Label	Ground Elevation (m)	Rim Elevation (m)	Sump Elevation (m)	Manhole Diameter (m)	Manhole Depth (m)
MH-1	541.55	451.55	540.30	1.20	1.20
MH-2	540.00	540.00	538.75	1.20	1.25
MH-3	539.26	539.26	537.70	1.20	1.56
MH-4	534.95	534.95	533.70	1.20	1.25
MH-5	534.79	534.79	531.24	1.20	3.55
MH-6	528.69	528.69	526.79	1.20	1.9
MH-7	524.34	524.34	519.57	1.20	4.77
MH-8	513.82	513.82	512.57	1.20	1.25

Pipe Report									
Label	Upstream Manhole	Downstream Manhole	Length (m)	Total Flow (l/s)	Section Shape	Section Size (mm)	Average Velocity (m/s)	Average Pipe cover (m)	Slope (%)
P-1	MH-1	MH-2	79	13.584	Circular	250	1.50	1.00	1.96
P-2	MH-2	MH-3	40	18.866	Circular	250	1.85	1.15	2.63
P-3	MH-3	MH-4	40	24.397	Circular	250	3.20	1.15	10
P-4	MH-4	MH-5	45	29.514	Circular	250	2.72	2.15	5.47
P-5	MH-5	MH-6	38	32.517	Circular	250	3.47	2.15	10
P-6	MH-6	MH-7	37	39.785	Circular	250	3.68	1.32	10
P-7	MH-7	MH-8	70	51.632	Circular	250	3.96	2.76	10

CHAPTER FIVE

"BILL OF QUANTIT"

5.1 Bill Of Quantity For The Proposed Stormwater Collection System:

No.	EXCAVATION	UNIT	QTY	UNIT PRICE		TOTAL PRICE	
				$	C	$	C
A1	Excavation of pipes trench in all kind of soil for one pipe diameter 250 mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	464				
A2	Excavation of pipes trench in all kind of soil for one pipe diameter 300 mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	315				
A3	Excavation of pipes trench in all kind of soil for one pipe diameter 450 mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	651.5				

A3	Excavation of pipes trench in all kind of soil for one pipe diameter 600 mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	1193				
A3	Excavation of pipes trench in all kind of soil for one pipe diameter 750 mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	515				
Sub-Total							
B	**PIPE WORK**						
B1	Supplying, storing and installing of uPVC	LM	3138.5				
Sub-Total							
C	**PIPE BEDDING AND BACKFILLING** **Dimension and material**						
C1	Supplying and embedment of sand for one pipe diameter 250 mm depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	464				

C2	Supplying and embedment of sand for one pipe diameter 300 mm depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	315				
C3	Supplying and embedment of sand for one pipe diameter 450 mm depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	651.5				
C3	Supplying and embedment of sand for one pipe diameter 600 mm depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	1193				
C3	Supplying and embedment of sand for one pipe diameter 750 mm depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	515				

Sub-Total							
D	**MANHOLES, Details according to the drawing**						
D1	Supplying and installing of precasted manhole including excavation pipe connection, epoxytar coating, 25-ton cast iron cover and backfill, size 1200mm, depth up to 1.00m.	NR	55				
Sub-Total							
E	**Concrete Surround**						
E1	Suppying and installing of reinforced concrete (B 200) protection concrete encasement for sewer pipe.	LM	3138.5				
Sub-Total							
F	**Air And Water Leakage Test**						
F1	Air leakage test for sewer pipe lines 250,300,450,600 and 750 mm according tospecifications, including for all temporary works.	LM	3138.5				
F2	Water leakage tests for manholes, depth up to 1.00 meter according to specifications.	NR	55				

Sub-Total							
G	**Survey work**						
G1	Topographical survey required for shop drawings and as built DWGS using absoluet Elev. And coordinate system	LM	3138.5				

CHAPTER SIX

"CONCLUSION"

6.1 Conclusion

In this project, the trial is made to design storm water drainage system for Nuba town, considering the water runoff, the wide expansion, accelerated development and growth of the town. The result brought out many important conclusions. The main conclusions draw from the present study are summarized below:

1- Most of the areas in Nuba town do not have a natural drainage system. Heavy rainfall causes storm water to collect in low areas and flood streets and walk ways.

2- The accumulation of storm water in the main streets in Nuba town causes problems to the peoples, subsequently there is a big need for immediate steps for construction of the proposed storm water drainage system for the Nuba town.

3- The flow in the proposed storm water drainage system is going by gravity, hence, the topographical features of the area are allowed.

4- - The range of sewer diameters is lying from 250mm-750mm.

5- The max velocity in the pipe does not exceed 5m/s in the pipes.

6- The max cover in all sewers was 10 m where the min was 1m.

7- This design is based on the rational method which is the most popular in calculating the quantity of storm water and it also based on manning equation in the design calculation.

6.2 References

1- Al-Zogheir, M and Al-Joulani, R (2012), "Design of Storm water drainage system for the center of Halhul City", Palestine Polytechnic University, Hebron, Palestine.

2- Ad Dabbagh, "Biladuna Filisteen Mustafa Murad dabbagh", Dar Al-Huda, Haifa, Palestine.

3- Nuba Municipality, Hebron, West Bank, Palestine.

4- palestine ministry of agriculture, Ramallah, Palestine.

5- Sarikaya, H, (1984), "Sanitary Engineering", Civil Engineering Department, Jeddah.

6- "Palestinian Localities Study" , " Nuba Village Profile", The Applied Research Institute, Jerusalem, Palestine.

7- Qasim Sayed R. (1985), "Waste Water treatment plants planning, Design, and operation".

8- Viess man, Warren .JR. And Hammer, Mark J. (1985), “Water Supply and Pollution Control", Fourth Edition, Harper and Row, Publishers, Inc., New Yourk, U.S.A.

APPENDIX-A

CALCULATIONS TABLES FOR

STORM DRAINAGE

StormWater Design Computations

Line A

NUMBER	LOCATION			LENGTH	LENGTH COMULATIVE	AREA of Street							
	LINE NAME	UPPER MH. NO.	LOWER MH. NO.				C FACTOR Street	C.A STREET	SUM(AC) COMULATIVE	Tc	(i)	Q	Qi
				(m)	(m)	(ha)		(ha)	(ha)	(min)	(l/s.ha)	(l/s)	(l/s)
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	A P1	1	2	115	115	4.761	0.600	2.856	2.856	9.130	73.135	125.341	125.341
2	A P2	2	3	120	235	3.209	0.600	1.925	4.782	11.352	71.842	206.112	80.772
3	A P3	3	4	30	265	0.476	0.600	0.286	5.067	11.907	71.522	217.458	11.346
4	A P4	4	5	50	315	0.512	0.600	0.307	5.375	12.833	70.992	228.932	11.474
5	A P5	5	6	40	355	0.362	0.600	0.217	5.592	13.574	70.571	236.773	7.841
6	A P6	6	7	95	450	0.805	0.600	0.483	6.075	15.333	69.580	253.626	16.852
7	A P7	7	8	55	505	0.5408	0.600	0.324	6.400	16.352	69.014	264.995	11.370
8	A P8	8	9	140	645	1.4501	0.600	0.870	7.270	18.944	67.591	294.819	29.824
9	A P9	9	10	80	725	2.447	0.600	1.468	8.738	20.426	66.792	350.165	55.346
10	A P10	10	11	80	805	2.277	0.600	1.366	10.104	21.907	66.002	400.126	49.961
11	A P11	11	12	100	905	2.251	0.600	1.351	11.454	23.759	65.027	446.911	46.785
12	A P12	12	13	50	955	1.269	0.600	0.762	12.216	24.685	64.545	473.096	26.185
13	A P13	13	14	60	1015	1.400	0.600	0.840	13.056	25.796	63.972	501.123	28.027
14	A P14	14	15	50	1065	0.770	0.600	0.462	13.518	26.722	63.498	515.011	13.888
15	A P15	15	16	40	1105	0.633	0.600	0.380	13.897	27.463	63.121	526.329	11.318
16	A P16	16	17	108	1213	2.102	0.600	1.261	15.158	29.463	62.115	564.936	38.607
17	A P17	17	18	52	1265	0.869	0.600	0.521	15.680	30.426	61.637	579.859	14.923
18	A P18	18	19	55	1320	1.191	0.600	0.715	16.394	31.444	61.134	601.356	21.496
19	A P19	19	20	50	1370	1.020	0.600	0.612	17.006	32.370	60.681	619.180	17.824
20	A P20	20	21	45	1415	0.842	0.600	0.505	17.512	33.204	60.277	633.323	14.143
21	A P21	21	22	100	1515	2.761	0.600	1.657	19.168	35.056	59.387	683.000	49.677
22	A P22	22	23	50	1565	0.987	0.600	0.592	19.760	35.981	58.947	698.880	15.880
23	A P23	23	24	30	1595	0.665	0.600	0.399	20.159	36.537	58.684	709.826	10.946
24	A P24	24	25	60	1655	1.207	0.600	0.724	20.883	37.648	58.163	728.783	18.958
25	A P25	25	26	35	1690	0.531	0.600	0.319	21.202	38.296	57.861	736.060	7.276
26	A P26	26	27	65	1755	1.046	0.600	0.627	21.829	39.500	57.304	750.550	14.490
27	A P27	27	28	55	1810	0.313	0.600	0.188	22.017	40.519	56.837	750.847	0.297
28	A P28	28	29	40	1850	0.255	0.600	0.153	22.170	41.259	56.500	751.576	0.729
29	A P29	29	30	68	1918	0.602	0.600	0.361	22.531	42.519	55.931	756.126	4.550

StormWater Design Computations

Line B

NUMBER	LOCATION			LENGTH	LENGTH COMULATIVE	AREA of Street							
	LINE NAME	UPPER MH. NO.	LOWER MH. NO.				FACTOR C Street	C.A STREET	SUM(AC) COMULATIVE	Tc	(i)	Q	Qi
				(m)	(m)	(ha)		(ha)	(ha)	(min)	(l/s.ha)	(l/s)	(l/s)
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	B P1	1	2	115	115.000	1.631	0.600	0.979	0.979	9.130	73.135	42.940	42.940
2	B P2	2	3	40	155.000	9.4450	0.600	5.667	6.646	9.870	72.702	289.885	246.945
3	B P3	3	4	138.73	293.730	5.2078	0.600	3.125	9.770	12.439	71.217	417.482	127.597
4	B P4	4	5	30.366	324.096	1.5055	0.600	0.903	10.674	13.002	70.896	454.024	36.543
5	B P5	5	6	32.17	356.266	0.5598	0.600	0.336	11.009	13.598	70.557	466.076	12.052
6	B P6	6	7	38.89	395.156	1.9199	0.600	1.152	12.161	14.318	70.150	511.873	45.797
7	B P7	7	8	30	425.156	1.2081	0.600	0.725	12.886	14.873	69.838	539.968	28.095
8	B P8	8	9	33.08	458.236	0.1227	0.600	0.074	12.960	15.486	69.495	540.387	0.419
9	B P9	9	10	80.07	538.306	0.26	0.600	0.156	13.116	16.969	68.672	540.417	0.030
10	B P10	10	11	108	646.306	1.3759	0.600	0.826	13.941	18.969	67.578	565.278	76.493
11	B P11	11	12	65	711.306	0.719	0.600	0.431	14.373	20.172	66.928	577.163	11.885
12	B P12	12	13	65	776.306	0.932	0.600	0.559	14.932	21.376	66.284	593.849	16.686
13	B P13	13	14	95	871.306	1.2867	0.600	0.772	15.704	23.135	65.354	615.789	21.940
14	B P14	14	15	78	949.306	0.8356	0.600	0.501	16.205	24.580	64.600	628.119	12.330
15	B P15	15	16	46	995.306	0.48	0.600	0.288	16.493	25.432	64.160	634.923	6.804
16	B P16	16	17	58	1053.306	0.3714	0.600	0.223	16.716	26.506	63.608	637.973	3.051

StormWater Design Computations

Line C

NUMBER	LOCATION: LINE NAME	UPPER MH. NO.	LOWER MH. NO.	LENGTH (m)	LENGTH COMULATIVE (m)	AREA of Street (ha)	C FACTOR Street	C.A STREET (ha)	SUM(AC) COMULATIVE (ha)	Tc (min)	(i) (l/s.ha)	Q (l/s)	Qi (l/s)
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	B P1	1	2	79	79.000	0.5132	0.600	0.308	0.308	8.463	73.528	13.584	13.584
2	B P2	2	3	40	119.000	0.2038	0.600	0.122	0.430	9.204	73.092	18.866	5.282
3	B P3	3	4	40	159.000	0.2157	0.600	0.129	0.560	9.944	72.658	24.397	5.530
4	B P4	4	5	45	204.000	0.2032	0.600	0.122	0.682	10.778	72.174	29.514	5.117
5	B P5	5	6	38	242.000	0.1227	0.600	0.074	0.755	11.481	71.767	32.517	3.004
6	B P6	6	7	37	279.000	0.2898	0.600	0.174	0.929	12.167	71.373	39.785	7.268
7	B P7	7	8	70	349.000	0.4821	0.600	0.289	1.218	13.463	70.634	51.632	11.847

APPENDIX-B

GRAVITY PIPE REPORTS AND MANHOLE REPORTS

FOR STORM DRAINAGE

Manhole Report For Line A					
Label	Ground Elevation (m)	Rim Elevation (m)	Sump Elevation (m)	Manhole Diameter (m)	Manhole Depth (m)
MH-1	538.95	538.95	532.07	1.2	6.88
MH-2	529.92	529.92	524.98	1.2	4.94
MH-3	522.68	522.68	519.59	1.2	3.09
MH-4	519.99	519.99	518.69	1.2	1.30
MH-5	518.88	518.88	517.42	1.2	1.46
MH-6	518.16	518.16	515.62	1.2	2.54
MH-7	514.23	514.23	512.66	1.2	1.57
MH-8	512.47	512.47	505.91	1.2	6.56
MH-9	503.17	503.17	498.12	1.2	5.05
MH-10	497.18	497.18	491.96	1.2	5.22
MH-11	491.17	491.17	487.56	1.2	3.61
MH-12	486.17	486.17	484.15	1.2	2.02
MH-13	484.26	484.26	481.50	1.2	2.76
MH-14	481.31	481.31	478.89	1.2	2.42
MH-15	479.00	479.00	475.44	1.2	3.56
MH-16	475.85	475.85	470.77	1.2	5.08
MH-17	469.14	469.14	467.15	1.2	1.99
MH-18	467.20	467.20	463.86	1.2	3.34
MH-19	463.82	463.82	459.84	1.2	3.98
MH-20	459.95	459.95	456.91	1.2	3.04
MH-21	457.17	457.17	452.42	1.2	4.75
MH-22	451.03	451.03	448.28	1.2	2.75
MH-23	448.39	448.39	446.03	1.2	2.36
MH-24	446.74	446.74	443.10	1.2	3.64
MH-25	442.91	442.91	438.92	1.2	3.99
MH-26	439.48	439.48	432.31	1.2	7.17
MH-27	431.97	431.97	428.34	1.2	3.63
MH-28	428.30	428.30	425.53	1.2	2.77
MH-29	425.94	425.94	422.77	1.2	3.17
O-1	422.34	422.34	420.73	1.2	1.61

Pipe Report For Line A									
Label	Upstream Manhole	Downstream Manhole	Length (m)	Total Flow (l/s)	Section Shape	Section Size (mm)	Average Velocity (m/s)	Average Pipe cover (m)	Slope (%)
P-1	MH-1	MH-2	115	80.77	Circular	300	2.11	3.79	3.00
P-2	MH-2	MH-3	120	92.12	Circular	300	2.18	2.82	3.00
P-3	MH-3	MH-4	30	103.59	Circular	300	2.23	1.89	3.00
P-4	MH-4	MH-5	50	111.43	Circular	300	2.12	1.08	2.52
P-5	MH-5	MH-6	40	236.77	Circular	450	2.36	1.04	1.99
P-6	MH-6	MH-7	95	253.63	Circular	450	2.81	1.54	3.00
P-7	MH-7	MH-8	55	265.00	Circular	450	2.84	1.05	3.00
P-8	MH-8	MH-9	140	294.82	Circular	450	2.91	3.55	3.00
P-9	MH-9	MH-10	80	350.17	Circular	450	3.01	2.79	3.00
P-10	MH-10	MH-11	80	400.13	Circular	600	3.14	2.80	3.00
P-11	MH-11	MH-12	100	446.91	Circular	600	3.23	2.00	3.00
P-12	MH-12	MH-13	50	473.10	Circular	600	3.28	1.20	3.00
P-13	MH-13	MH-14	60	501.12	Circular	600	3.33	1.57	3.00
P-14	MH-14	MH-15	50	515.01	Circular	600	3.35	1.40	3.00
P-15	MH-15	MH-16	40	526.33	Circular	600	3.37	1.97	3.00
P-16	MH-16	MH-17	108	564.94	Circular	600	3.43	2.73	3.00
P-17	MH-17	MH-18	52	579.86	Circular	600	3.45	1.19	3.00
P-18	MH-18	MH-19	55	601.36	Circular	600	3.48	1.86	3.00
P-19	MH-19	MH-20	50	619.18	Circular	600	3.50	2.18	3.00
P-20	MH-20	MH-21	45	633.32	Circular	600	3.52	1.71	3.00
P-21	MH-21	MH-22	100	683.00	Circular	600	3.58	2.57	3.00
P-22	MH-22	MH-23	50	698.88	Circular	600	3.59	1.57	3.00
P-23	MH-23	MH-24	30	709.83	Circular	600	3.60	1.37	3.00
P-24	MH-24	MH-25	60	728.78	Circular	600	3.62	2.01	3.00
P-25	MH-25	MH-26	35	736.06	Circular	600	3.63	2.19	3.00
P-26	MH-26	MH-27	65	750.55	Circular	600	3.64	3.78	3.00
P-27	MH-27	MH-28	55	750.85	Circular	600	3.64	2.01	3.00
P-28	MH-28	MH-29	40	751.58	Circular	600	3.64	1.58	3.00
P-29	MH-29	O-1	68	756.13	Circular	600	3.65	1.78	3.00

Manhole Report For Line B					
Label	Ground Elevation (m)	Rim Elevation (m)	Sump Elevation (m)	Manhole Diameter (m)	Manhole Depth (m)
MH-1	541.55	541.55	538.10	1.2	3.45
MH-2	535.90	535.90	534.44	1.2	1.46
MH-3	535.26	535.26	527.65	1.2	7.61
MH-4	524.94	524.94	523.12	1.2	1.82
MH-5	523.66	523.66	519.83	1.2	3.83
MH-6	520.33	520.33	518.72	1.2	1.61
MH-7	519.61	519.61	515.33	1.2	4.28
MH-8	516.04	516.04	514.43	1.2	1.61
MH-9	515.42	515.42	513.81	1.2	1.61
MH-10	513.82	513.82	512.06	1.2	1.76
MH-11	513.32	513.32	508.86	1.2	4.46
MH-12	508.67	508.67	498.99	1.2	9.68
MH-13	498.80	498.80	494.38	1.2	4.42
MH-14	493.29	493.29	491.53	1.2	1.76
MH-15	491.94	491.94	483.64	1.2	8.30
MH-16	483.84	483.84	477.29	1.2	6.55
O-1	477.31	477.31	475.55	1.2	1.76

Pipe Report For Line B									
Label	Upstream Manhole	Downstream Manhole	Length (m)	Total Flow (l/s)	Section Shape	Section Size (mm)	Average Velocity (m/s)	Average Pipe cover (m)	Slope (%)
P-1	MH-1	MH-2	115	42.940	Circular	250	2.43	2.10	3.00
P-2	MH-2	MH-3	40	289.885	Circular	450	3.45	1.10	2.11
P-3	MH-3	MH-4	139	417.482	Circular	450	4.30	4.07	3.00
P-4	MH-4	MH-5	30.5	454.024	Circular	450	4.38	1.18	3.00
P-5	MH-5	MH-6	32	466.076	Circular	450	4.41	2.19	3.00
P-6	MH-6	MH-7	39	511.873	Circular	600	4.06	1.08	2.24
P-7	MH-7	MH-8	30	539.968	Circular	600	4.59	2.34	3.00
P-8	MH-8	MH-9	33	540.387	Circular	600	3.86	1.00	1.88
P-9	MH-9	MH-10	80	540.417	Circular	600	4.08	1.08	2.20
P-10	MH-10	MH-11	108	565.278	Circular	750	4.67	2.35	2.96
P-11	MH-11	MH-12	65	577.163	Circular	750	4.72	2.35	3.00
P-12	MH-12	MH-13	65	593.849	Circular	750	4.75	4.96	3.00
P-13	MH-13	MH-14	95	615.789	Circular	750	4.79	2.33	3.00
P-14	MH-14	MH-15	78	628.119	Circular	750	3.95	1.00	1.73
P-15	MH-15	MH-16	46	634.923	Circular	750	4.83	4.36	3.00
P-16	MH-16	MH-17	58	637.973	Circular	750	4.84	3.40	3.00

Manhole Report For Line C					
Label	Ground Elevation (m)	Rim Elevation (m)	Sump Elevation (m)	Manhole Diameter (m)	Manhole Depth (m)
MH-1	541.55	451.55	540.30	1.20	1.20
MH-2	540.00	540.00	538.75	1.20	1.25
MH-3	539.26	539.26	537.70	1.20	1.56
MH-4	534.95	534.95	533.70	1.20	1.25
MH-5	534.79	534.79	531.24	1.20	3.55
MH-6	528.69	528.69	526.79	1.20	1.9
MH-7	524.34	524.34	519.57	1.20	4.77
MH-8	513.82	513.82	512.57	1.20	1.25

Pipe Report For Line C									
Label	Upstream Manhole	Downstream Manhole	Length (m)	Total Flow (l/s)	Section Shape	Section Size (mm)	Average Velocity (m/s)	Average Pipe cover (m)	Slope (%)
P-1	MH-1	MH-2	79	13.584	Circular	250	1.50	1.00	1.96
P-2	MH-2	MH-3	40	18.866	Circular	250	1.85	1.15	2.63
P-3	MH-3	MH-4	40	24.397	Circular	250	3.20	1.15	10
P-4	MH-4	MH-5	45	29.514	Circular	250	2.72	2.15	5.47
P-5	MH-5	MH-6	38	32.517	Circular	250	3.47	2.15	10
P-6	MH-6	MH-7	37	39.785	Circular	250	3.68	1.32	10
P-7	MH-7	MH-8	70	51.632	Circular	250	3.96	2.76	10