Palestine Polytechnic University

College of Engineering and Technology
Civil & Architecture Engineering Department

Project Title

Design Of WastewaterCollection system

For Idhna Town

Project Team

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Hebron – Palestine

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Design Of Waste water Collection system For Idhna Town

BY

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Project Supervisor

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The Senior Project Entitled:

Design Of Waste water Collection system For Idhna Town

Prepared By:

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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

Eng. Samah Al-Jabari

May, 2014

إهـــــــــــداء

إلى أقرب من في الوجود إلى نفسي ... والدي الحبيبين .

إلى أغلى من في الحياة على قلبي ... **إخوتي الأعزاء** .

إلى من أهدتني بهم السماء ... **أصدقائي الأحباء** .

إلى المنارات التي أضاءت لي الدرب ... أساتذتي الأجلاء .

إلى كل اللحظات السعيدة التي قضيناها داخل اسوار هذه الجامعة الغراء .

إلى أرواح كل الشهداء ... إلى فلسطين الإباء .

إلى كل شيء طاهر جميل في هذا الوطن **المعطاء** .

إلى كل هؤلاء ... أهدي ما جنيت بعناء .

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Work Team

ABSTRACT

Design Of Waste water Collection system For Idhna Town

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Supervised By:

Eng. Samah Al-Jabari

The disposal of raw waste water and storm water without treatment creates major potential health and environmental problems . in Hebron rural areas the sewage facilities do not exist.The people disposal sanitary waste in cesspits , laterains and open drains , the waste water has been seeping into the ground through the overflows of the deteriorated cesspits and laterains causing serious environmental and health problem .

Idhna like other towns in the Hebron district has no wastewater collection system . these laterains and cesspit are deteriorating and they are in very bad condition , adding to this the increasing in water consumption and consequently increasing in waste water production , resulting in over flows from the cesspits and excessive recharges of ground water in Idhna. For all these reasons, this study is conducted to design wastewater collection system for Idhna Town of the Hebron district.

The present study considered the annual population growth (3.5) and their water consumption for the coming 25 years 120 l/d that will be the design period, along with the commercial and industrial development in the area .The necessary hydraulic

calculation need for the design of the main trunk was carried out by simple calculation.

The results of the present study show that the waste collection system for Idhna town will cover all the area of the town , the collection system consist of four line as main line and seven submain , nine line designed by gravity and two line must used pump because of its outfall setuation near the .

TAPLE OF CONTENTS

CHAPTER THREE : DESIGN CRITERIA

CHAPTER FOUR : ANALYSIS AND DESIGN

CHAPTER FIVE : BILL OF QUANTITY

CHAPTER SIX:CONCLUSIONS

REFERENCES

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

1 INTRODUCTION

CHAPTER TWO

2 CHARACTERISTICS OF THE PROJECT AREA

CHAPTER THREE

3 DESIGN BASICS

CHAPTER FOUR

4 ANALYSIS AND DESIGN

CHAPTER FIVE

5 BILL OF QUANTITY

CHAPTER SIX

6 CONCLUSIONS

1.1General

Most of the cities and villages in Palestine were suffering from many major sewage system developments. These cities and villages are still suffering from lack of suitable sewage system networks, even though 60% to 70% of the cities in Palestine are served with sewage system network.

At the present time, most of the Palestinian cities have no wastewater treatment plants. The wastewater produced from the cities, villages and refugee camps flows in open channels in most cases, which create a health hazardous and have adverse on our environment.

Idhna Town like other towns in Palestine have no sewerage facility. Most of people are using septic tanks, which are emptied by cesspit emptier and tankers from time to time. These latrines and cesspits are deteriorating and they are in a bad condition, for all these reasons, this evaluation and design of wastewater collection system study for Idna Town have been conducted.

1.2 Problem Definition

The accelerated expansion and development of Idhna Town have resulted in increasing of water consumption and consequently in generation of large quantities of wastewater from various sources such as residential areas, commercial establishments and different industries. Due to the absence of wastewater collection system, the wastewater has been seeping into the ground through the overflows of the deteriorated cesspits and latrines that are commonly used in Idhna. Moreover, in some areas wastewater is flows directly to the "Wadis" through open drains in different routes causing serious environmental and health problems.

The main damaging consequences of the wastewater routes are smells, soil contamination, and polluting of existing aquifers.

In view of these bad conditions, and since there is no sewage networks exist, along with fast increasing of the environmental and health problem, the design of wastewater collection system study becomes a pressing necessity so as to solve all problems that mentioned above. This study will consider the annual growth of the people and their water consumption for the coming 25 years, which will be the design period.

1.3 Objectives Of The Project

This project entitled “Design Of WastewaterCollection System For Idhna Town", which includes the following:

Study and design the sanitary network and system including all its subsidiaries with proper inclinations, connecting to the main municipality lines, manholes, connection systems within the project, disposal methods, design of the wastewater flows and loadings and prepare all engineering design drawings and details for the sanitary system network and disposal methods.

1.4Methodology

1. Many Site visits to Idhna Town and cooperation with Edna Municipality to make a sufficent system.
2. All needed maps and the previous studies that contain different information about Idhna Town were obtained.
3. The amounts of water consumption for different purposes and consequently the amount of wastewater production for each area were obtained.
4. The different layouts of the purposed wastewater collection system were proposed.
5. The necessary hydraulic calculations for wastewater collection system will carried out.
6. Finalizing the project which contains the report, the needed maps and drawings, and the bill of quantities will be done next semester.

1.5 Phases Of The Project

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

Title	Duration								
	09/13	10/13	11/13	12/13	01/14	02/14	03/14	04/14	05/14
Data collection and survey									
Preparing layout for wastewater collection system and calculate the amount of wastewater									
Design of wastewater collection system									
Writing the report and preparing maps									

Table (1.1): Phases Of The Project With Their Expected Duration

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 the town and the municipality were done. This phase includes the following tasks:

1. Collecting of aerial and topographical maps for all area.
2. Collecting of meteorological and hydraulically data (temperature, wind speed, rainfall, evaporation . . . . etc) from different sources.
3. Evaluation of town population densities in each zone of the town with their water consumption and predicting their numbers, densities and their water consumption in year 2038.

1.5.2 Second Phase: - Preparing Layout For Wastewater Collection System And calculate The Amount Of Wastewater

In this phase layout was prepared and put in its final shape and then quantities of wastewater will determine.

This phase includes the following tasks:

1. Draw the layout of wastewater collection system and compare it with the real situation in Idhna Town then make adjustments and draw the final layout, this task 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 wastewater quantities and projection of the wastewater production in year 2038.

1.5.3 Third Phase: - Design Of Wastewater Collection System

In this phase the necessary hydraulic calculations needed for the design of main trunks will carried out. 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 hydraulic calculations.

4. Preparing needed different drawings for the designed sewers.

1.5.4 Fourth Phase: - Writing the report and preparing maps

After finishing the design calculations of the main trunks the project team will prepared the specifications drawing, bill of quantities and preliminary maps. Final report prepared and submitted to the Department Of Civil And Architectural Engineering at Palestine Polytechnic University and this will be done next semester.

1.6 Organization Of The Project

The study report has been prepared in accordance with the objectives and scope 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 “Characteristic Of The Project Area” presents basic background data and information on the project area, water supply, wastewater disposal.

Chapter three entitled “Design Criteria” deals with municipal sewage system, types of wastewater collection systems, sewer appurtenances, flow in sewers, design of sewer system, and sewer construction and maintenance.

Chapter four entitled “Analysis And Design” presents the design calculations and maps of the system.

Chapter five entitled “Bill Of Quantities” deals with the items of the project estimated quantity of each them in next semester.

Chapter six entitled “Conclusions” discusses the conclusions of the study.

2.1 General

In this chapter, the basic data ofIdhna Town will be briefly discussed. The location, topography, and climate will be described. The water supply and wastewater production will be briefly presented.

2.2 Project Area

IdhnaTown is located 15 km northwest of Hebron City in the southern part of the West Bank. Idhna is bordered by Tarqumiya Town to the north, Taffuh Town and Hebron city to the east, Al Kum village to the south and the 1949 Armistice Line (the Green Line) to the west, as shown on the project location maps Figure (2.1), and (2.2) ; the average elevation of the Town is 500 m above sea level .Idhna's primary source of income is agriculture and the Town's total land area is 21,526 dunams of which 2,809 dunams are built up area. the total population of Idhna in 2007 was 19,012; of these, 9,723 were males and 9,289 were females.

2.3 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; humidity, temperature, and wind. These factors are affecting evaporation and transpiration. So this study will include needed data about these factors, since they play big role in the determination of water demand.

The climate of Idhna Town tends to be cold in winter with limited amount of rain, and warm in summer and relatively humid.

The climatologically data presented in the following sections were obtained from a survey carried out by the meteorological station of Hebron city.

2.3.1 Rainfall

The mean annual rainfall in Idhna between 410 and 440 mm . RainfalloccursbetweenOctoberandMay whileitrarelyrainsinthesummerseasonfromJunetoSeptember. The monthly rainfall of Idhna Town (2012/1013)is shown in Table (2.1).

2.3.2 Temperature

The temperature is characterized by considerable variation between summer and winter times. The average annual temperature of 19 ^{0}C. The mean temperature values at Idhna Town are given in Table (2.1).

The following minimum and maximum values were shown:

- The mean maximum temperature: 20 ^{0}C
- The mean minimum temperature: 11 ^{0}C

2.3.3 Relative Humidity

The average annual humidity is about 60 %. The relative humidity of Idhna Town is shown in Table (2.1).

Month	Rainfall (mm)	Maximum Temperature (˚C)	Minimum Temperature (˚C)	Relative Humidity (%)
September	0.0	33	15	62
October	0.0	30.5	12	61
November	48	29.5	9	70
December	٦٥	23.5	4	80
January	١79.5	15	0.6	83
February	52	17.6	-1	70
March	7	24	-1	67
April	10	29.4	6.5	45
May	7	31.6	11	49
June	0.0	36	15	44
July	0.0	36.8	17	53
August	0.0	33.4	17.8	53

Table (2.1): Meteorological Conditions At Idhna Town Weather Station for (2012-2013)

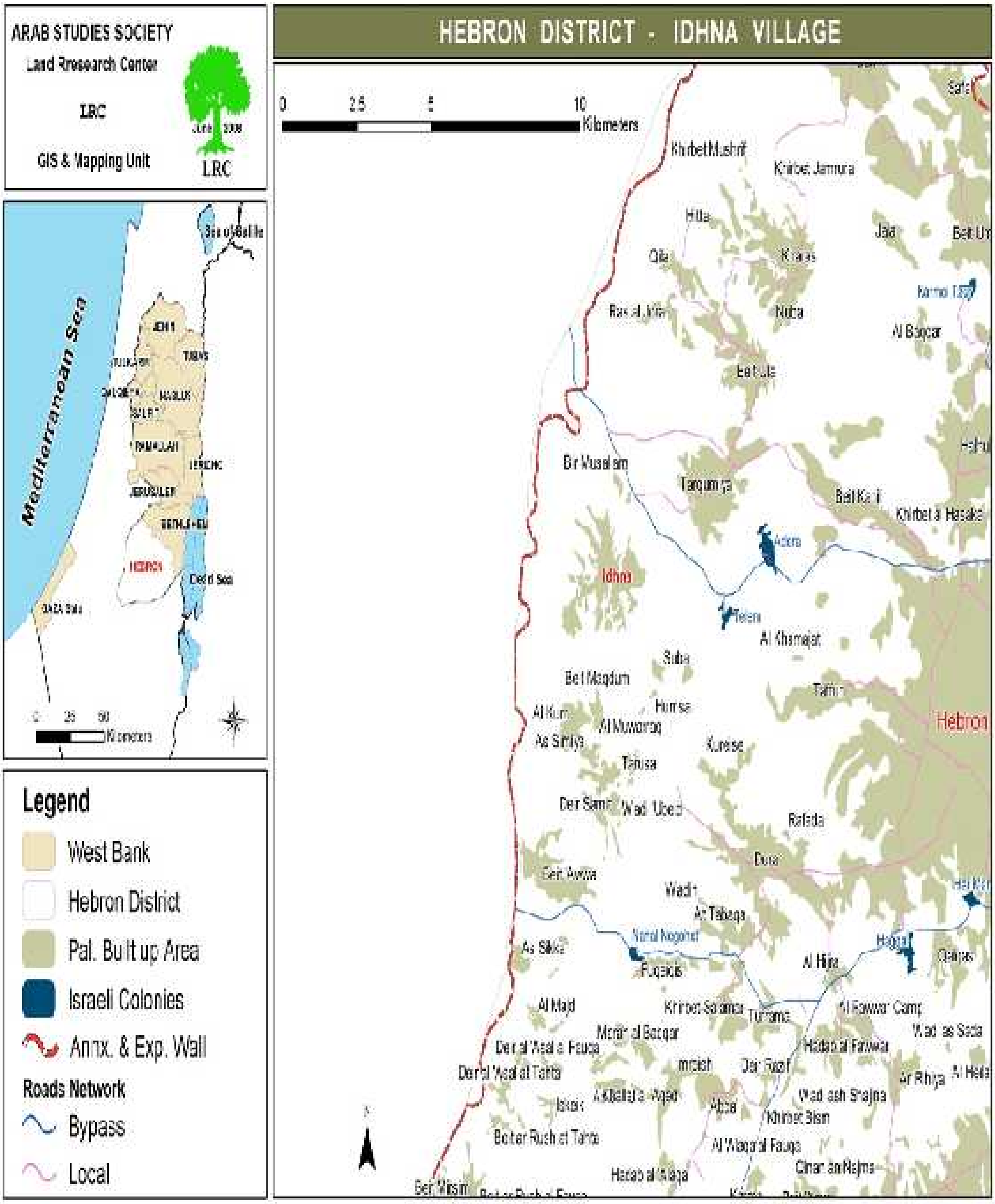

Figure (2.1) Idhna map

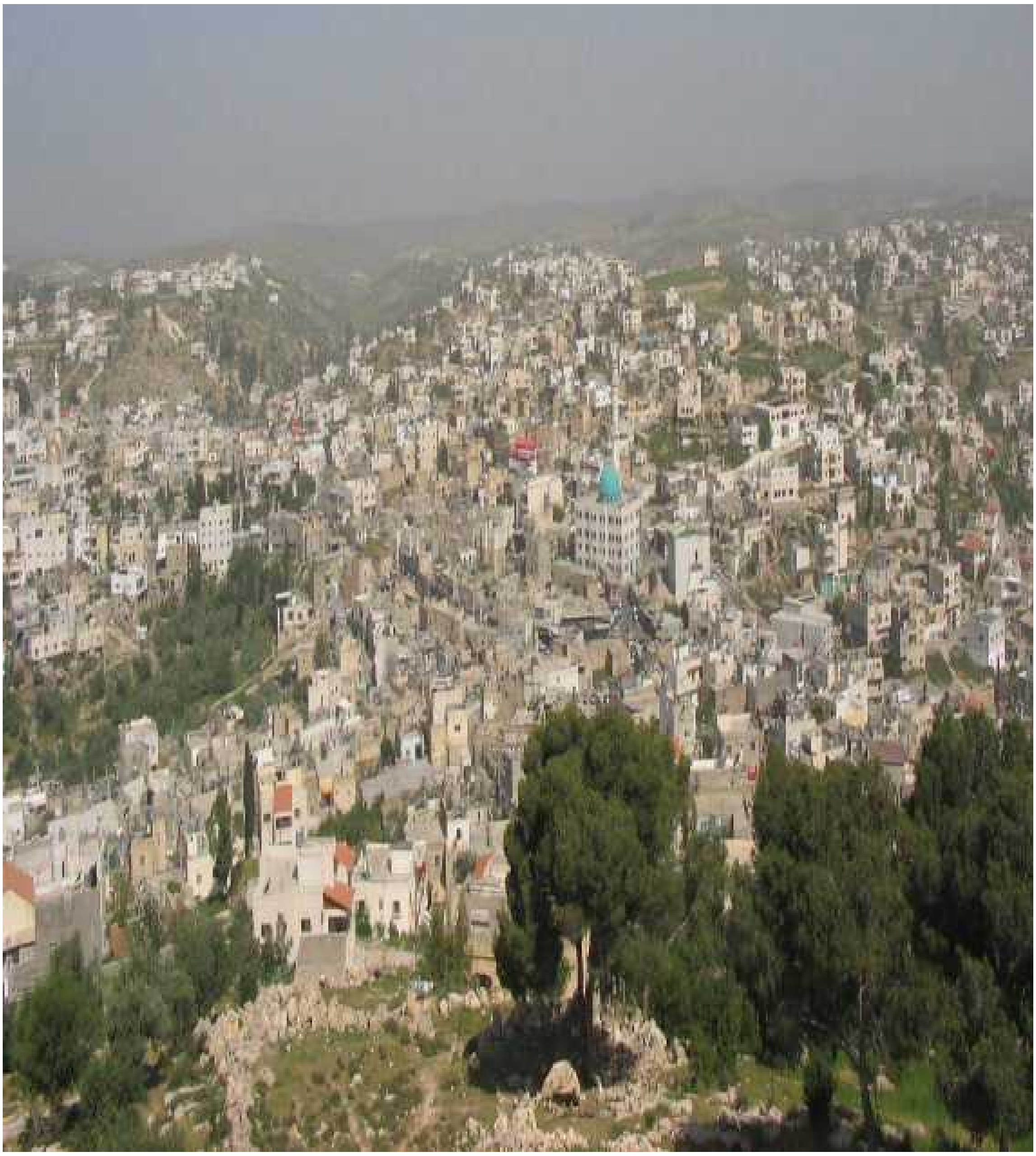

Figure (2.2): **Photo of Idhna**

2.4 Water supply

Since Idhna municipality assumed control of the water network, it has investeda great amount of time, energy, and money into the expansion and rehabilitation of the water system.

The network was originally provided in 1974 by the Israeli Water Company (MECOROT) during the Israeli occupation of the West Bank. Until recently, the water network served only 40% of housing units. Currently, municipal officials estimate that 95% of housing units have access to the water network. Nonetheless, there is still heavy dependence on alternative water sources. People are sometimes forced to draw from communal wells, but the water is becoming increasingly polluted. In addition, there are about 10 springs in the town, the main springs being: Al Balouta spring, Al Balad spring and Al Bas springs. Furthermore, thewater is also utilized for livestock and agriculture. Idhna possesses a reservoir with a 500 cubic meter capacity.

2.5 Water Consumption

According to the water consumption data obtained from the previous studies and Idhna municipality, the water consumption is 80 liters/per capita per day.

2.6 Wastewater Disposal

Discharge of raw wastewater is harmful to both environment and health, especially to human health. This problem is intensified through population growth and increased of water consumption and subsequent increase of generated wastewater. So, wastewater disposal is imperative to the protection of the environment and community.

Wastewater collection disposal and treatment has been neglected inIdhna Town, like many places in Palestine, because the town is considered to be unsewered area, using cesspits,Septic Tanks and open drains, which cause different environmental problems and pollution of groundwater. These conditions bring the whole area to a bad condition. As we are going to design the wastewater collection network forIdhna town.

2.7 Wastewater Quantity

In general the amount of domestic wastewater produced per capita per day is usually (70-80 %) of water consumption.

3.1 General

Once used for its intended purposes, the water supply of a community is Considered to be wastewater. The individual conduits used to collect and transport wastewater to the treatment facilities or to the point of disposal are called sewers.

There are three types of sewers: sanitary, storm, and combined. Sanitary sewers are designed to carry wastewater from residential, commercial, and industrial areas, and a certain amount of infiltration /inflow that may enter the system due to deteriorated conditions of sewers and manholes. Storm sewers are exclusively designed to carry the storm water. Combined sewers are designed to carry both the sanitary and the storm flows.

The network of sewers used to collect wastewater from a community is known as wastewater collection system. The purpose of this chapter is to define the types of sewers used in the collection systems, types of wastewater collection systems that are used, the appurtenances used in conjunction with sewers, the flow in sewers, the design of sewers, and the construction and maintenance of sewers.

3. 2 Municipal Sewerage System

3.2.1 Types Of Sewers

The types and sizes of sewers used in municipal collection system will vary with size of the collection system and the location of the wastewater treatment facilities. The municipal or the community sewerage system consists of (1) building sewers (also called house connections), (2) laterals or branch sewers, (3) main and submain sewers, (4) trunk sewers.

House sewers connect the building plumbing to the laterals or to any other sewer lines mentioned above. Laterals or branch sewers convey the wastewater to the main sewers. Several main sewers connect to the trunk sewers that convey the wastewater to large intercepting sewers or the treatment plant. The types of sewers usually used in wastewater collection system are shown in Figure (3.1).

The diameter of a sewer line is generally determined from the peak flow that the line must carry and the local sewer regulations, concerning the minimum sizes of the laterals and house connections. The minimum size recommended for gravity sewer is 200 mm (8inch).

3.2.2 Sewer Materials

Sewers are made from concrete, reinforced concrete, vitrified clay, asbestos cement, brick masonry, cast iron, ductile iron, corrugated steel, sheet steel, and plastic or polyvinylchloride or ultra polyuinyl chloride. Concrete and ultra polyvinyl chlorides are the most common materials for sewer construction.

3. 3 Types Of Wastewater Collection Systems

3.3.1 Gravity Sewer System

Collecting both wastewater and storm water in one conduit (combined system) or in separate conduits (separate system). In this system, the sewers are partially filled. A typical characteristic is that the gradients of the sewers must be sufficient to create self-cleansing velocity for the transportation of sediment. This velocity is 0.6 m/s minimum when sewers are flowing full or half-full. Manholes are provided at regular intervals for the cleaning of sewers.

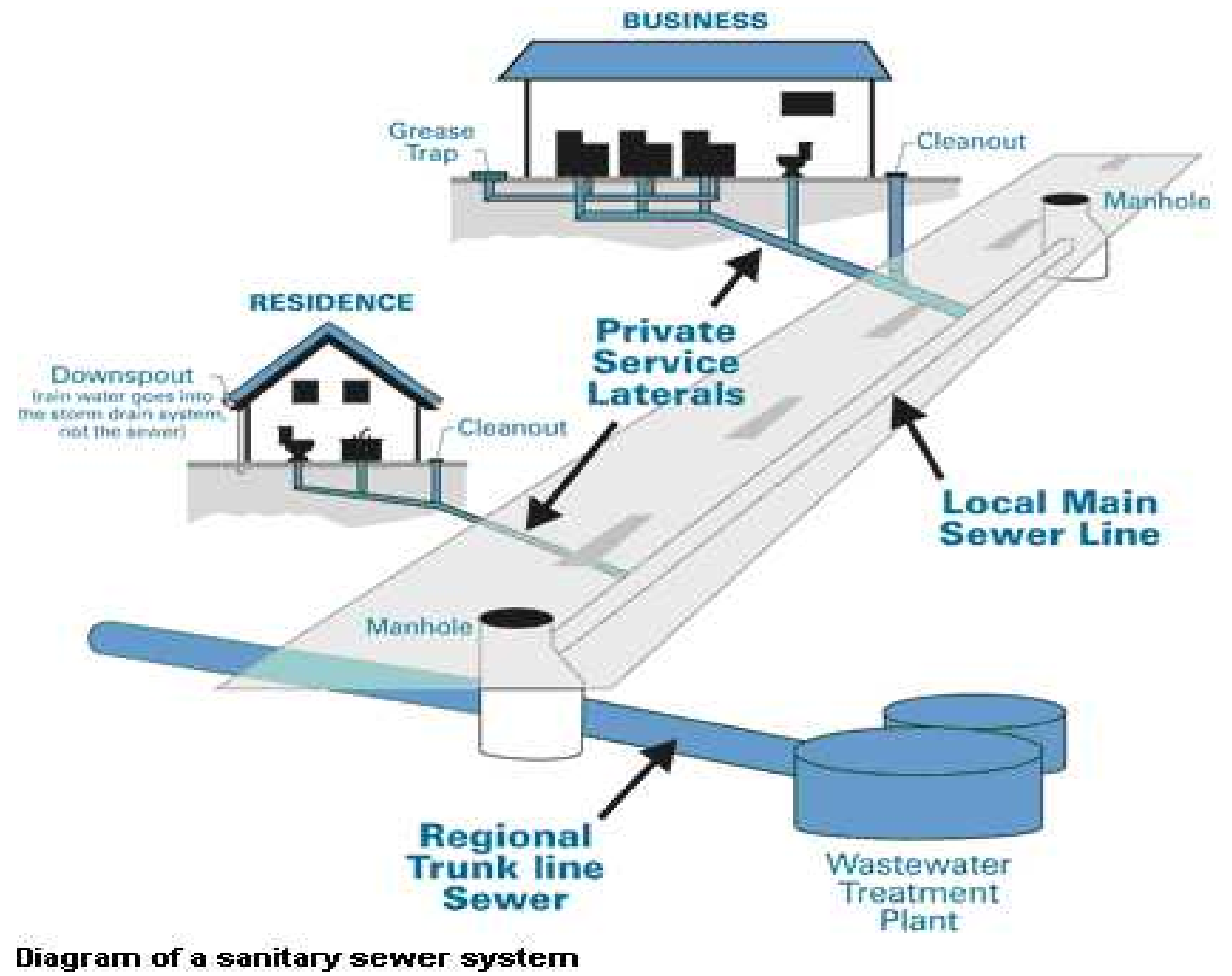

Figure (3.1): Types Of Sewers Used In Wastewater Collection System[9] .

Pressure and vacuum–types systems require a comparatively high degree of mechanization, automation and skilled manpower. They are often more economical than gravity system, when applied in low population density and unstable soil conditions. Piping with flexible joints has to be used in areas with expansive soils.

3.4 Sewer Appurtenances

3.4.1 Manholes

Manholes should be of durable structure, provide easy access to the sewers for maintenance, and cause minimum interference to the sewage flow. Manholes should be located at the start and at the end of the line, at the intersections of sewers, at changes in grade, size and alignment except in curved sewers, and at intervals of 35-50 m in straight lines.

The general shapes of the manholes are square, rectangular or circular in plan, the latter is common. Manholes for small sewers are generally 1.0-1.2 m in diameter. For larger sewers larger manhole bases are provided. The maximum spacing of manholes is 30-55 m depending on the size of sewer and available size of sewer cleaning equipment . [9]

Standard manholes consist of base, risers, top, frame and cover, manhole benching, and step-iron. The construction materials of the manholes are usually precast concrete sections, cast in place concrete or brick. Frame and cover usually made of cast iron and they should have adequate strength and weight.

Drop Manholes

A drop manhole is used where an incoming sewer, generally a lateral, enters the manhole at a point more than about 0.6 m above the outgoing sewer. The drop pipe permits workmen to enter the manhole without fear of being wetted, avoid the splashing of sewage and corrosion of manhole bottom .[4]

3.4.2 House Connections

The house sewers are generally 10-15 cm in diameter and constructed on a slope of 2% m/m. house connections are also called, service laterals, or service connections. Service connections are generally provided in the municipal sewers during construction. While the sewer line is under construction, the connections are conveniently located in the form of wyes or tees, and plugged tightly until service connections are made. In deep sewers, a vertical pipe encased in concrete is provided for house connections . [9]

3.4.3 Inverted Siphons

An inverted siphon is a section of sewer, which is dropped below the hydraulic grade line in order to avoid an obstacle such as a railway or highway cut, a subway, or a stream. Such sewers will flow full and will be under some pressure; hence they must be designed to resist low internal pressures as well as external loads. It is also important that the velocity be kept relatively high (at least 0.9 m/s) to prevent deposition of solids in locations, which would be very difficult or impossible to clean. [5]

Since sewage flow is subject to large variation, a single pipe will not serve adequately in this application. If it is small enough to maintain a velocity of 0.9 m/s at minimum flow, the velocity at peak flow will produce very high head losses and may actually damage the pipe. Inverted siphons normally include multiple pipes and an entrance structure designed to divide the flow among them so that the velocity in those pipes in use will be adequate to prevent deposition of solids . [5]

3.4.4 Pumping of Sewer

There are many communities in which it is possible to convey all the sewage to a central treatment location or point of discharge in only a gravity system. In other areas with flat terrain, more than drainage area, low-lying sections, or similar complications, pumping may be required. Pumping may also be required at or within sewage treatment plants, in the basements of buildings which are below the grade of the sewer, and to discharge treated wastewater to streams which are above the elevations of the treatment plant . [5]

Pumping of untreated sanitary sewage requires special designs, since sewage often contains large solids. Nonclog pumps have impellers, which are usually closed and have, at most, two or three vanes. The clearance between the vanes is sufficiently large that anything which will clear the pump suction will pass through the pump. A bladeless impeller, sometimes used as a fish pump, has also been applied to this service. For a specified capacity, bladeless impellers are large and less efficient than vaned designs. [5]

3.5 HYDRAULICS OF SEWER DESIGN

3.5.1 Introduction

Wastewater systems are usually designed as open 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 sewer remains constant . [6]

3.5.2 Flow Formulas

In principle all open channel flow formulas can be used in hydraulic design of sewer pipes through Manning's formula. The following are the most important formulas:

1. Chezy's formula:

$$V = C\sqrt{RS} \qquad (3.1)$$

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

R: the hydraulic radius (m).

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

C: the Chezy coefficient; $C = \dfrac{100\sqrt{R}}{m+\sqrt{R}}$,

where m = 0.35 for concrete pipe 0.25 for vitrified clay pipe .

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-Weishbach formula states that

$$H = \lambda L * V^2/(D * 2g) \qquad (3.2)$$

Where H: the pressure head loss (mwc).

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 open 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:

$$V = (1/n)\ R^{2/3}\ S^{1/2} \qquad (3.3)$$

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= [(b*d)/ (b+2d)].

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 (3.1)

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
PVC	0.011

Table (3.1) Common Values of Roughness Coefficient Used in the Manning Equation [6]

- **The peak coefficient**

In general, this coefficient increases when the average flow decrease, it will be determined from the practice and experience of the designer. The following relation has been used commonly by the designer and gives satisfactory results:

$$Pf = 1.5 + 2.5 / \sqrt{q} \qquad (3.4)$$

Where, q in (l/s) is the daily average flow rate of the network branch under consideration and Pf is the peak factor.

3.5.3 Hydraulics of Partially Field Section

The filling rate of a sewer is an important consideration, as sewers are seldom running full, so sanitary 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 open 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%.

3.6 Design system and construction community sewerage system

Designing a community sewage 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 sewer network that is efficient and cost-effective. The design engineer needs to generally undertake the following tasks [9]:

1. Define the service area.
2. Conduct preliminary investigations.
3. Develop preliminary layout plan.
4. Selection of design parameters.
5. Review construction considerations.
6. Conduct field investigation and complete design and final profiles.

3.6.1 Service Area

Service area is defined as the total area that will eventually be served by the sewage system. The service area may be based on natural drainage or political boundaries, or both. It is important that the design engineers and project team become familiar with the surface area of the proposed project.

3.6.2Preliminary Investigation

The design engineer must conduct the preliminary investigations to develop a layout plan of the sewerage 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 [9].

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, streams, and the like. All these factors influence the sewer layout.

3.6.3 Layout Plan

Proper 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 [9]:

1. Select the site for disposal of the wastewater treatment plant. For gravity system, the best site is generally the lowest elevation of the entire drainage area.
2. The preliminary layout of 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 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 sewers are started from the trunk line and extended uphill intercepting the laterals.
5. All laterals or branch lines are located in the same manner as the main sewers. Building sewers are directly connected to the laterals.

6. Preliminary layout and routing of sewage flow is done by considering several feasible alternatives. In each alternative, factors such as total length of 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 sewerage system.
7. After the preliminary sewer layout plan is prepared, the street profiles are drawn. These profiles should show the street elevations, existing sewer lines, and manholes. These profiles are used to design the proposed lines.

Finally, these layout plans and profiles are revised after the field investigations and sewer designs are complete . [10]

3.6.4Selection of Design Parameters

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

1. Design period: Design period should be based on ultimate tributary population. It is not uncommon to design sewers for design period of 25-50 years or more.

2. Design Population: Population projection must be made for population at the end of the design year. Discussion on population projection can be found in Chapter Two.

3. Design Flow Rate: Sanitary sewers should be designed to carry peak residential, commercial, and industrial flows, and normal infiltration and inflow where unfavorable conditions exist.

4. Minimum Size: The minimum sewer size recommended is 200 mm. Many countries allow 150mm lateral sewers.

5. Minimum and Maximum Velocities: In sanitary 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. A good practice is to maintain velocity above 0.3 m/s under low flow conditions. Under peak dry weather condition, the lines must attain velocity greater than 0.6 m/s. This way the lines will be flushed out at least once or twice a day. Velocities higher than 3 m/s should be avoided as erosion and damage may occur to the sewers or manholes

6. Slope: Flat sewer slopes encourage solids deposition and production of hydrogen sulfide and methane. Hydrogen sulfide gas is odorous and caused explosions. The minimum slopes are such that a velocity of 0.6 m/s is reached when flowing full and n = 0.013. Minimum sewer slopes for different diameter lines are summarized in Table (3.2) .

Pipe Diameter (D)		Slope
mm	**Inch**	**m/m**
150	6	0.006
200	8	0.004
250	10	0.0028
310	12	0.0022
360	14	0.0017
380	15	0.0015
410	16	0.0014
460	18	0.0012
610	24	0.0008
690	27	0.00067
760	٣٠	0.00058
910	36	0.00046
1050	42	0.00038
1200	48	0.00032
1370	54	0.00026

Table (3.2) Minimum Recommended Slopes of Sanitary Sewer[10].

7. Depth: The depth of sewers is generally 1-2 m below the ground surface. Depth depends on the water table, lowest point to be served, topography, and the freeze depth.

8. Appurtenances: Sewer appurtenances include manholes, building connection, inlets, outlets and outfall, and others. Appropriate storm sewer appurtenances must be selected in design of sanitary sewers. Manholes for small sewers are generally 1.2 m in diameter. For large sewers larger manholes bases are provided.

9. Design Equations and Procedures: Sanitary 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:

$$V = (1/n)\ R^{2/3}\ S^{1/2} \qquad (3.3)$$

Various types of nomographs have been developed for solution of problems involving sewers flowing full. Nomographs based on Manning's equation for circular pipe flowing full and variable n values are provided in Figure (3.1). Hydraulic elements of circular pipes under partially-full flow conditions are provided in Figure (3.2). It may be noted that the value of n decreases with the depth of flows Figure (3.1). 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 (3.3) and (3.4) and Figures (3.1) and (3.2) will be shown in the design calculation in chapter five .

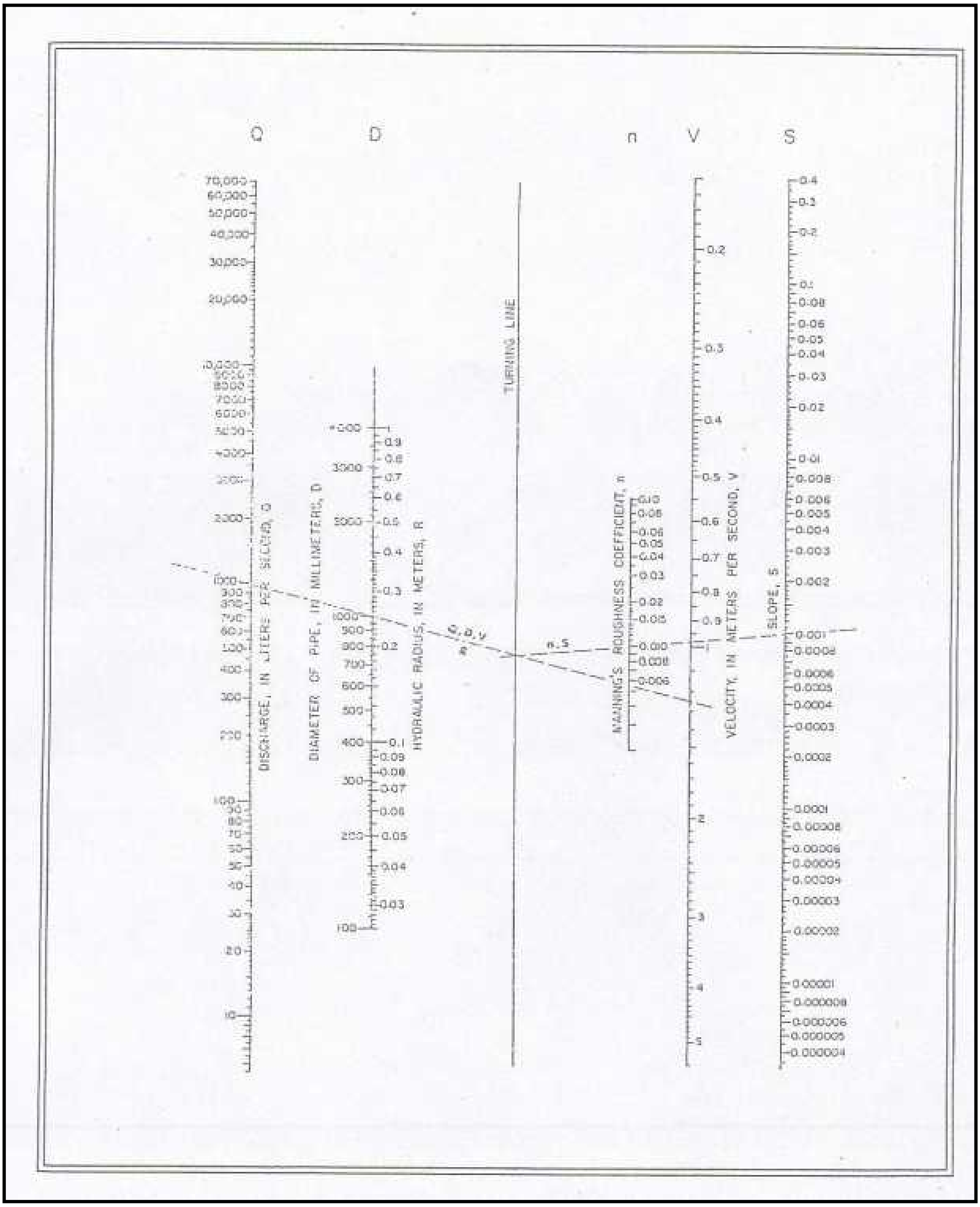

Figure (3.2) : Nomograph for solution of manning formula[9].

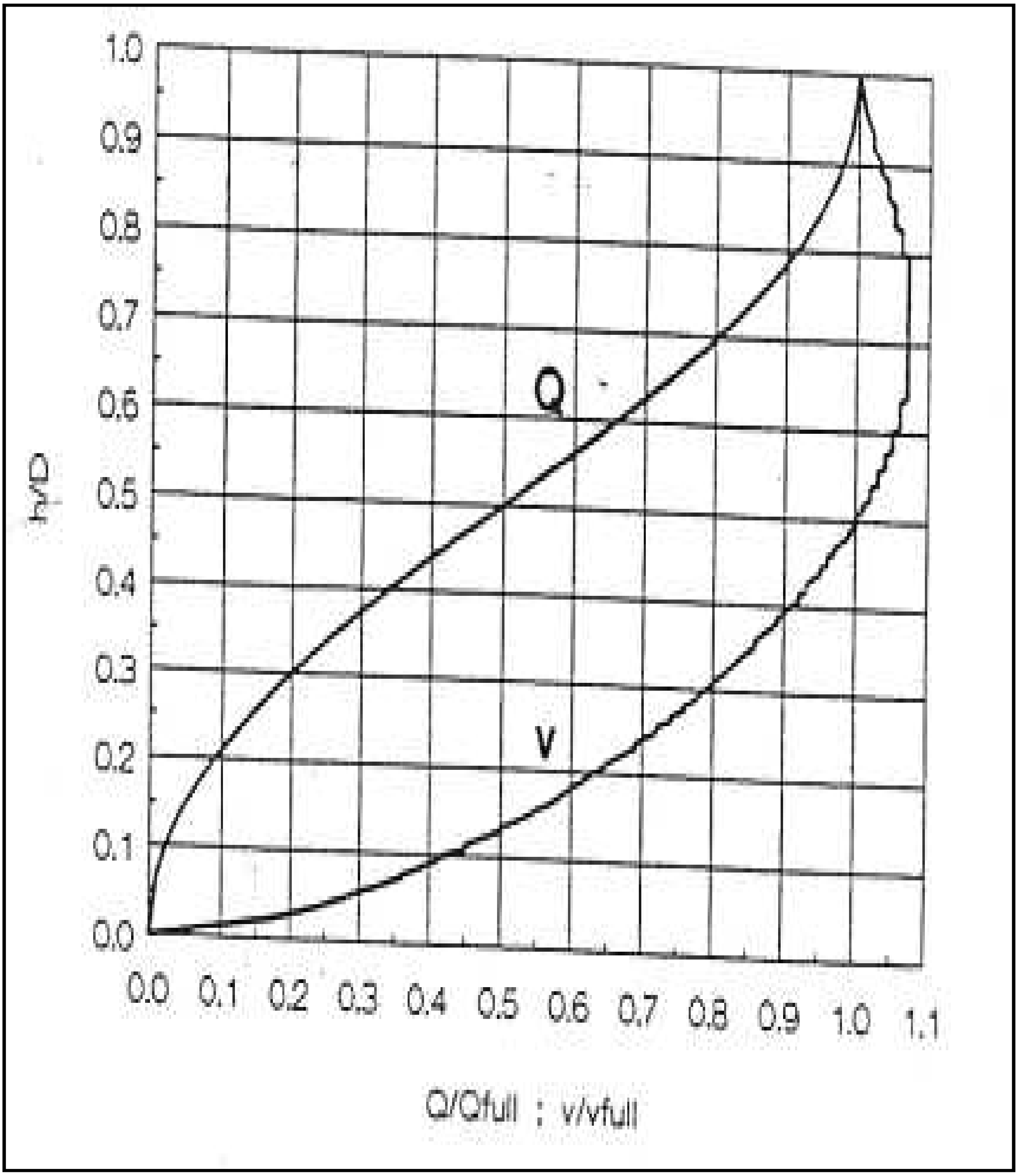

Figure (3.3) Hydraulic properties of circular sewer[9].

10. Design Computation

After the preliminary sewer layout plan and profile are prepared, the design computations are accomplished. Design computations for sewers are repetitious and therefore, are best performed in a tabular format .[10]

3.6.5 Construction Consideration

1. Construction Material: As mentioned earlier, sewers are made from concrete, reinforced concrete, vitrified clay, asbestos cement, brick masonry, cast iron, corrugated steel, sheet steel, and plastic. Important factors in selection of sewer material include the following:

- Chemical characteristics of wastewater and degree of resistance to corrosion against acid, base, gases, solvent, etc.
- Resistance to scour and flow.
- External forces and internal pressure.
- Soil conditions.
- Type of backfill and bedding material to be used.
- Useful life.
- Strength and water tightness of joints required, and effective control of infiltration and inflow.
- Availability in diameter, length, and ease of installation.
- Cost of construction and maintenance.

2. Sewer Construction: Sewer construction involves excavation, sheeting and bracing of trenches, pipe installation, and backfilling. Each of these construction steps is discussed briefly below [9].

- Excavation And Backing fill

Great care is not necessary in lying water pipes accurately to grade, but sufficient cover is necessary to give protection against traffic loads and to prevent freezing. The filling height is usually between 1 to 1.5 m measured from the upper tip of the pipe, this depends mainly on the volume and density of the traffics in the area of the project, in addition to the material of pipes and type of filling materials.

Trenches or ditches should be wide enough to allow good workmanship. Required widths range from 0.5 to 1.2 m depends on pipe size. In rock excavation the rock should be removed so that it is at least 150 mm away from the finished pipeline. A cushion of sand or earth should be placed between rock and the pipe

Backfill material should be free from cinders, refuse, or large stones. Backfill from the trench bottom to the centerline of the pipe should be with sand, gravel, shell or other satisfactory material laid in layers and tamped. This material should extend to the trench sides. Excavation material can be used as filling material depending on the type of soil excavation and this will save money.

- **Sheeting and Bracing:** Trenches in unstable soil condition require sheeting and bracing to prevent caving. Sheeting is placing planks in actual contact with the trench side. Bracing is placing crosspieces extending from one side from the trench to the other. Sheeting and bracing may be of various types depending on the depth and width of the trenches and the type of soils supported. Common types are stay bracing , poling board, box sheeting, vertical sheeting, and skeleton sheeting. In many situations pumping may be necessary to dewater the trenches.

- **Sewer Installation:** after the trench is completed, the bottom of the trench is checked for elevation and slope. In firm, cohesive soils the trench bottom is shaped to fit the pipe barrel and projecting collars. Often granular material such as crushed stones, slag, gravel, and sand are used to provide uniform bedding of the pipe. The pipes are inspected and lowered with particular attention being given to the joints. The pipe lengths are placed on line and grade with joints pressing together with a level or winch. The joints are then filled per specefications.

3.6.6 Field Investigations and Completion of Design

Fieldwork should be conducted to establish benchmarks on all streets that will have sewer lines. Soil borings should be conducted to develop subsurface data needed for trenching and excavation. The depth of boring should be at least equal to the estimated depth of the sewer lines. Detailed plans should be drawn showing the following: (1) contours at 0.5 m intervals in map with scale 1 cm equal to 6 m, (2) existing and proposed streets, (3) streets elevations, (4) railroads, building, culverts, drainage ditches, etc, (5) existing conduits and other utility lines, and (6) existing and proposed sewer lines and manholes. The sewer profiles should also be developed showing ground surface and sewer elevations. Profile drawing should be prepared immediately under the sewer plan for ready reference.

3.7 Important Numbers

For a wastewater collection system the following numbers should be taken in design:

- Maximum velocity = 3 m/s.
- Minimum velocity = 0.6 m/s.
- Maximum slope = 15%.
- Minimum slope = 0.5%.
- H/D = 50%.
- Minimum diameter 200 mm.
- Maximum diameter 600 mm.
- Minimum cover 1.5 m.
- Maximum cover 5 m.

4.1General

In this project, design of wastewater collection system for IdhnaTown is made, and develop a future plans for construction of the collection system, corresponding to the vision of Idhna 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 computation procedures and tables are given along the drawings of layout.

4.2 Population

4.2.1 Introduction

The ideal approach for the population forecasting is by the study and use of previous census records, which cover along period. The longer the period, and the more comprehensive the census data, the more accurate will be the results, which will be obtained. In the analysis of these data, demographical, economical and political factors should be considered in order to develop a method of forecasting which will predict the expected growth rate, future population and its distribution in the different zones of the area under consideration.

In the town of Idhna, as well as other Palestinian cities and towns, there is great uncertainty in the political and economical future. Additionally, there were no accurate population data since the occupation of the West Bank in 1967, until 1997 when the Palestinian Central Bureau of Statics (PCBS) conducted comprehensive census covering the West Bank and Gaza Strip. The final results of this census show that the total population ofIdhna town is 25000inhabitants.

4.2.2 Population Forecast

The rate of 3.5% per year was used for the future growth of the population of Idhna Town.

To calculate the population at the end of the design period (year 2038), a geometric increase is assumed, represented by the following equation:

$$P = P_{\circ} (1+R)^{n} \qquad (4.1)$$

Where, P is the future population, $P_{\circ}$ is the present population, R is the annual population growth rate, and n is the period of projection.

The number of population along 25 year shown in Table (4.1):

Year	2007	2017	2027	2037
Population	**19012**	**26818**	**37829**	**55229**

Table(4.1) : The Number Of Population Along 25 Year

4.2.3 Population Density

In our project the population densities on the town structure plan, which serves for issuing buildings permit. The data obtained for population density from Idhna municipality are shown in Figure (4.1).

4.3 Layout of the System

The first step in designing a sewerage system is to establish an overall system layout that includes a plan of the area to be sewered, showing roads, streets, buildings, other utilities, topography, and the lowest floor elevation or all buildings to be drained.

In establishing the layout of wastewater collection system for Idhna, the following basic steps were followed:

1. Obtain a topographic map of the area to be served.

2. Visit the location.

3. Locate the drainage outlet. This is usually near the lowest point in the area and is often along a stream or drainage way. In Idhna town, the lowest point is in Wadialbir.

4. Sketch in preliminary pipe system to serve all the contributors.

5. Pipes are located so that all the users or future users can readily tap on. They are also

Layout of pop density

6. located so as to provide access for maintenance and thus are ordinarily placed in streets or other rights-of-way.

7. Sewers layout is followed natural drainage ways so as to minimize excavation and pumping requirements. Large trunk sewers are located in low-lying areas closely paralleled with streams or channels.

8. Revise the layout so as to optimize flow-carrying capacity at minimum cost. Pipe lengths and sizes are kept as small as possible, pipe slopes are minimized, and followed the ground surface slope to minimize the depth of excavation, and the numbers of appurtenances are kept as small as possible.

9. The pumping is avoided across drainage boundaries. Pumping stations are costly and add maintenance problems. But in this system we must use one pump .

The final layout of waste water collection system for Idhna Town is illustrated in (Fig 4.2), (Fig 4.3) and Figure of profiles in appendix C .

Four main trunks are located on the layout and each has catchment and sub catchment area.

main trunk 1 start from the center of the Town and running by gravity to reach Wade Al resha, it has 3 sub main which is called 1.1 ,1.2 ,1.3, main trunk 2 startfrom the center of the Town and running by gravity to reach Alzkhrh area and end in Wade Al resha.

main trunk 3 start from the center of the Town and running by gravity to reach Wade Franks area , it hastowsubmain which is called 3.1, 3.2 .

main trunk 4 start from the center of the Town and running by gravity to reach wade Al balota , it has towsubmain which is called 4.1 ,4.2 .

Layout of wastewater with contor

Layout of wastewater without contor

4.4 Quantity Of Wastewater

The detailed design of sanitary sewers involves the selection of appropriate pipe sizes and slopes to transport the quantity of wastewater expected from the surroundings and upstream areas to the next pipe in series, which is subjected to the appropriate design constrains. The design computations are in the example given below.

After preparing the layout of the wastewater collection system the quantity of wastewater that the system must carry will be calculated using the data collected about the area.

Design example: Design a gravity flow sanitary sewer

Design a gravity flow trunk sanitary sewer for the area to outfall (line 3.1) in (Fig 4.4). The following data will collect and analyzed.

1. For current water consumption uses 80 l/c.day.
2. For future water consumption 120 l/c.day.
3. For current population.
4. For Population growth rate 3.5%.
5. For design period 25 year.
6. The waste water calculates as 80% of the water consumption.
7. For infiltration allowance use 10% of the domestic sewerage flow.
8. Peaking factor depending on the formula :

$$Pf = 1.5 + (2.5/\sqrt{q}) \qquad (4.2)$$

Solution

1. Lay out the trunk sewer. Draw a line to represent the proposed sewer Fig (4.4).
2. Locate and number the manholes. Locate manholes at (1) change in direction, (2) change in slope, (3) pipe junctions, (4) upper ends of sewers, and (5) intervals from 35 to 50 m or less. Identify each manhole with a number.
3. Prepare a sewer design computation table. Based on the experience of numerous engineers, it has been found that the best approach for carrying out sewer computations is to use a computation table. The necessary computations for the sanitary sewer are presented in Table (4.2). The data in the table are calculated as follow:

a. The entries in columns 1 and 2 are used to identify the line numbers and street sewer name.

b. The entries in columns 3 through 5 are used to identify the sewer manholes, their numbers and the spacing between each two manholes.

c. The entries in column 6 used to identify unit sewage. the unit sewage for year 2036 which is equal (80% * 120 * future density this area divided by area).

d. The entries in columns 7 and 8 are used tributary area, column 7 used incremental area, column 8 used total area in dounm.

e. To calculate municipal maximum flow rates columns 9, 10, 11 are used. Column 9 is municipal average sewage flow (unit sewage *total area), the peak factor column 10 is calculated using equation 4.2 as: $P_f = 1.5 + 2.5/ \sqrt{q}$, where q = Average wastewater quantity sewage flow (Column 9).

f. Column 11 used to calculate the Q max in year 2013, the value of it comes from multiply column 10 * column 9. Column 12 calculate the infiltration which equal to 10% of $Q_{average}$ (10% * column 9).Column 13 used to calculate total average which is equal to column 9 + column 12. Column 14 and column 15 used to show the maximum flow design for year 2011 which is come from column 11 + column 12.

The quantity of waste water for the main trunks is calculated andit's shown on tables in (Appendix A).

To make Design for the collection system Sewer CAD used to option the pipe slopes diameters and to prepare the profile drawings for all line . Section 4.5 show the basics of Sewer CAD .

Santary r3.1 line sample

Table of sanitary sewar design for 3.1

SewerCAD Program Works **٤.٥**

4.5 Sewer CAD Program Works :

- Open SewerCAD, select file → import →DXF Background to import the DXF file, figure (4.5) below shows this step.

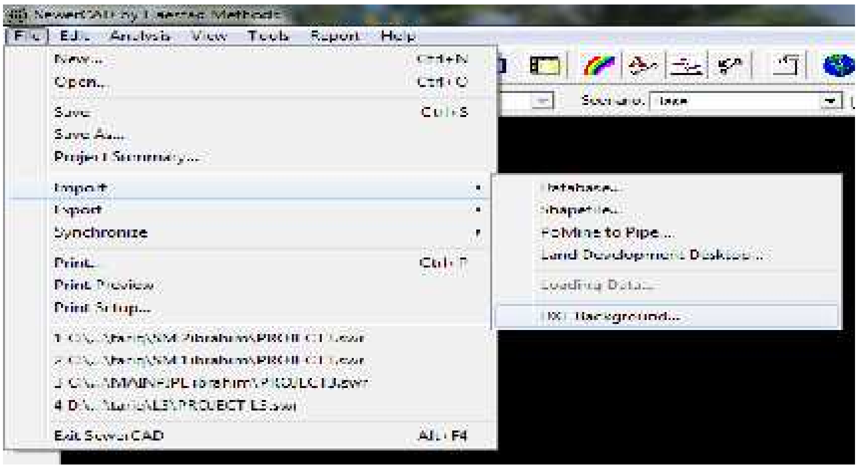

Figure (4.5) Importing DXF File

- Specify file locationandthen press open, figure (4.6) below shows this step.

Figure (4.7) shows a line example.

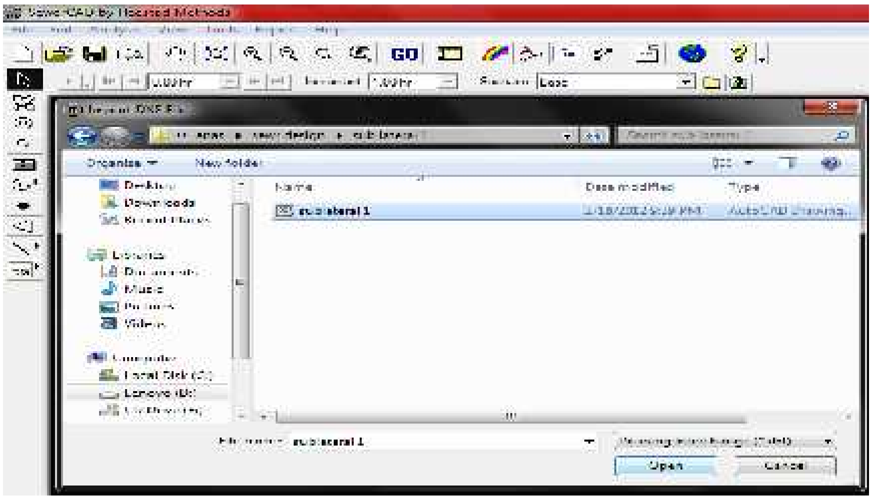

Figure (4.6): Opening The DXF File.

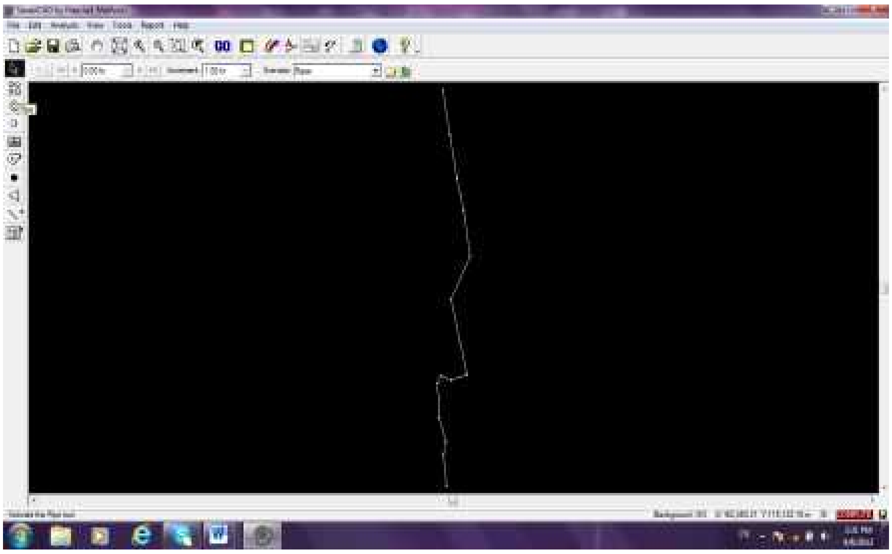

Figure (4.7): Line Example

- Press pipe icon, a massage will appear tell you to create a project see figure (4.8).

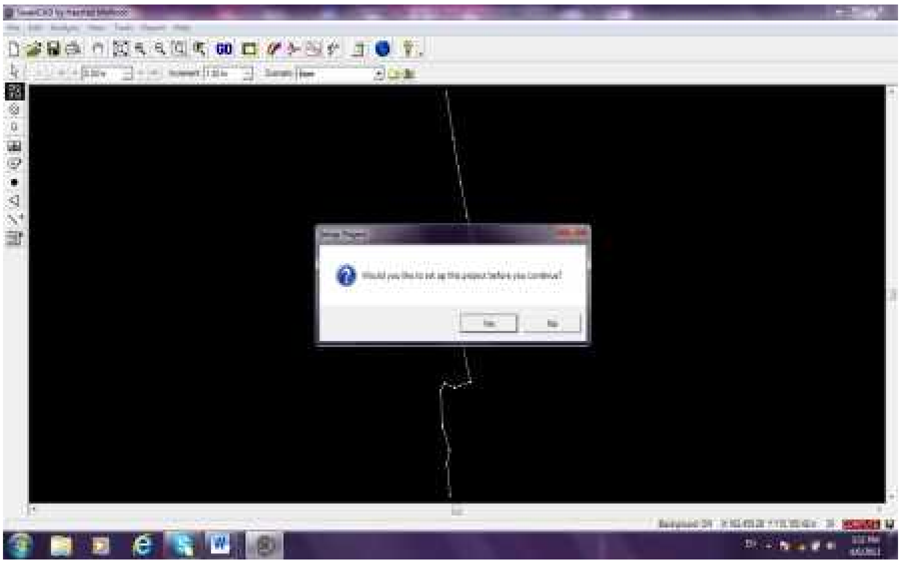

Figure (4.8): Creating Project

- Press yes and define the project then press next twice, then select finish, the figure (4.9) below shows this step.

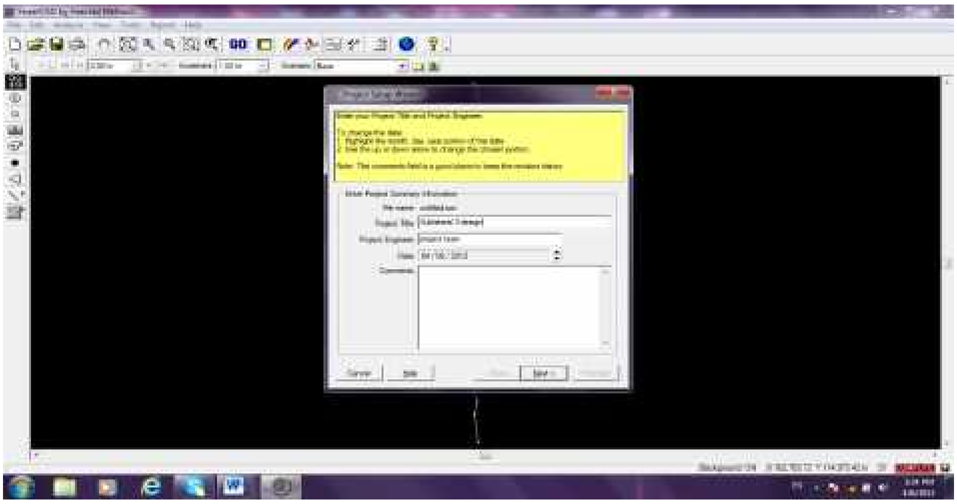

Figure (4.9): Defining The Project

- Press pipe icon and connect between manholes, figure (4.10) below shows the step.

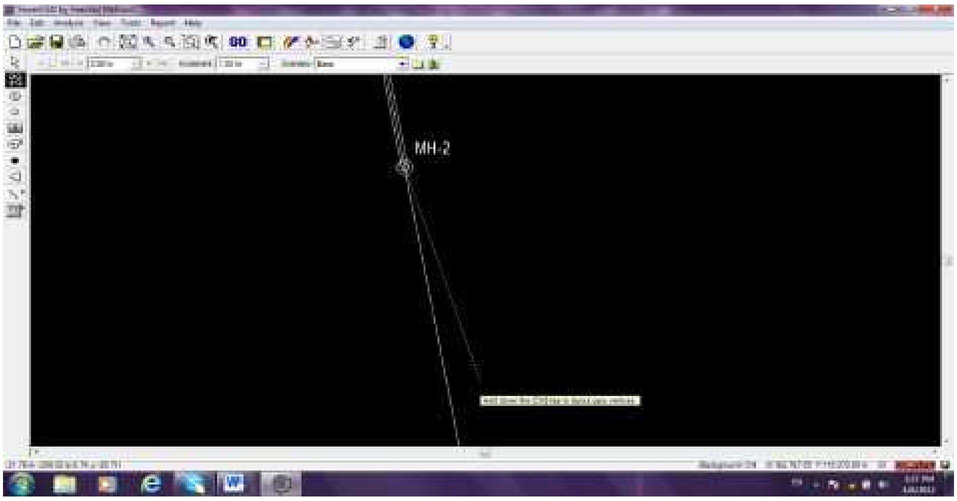

Figure (4.10) Creating a pipe network.

- After you connect between all manholes, press on the outlet icon and click on the last manhole, then press yes to replace the manhole with outlet, the figure (4.11) below shows the step.

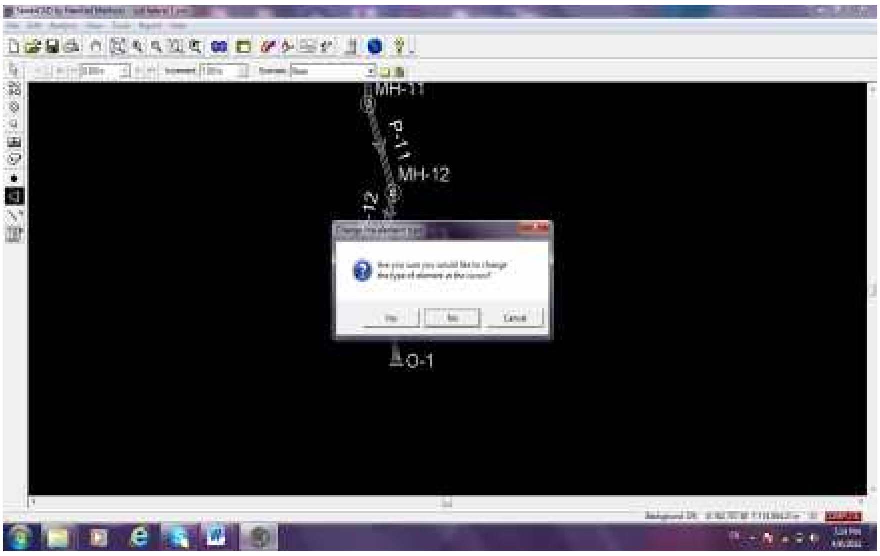

Figure (4.11): Creating Outlet

- Save your project, then select analysis → alternatives → physical properties → edit, then start editing gravity pipe, see figure (4.12).

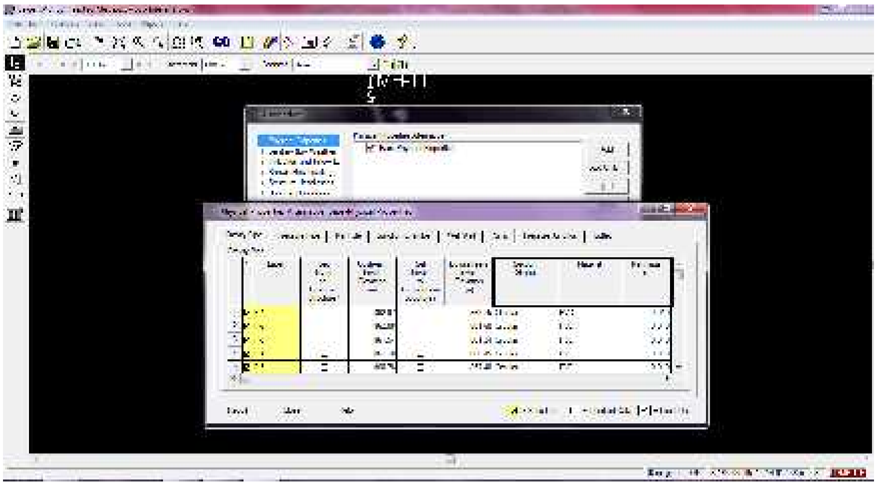

Figure (4.12): Editing Design Parameters – Part1

- Select manhole to enter the ground elevations of manholes, then select outlet to enter its elevation. Then press close. Figure (4.13) below shows the step.

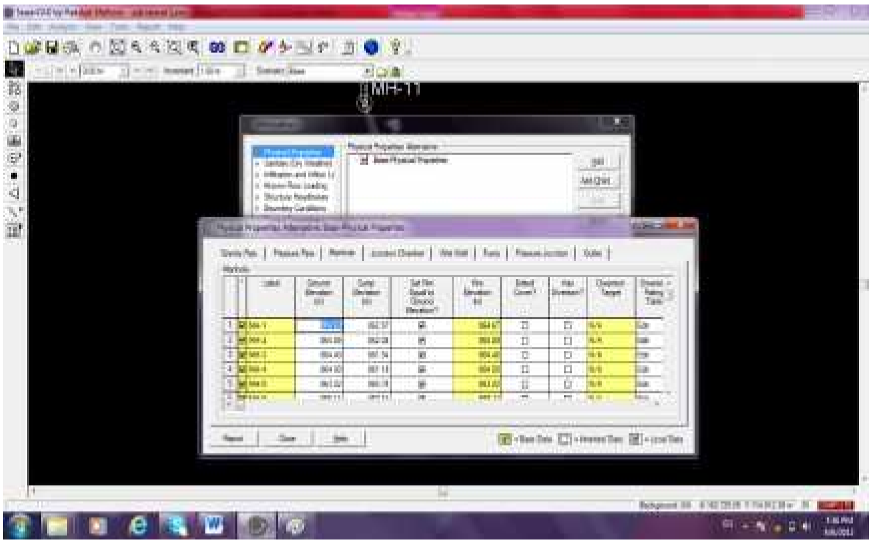

Figure (4.13): Editing Design Parameters– Part2

- Select sanitary (dry weather) → edit → manhole to select the type of load and to enter the load for each manhole, figure (4.14) below shows the step.

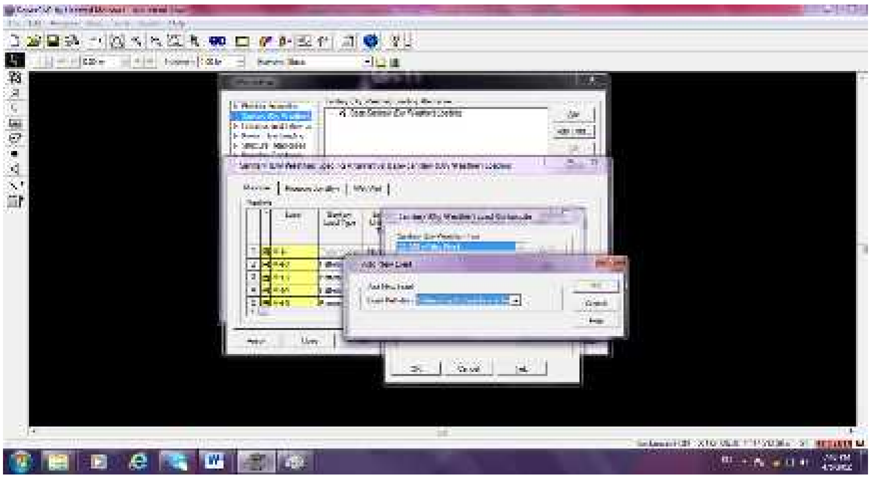

Figure (4.14): Editing Design Parameters– Part3

- After doing this for each manhole press close, then select design constrains → edit to enter the design specifications, figure(4.15) below shows the step.

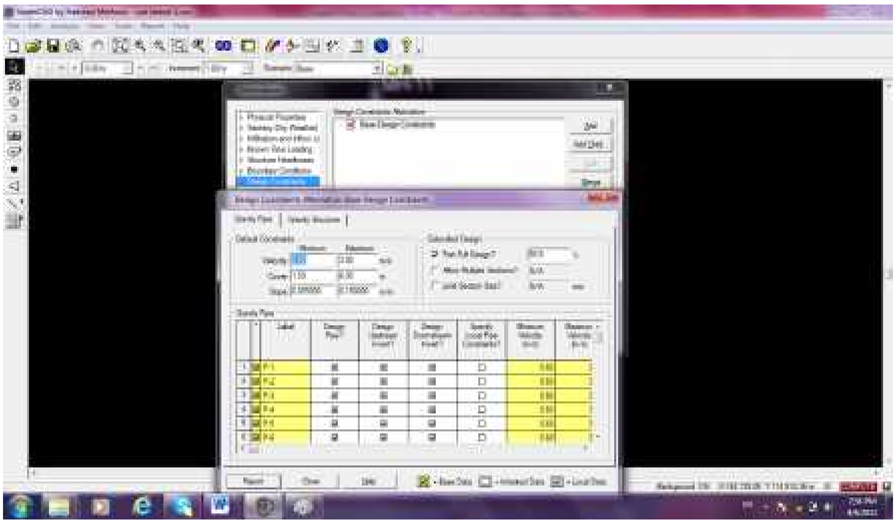

Figure (4.15): Editing Design Parameters– Part4

- Last step press save, press GO button to start design then press on GO, figure (4.16) below shows the step.

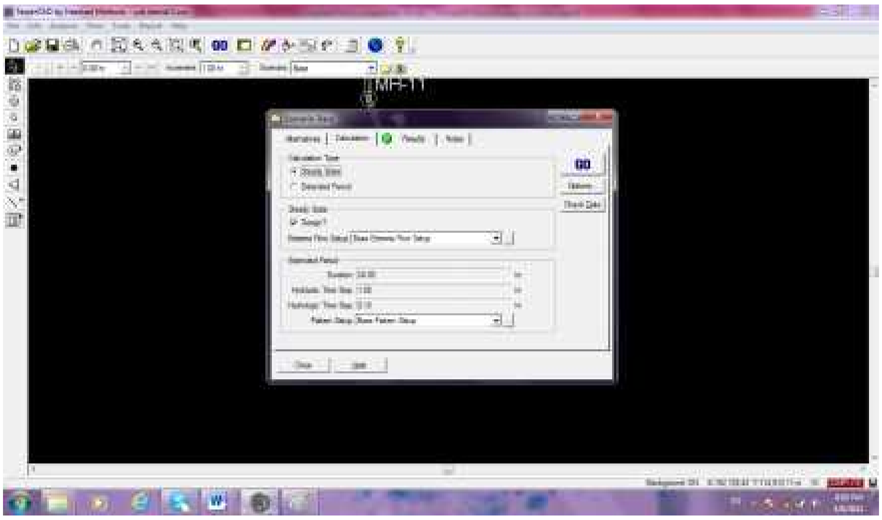

Figure (4.16):Checking The Design

- 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.
- After finishing design work we need to show the pipe line profile and the profile, gravity pipe report and gravity node report. Press profile button to make the profile see figure (4.17), here we should put the scale of the profile.

- The profile for line 4.2 sampleshown in (Figure 4.18).

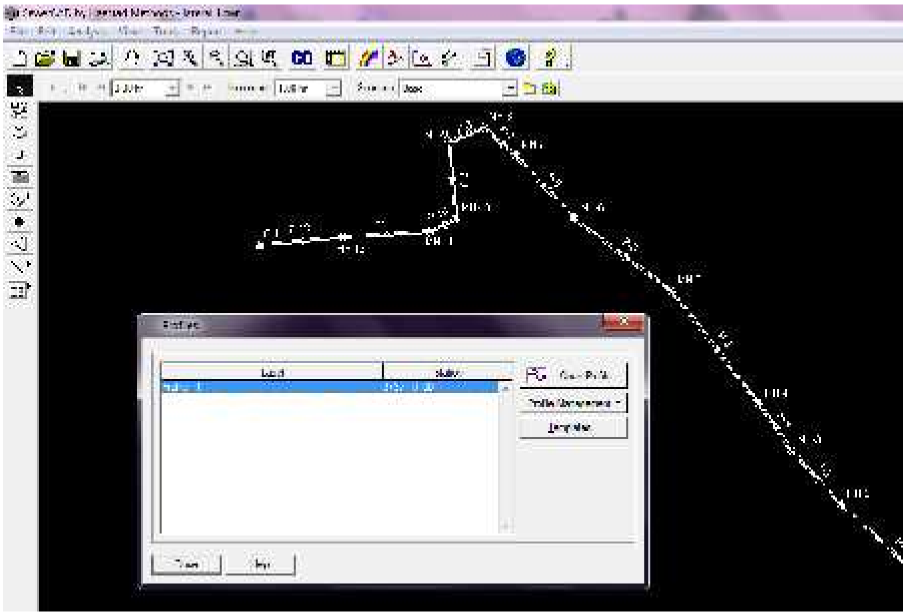

Figure (4.17): Creating Profile

- We can get the required tables by pressing tabular report button see figure (4.19), and then choose gravity pipe report and gravity node report.
- The required tabular reports for line 4.2 sampleshown in table(4.3).

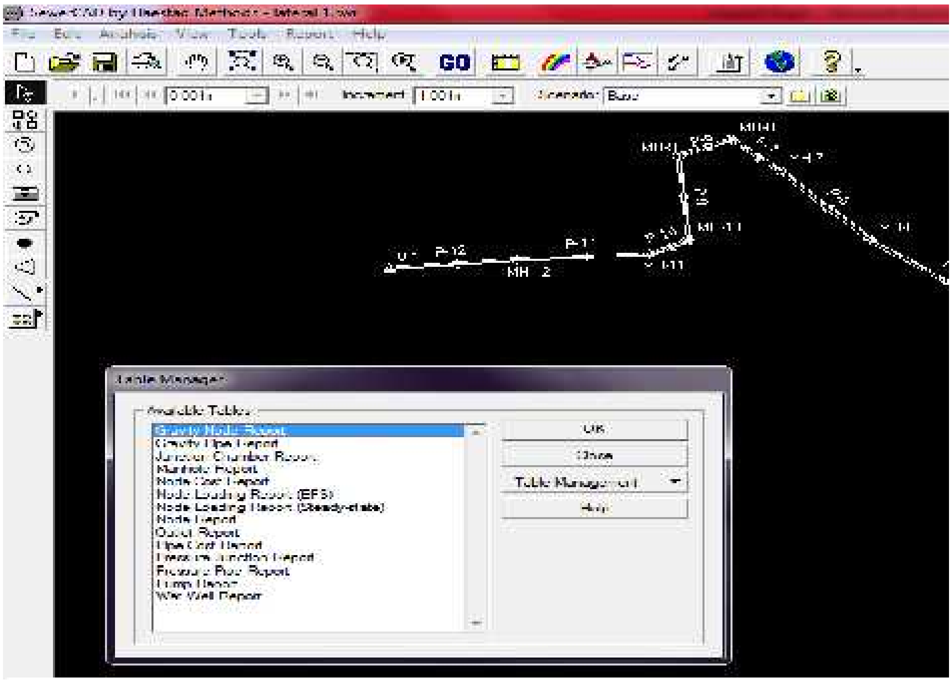

Figure (4.18) :Creating Tables

Sample calculation for pipes diameters ,slopes,velocities and profile are calculated using Sewer CAD it's shown on tables (4.3) and the profile drawing shown in figure (4.19) . calculation and drawings for all other lines are shown in (Appendix B)and the profiles for all lines are shown in (Appendix C).

5.1 BILL OF QUANTITYFOR THE PROPOSED WASTEWATER 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 8 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	12123				
A2	Excavation of pipes trench in all kind of soil for one pipe diameter 10 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	673				
A3	Excavation of pipes trench in all kind of soil for one pipe diameter 12 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	1293				
A4	Excavation of pipes trench in all kind of soil for one pipe diameter 15 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	7825				
A5	Excavation of pipes trench in all kind of soil for one pipe diameter 18 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	89				

Sub-Total							
B	**PIPE WORK**						
B1	Supplying, storing and installing of uPVC	LM	18182.5				
Sub-Total							
C	**PIPE BEDDING AND BACKFILLING** **Dimension and material**						
C1	Supplying and embedment of sand for one pipe diameter 8 inch, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	12123				
C2	Supplying and embedment of sand for one pipe diameter 10 inch, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	873				
C3	Supplying and embedment of sand for one pipe diameter 12 inch, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	1293				

C4	Supplying and embedment of sand for one pipe diameter 15 inch, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	782.5				
C5	Supplying and embedment of sand for one pipe diameter 18 inch, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	89				
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	384				
D2	Supplying and installing of precasted manhole including excavation pipe connection, epoxytar coating, 25-ton cast iron cover and backfill, size 1000mm, depth up to 2.5m.	NR	49				
Sub-Total							
E	**Concrete Surround**						
E1	Suppying and installing of reinforced concrete (B 200) protection concrete encasement for sewer pipe.	LM	18182.5				

Sub-Total							
F	**Air And Water Leakage Test**						
F1	Air leakage test for sewer pipe lines 8,10,12,15 and 18 inch according to specifications, including for all t emporary works.	LM	18182.5				
F2	Water leakage tests for manholes, depth up to 1.00 meter according to specifications.	NR	384				
F3	Water leakage test for manholes , depth up to 2.5 meter according to specification	NR	49				
Sub-Total							
G	**Survey work**						
G1	Topographical survey required for shop drawings and as built DWGS using absoluet Elev. And coordinate system	LM	18182.5				

CHAPTER SIX

CONCLUSION

In this project, the trial is made to design waste water collection system for Idhna town considering the annual growth of the people and their water consumption for the coming 25 years,and catchment area. The result brought out many important conclusions. The main conclusions drawn from the present study are summarized below:

1. Idhna town like other twons in Palestine has no sewage facility. The people are using laterains cesspits and septic tanks. The waste water has been seeping into the ground through the over flow of the deteriorated cesspits and laterains, causing series environmental and health problem.

2. the proposed waste water collection system for Idhna Town covers most of the areas of the Idhna.

3. The present water consumption of Idhna Town is 80 L/c.day and the future water consumption is estimated to be 120 L/c.day depending on 3.5 % increase use rate.

4. The proposed waste water collection system for Idhna Town is running by gravity Except in The place called Abu Madi it must use pumps.

5. The proposed waste water collection system for Idhna Town having for4 main trunk main trunk 1, main trunk 2, main trunk 3,and main trunk 4.

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APPENDIX A

CALCULATION TABLES

APPENDIX B

CALCULATION TABLES FROM SEWERCAD

APPENDIX C

PROFILES DRAWING FOR ALL LINE