DESIGN OF WASTEWATER COLLECTION SYSTEM FOR DORA CITY

BY

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Submitted to the College of Engineering
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CERTIFICATION

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The Senior Project Entitled:

DESIGN OF WASTEWATER COLLECTION SYSTEM FOR DORA CITY

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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 Civil Engineering.

Project Supervisor **Department Chairman**

Dedication

To Palestine…

To our parents…

To the soul of Martyrs…

To our teachers…

To our friends…

To whom we love…

To every one who gave us help…

To Eng.SAMAH AL-JABARI

Thank you deep from our hearts for all support that

You have given to us.

Work Team

A KNOWLEDGEMENT

We would like to thank and gratitude to Allah, who gives us, the most Merciful who granted us the ability and willing to start project.

We thank “Palestine Polytechnic University”,” Departement of civil and architectural engineering” and wish to it more progress and success ,We express our thanks to “Eng. Samah Al-Jabari”, who gave us knowledge, valuable help, encouragement, supervision and guidance in solving the problems that we faced from time to time during this project. We also thank Dora municipality for there precious help.

Finally our deep sense and sincere thanks to our parents, brothers and sisters for their patience, and for their endless support and encouragement also for every body who tried to help us during our work and gave us strength to complete this task.

Work Team

ABSTRACT

DESIGN OF WASTEWATER COLLECTION SYSTEM FOR DORA CITY

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The disposal of raw wastewater without treatment creates major potential health and environmental problems. In Dora city, the sewage facilities do not exist.
The People disposal sanitary waste in cesspits, latrines and open drains. The wastewater has been seeping into the ground through the overflows of the deteriorated cesspits and latrines causing serious environmental and health problems.

The People are using cesspits, latrines and septic tanks. These latrines and cesspits are deteriorating and they are in bad condition, adding to this the increasing in water consumption and consequently increasing in wastewater production, resulting in over flows from the cesspits and recharges of ground water in Dora city.

This study is showing the design wastewater collection system for Dora city, which cover all of the city with four main trunks and three sub-main ,which flowing by gravity without pumping.

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CHAPTER ONE

1 INTRODUCTION

1.1 General

Drainage is the term applied to systems for dealing with excess water. It is importante for the disposal of surplus irrigation water, storm water, and wastewater.Water drainage is a natural phenomenon which takes place naturaly and depends on the geomorphological and hydrological features, water drainage is often considered as minor problem, but with rapid increase in population and concequent in all round activities of man, the problem has been Exacerbated.

The wide expansion and accelerated development of Dora city had led to change in the hydrological and geomorphological features and the drainage system had become more complex, hence the amount of wastewater and running water has increased. At the same time wastewater collection system are not exist.

In view of this prevailing condition, the drainage system in Dora city would have a new characteristics . This study is conducted to design a wastewater collection system for Dora city.

Dora like other Cities in Palestine have no sewerge facility. The people are using latrines, cesspits and few of them use septic tanks, which are emptied by cesspit emptier and tankers from time to time. These latrines and cesspits are deteriorating and they are in very bad condition, adding to this the increasing water consumption and consequently increasing in wastewater production resulting in over flows from the cesspits and excessive recharge of ground water in Dora area. For all the reasons mentioned, this evaluation and design of wastewater collection system for Dora have been conducted.

1.2 Problem Definition

The acceleration expansion and developed of Dora has 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 deteiorated cesspits and latrines that are commonly used in Dora Moreover, in some areas wastewater is flows to the wadis through open drains in different routes causing serious environmental and health problems.

The main damaging consequences of these wastewater routes are offensive adors and smells, proper media for breeding of mosquitoes, soil contamination and polluting of the existing aquifers. The municipality of Dora is receiving on daily bases complains from the people asking a comprehensive solution for the wastewater problems in the city.

In view of these bad conditions, and since there is no seweage networks exist, along with fast increasing of the environmental and health problem. The design of wastewater collection system study become a pressing necessity so as to solve all problems that were 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, along with the commercial industrial development in the area .

1.3 Objecives Of The Project

The main objectives of this project are:-

1. Division of Dora area into catchment and sub-catchment areas according to existing situation and the topographic maps and classifying them into classes.
2. Estimation of population and their densities for the design period for each catchment area.
3. Determination of the water consumption and consequently the wastewater production from the different sources for each catchment area.
4. Evaluation of the collected data, propose collection system of the city and design of the main trunks of the network.
5. Showing the proposed wastewater network its parts on different maps for different purposes.
6. Preparation of Bill of Quantities for the main trunks.

1.4 Methadology

1. Many site visits to Dora city and Municipality were done.
2. All needed maps and the previous studies that contain different information about Dora were obtained.

3. The amounts of water consumption for different purposes and consequently the amounts of wastewater production for each area were obtained.
4. The different layouts of the proposed wastewater collection system were ploted.
5. The necessary hydraulic calculation for the systems and other design requirements were carried out.
6. Bill of quantity of the designed wastewater main trunks were prepared with needed recommendations.
7. Finalizing of the project that will contain the report and the needed maps and drawings.

1.5 Phases Of The Project

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

TABLE 1.1:- Phases Of The Project WithTheir Expected Duration

Title	Duration							
	9/14	10/14	11/14	12/14	2/15	3/15	4/15	5/15
Data collection and survey								
Preparing layout for wastewater collection system and collect the amount of wastewater								
Design of wastewater 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 the city and the municipality were done. This phase include the following tasks.

1. Collecting of topographical maps for all the area.
2. Collecting of meteorological and hydrological data(temperature, wind , speed, rainfall, evapoeration…etc) from different sources.
3. Evaluation of population densities in each zone of the city with their water consumption and predicting their numbers, densities and their water consumption in year 2039.

1.5.2 Second Phase:- Preparing Layout For The Network And Calculate The Amount Of WasteWater .

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

This phase include the following tasks:

1. Draw the layout of the network and compare it with the real setuation in Dora city then make adjusment and last draw the final layout , this task is the most improtant.
2. Evaluation of the contour maps and matching it with actual ground levels in the city.
3. Determination of the wastewater quantities.
4. Determination of the wastewater quantities and projection of the wastewater production in year 2039.

1.5.3 Third Phase:- Design Of WasteWater Collection Systems

In this phase the necessary hydraulic calculation needed for the design of the main trunks were carried out. This phase include the following tasks:

1. Establish a system layout, which includes the areas that are going to be served, 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 Other Needed Jobs

After finishing the design calculation of the main trunks the project team prepared the specifications drawing, bill of quantities and preliminary maps.Final report of the project was 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 scope of work. The report consists of five 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 Bill of quantities deals with the quantities of pipes manhole excavation, backfilling and…etc.

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

CHAPTER TWO

2 CHARACTERISTICS OF THE PROJECT AREA

2.1 General

In this chapter, the basic data of Dora city will be briefly discussed. The topography, population water consumption, and wastewater production will be briefly presented.

2.2 Project Area

Dora situated 9 Km to the west of Hebron city, as shown on the project location plan Figure (2.1), and the location of city respect to other cities is shown on Figure (2.2) .

The average hight of the city is 839 m with respect to sea level, the ground elevations range from 910 m in east of the city to around 700 m in the north part of the city. The topography within the city is mountainous . as shown on Figure (2.3).

The population within the municipal administrative borders in year 2014 is around 27556 persons Living on an area of 15260 donum.. This population is expected to grow substantially up to the year 2039 planning horizon of this project.

2.3 Land Use

As mentioned earlier, the land area of Dora city is approximately 15260 donum. There is no clear town plan defining land use in the various zones of Dora. The land use can be distributed as follows:-

1. Old city : This area is consists of old buildings which have a historical importance, these buildings are used as resedinces, workshops, public building, and cemetry. Some of these buildings are very old and need to be maintained.
2. Old city surrounding: is distributed as follow

:-

3. Residential areas, food stories, workshop building, public buildings.
4. Agricultural areas.
5. Roads.

The land use of Dora shown in Figure (2.4).

2.4 Meteorological Data

The hydrology of the region depends primarily on its climate, and secondarily on its topography. Climate is largely dependent on geographical position of the earth surface humidity, temperature, and wind. These factors affect 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 Dora city tends to be cold in winter with good amount of rain, and warm in summer with relative humid.[4]

2.4.1 Temperature

Based on information obtained from Dora municipality ,The temperature is characterized by considerable variation between summer and winter times. The mean temperature values at Dora for the period 1995 to 2000 are given in below.[4]

- The Mean maximum temperature: 31˚C
- The Mean minimum temperature: 8˚C
- The Mean Maximum temperature record: 30˚C
- The Mean Minimum temperature record: 4.4˚C

2.4.2 Relative Humidity

Since Dora is situated at considerable distance from the sea in a mountains region, Dora has low values of relative humidity compared to those in the plains. The relative humidity in Dora city range from 54-78%, it reaches the maximum value in January (78%).[4]

2.4.3 Wind

The directions and velocities of wind vary depending on the season of the year. In winter, the wind blows in the morning from the southwest a rounds noon from southwest and west, and at night from west and northwest. In summer, northeasterly wind blows all day long. According to data obtained from Meteorological Station, average wind in winter is about 9.8km/h and in summer 5.4km/h.[4]

2.4.4 Rainfall

Based on information obtained from Dora municipality ,The average annual rainfall in Dora city for the last five year is approximately 400-500 mm. The maximum annual rainfall in the period from 2005 to 2010 is 330.1 mm. This was in year 2005/2006.The minimum annual rainfall is 268.8mm, which was in the year 2009/2010 Table (2.1) shows the monthly rainfall and number of raining days during the period from 2005-2010.[4]

Table 2.1 Monthly Rainfall And Number Of Raining Days During The Period From 2005-2010

Year / Month	2005/2006		2006/2007		2007/2008		2008/2009		2009/2010		5- Years Average Rainfall mm
	Monthly Rainfall mm	No. Of Raining Days	Monthly Rainfall mm	No. Of Raining Days	Monthly Rainfall mm	No. Of Raining Days	Monthly Rainfall mm	No. Of Raining Days	Monthly Rainfall mm	No. Of Raining Days	
September	0	0	0	0	0	0	0	0	0	0	0
October	5	1	4.5	1	5.5	2	5	1	6	1	5.2
November	6	2	4	2	5	1	0	0	0	0	3
December	85	7	80	6	73.5	5	70	5	63.9	4	74.48
January	79.5	10	75.5	6	72.3	6	70.1	7	70.5	8	73.58
February	75.5	9	75.1	8	75.5	7	73.1	8	72.4	8	74.32
March	39.5	5	35.2	3	30.3	2	26.9	3	26.6	4	31.7
April	35.6	2	31.8	3	29.6	2	31.2	3	29.4	2	31.52
May	4	1	3	2	2	1	0	0	0	0	1.8
Total	330.1	37	309.1	31	293.7	26	276.3	27	268.8	27	295.6

CHAPTER THREE

3 DESIGN CRITERIA

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, and (5) intercepting 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 (Qasim, 1985).

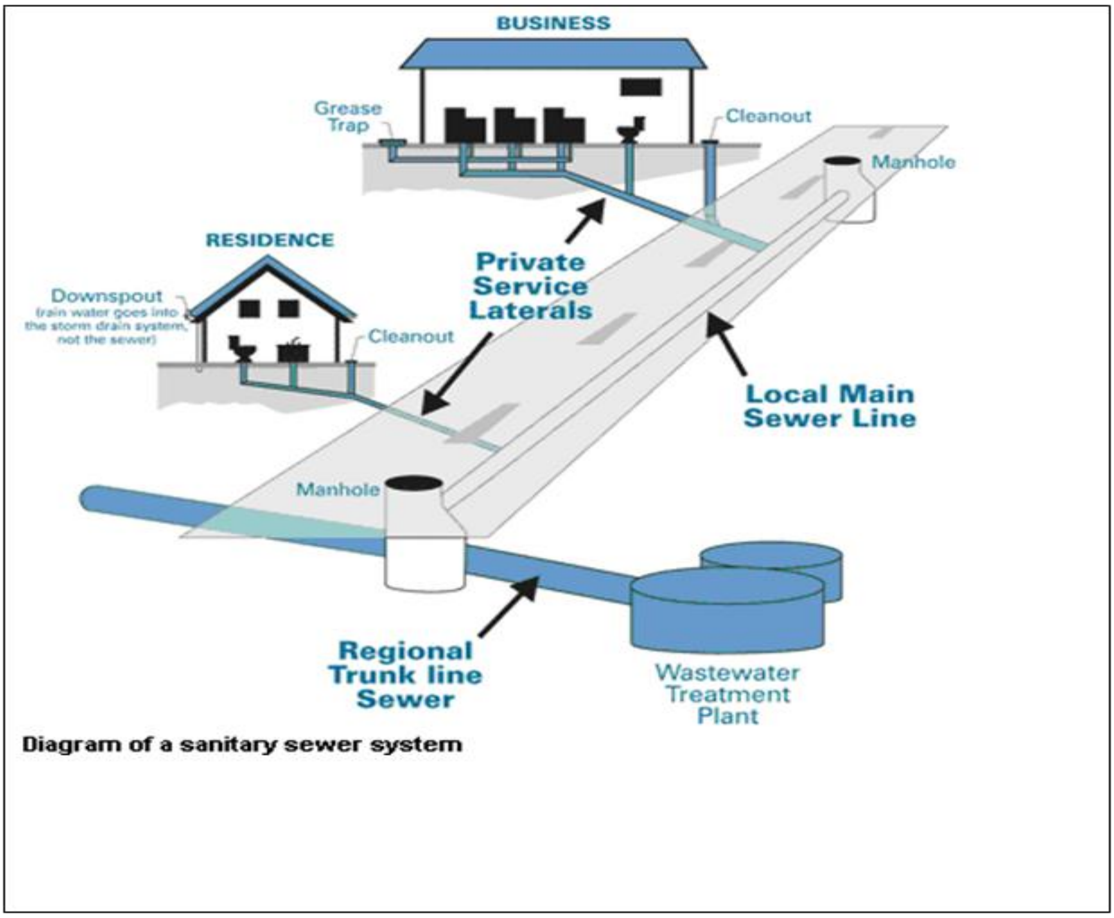


Figure (3.1): Types Of Sewers Used In Wastewater Collection System

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 (8 in).

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 polyvinyl chloride (PVC) or ultra polyuinyl chloride (uPVC). 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 velocities for the transportation of sediment. These velocities are 0.6 to 0.7 m/s when sewers are flowing full or half-full. Manholes are provided at regular intervals for the cleaning of sewers.

3.3.2 Pressure Type System

Collecting wastewater only. The system, which is entirely kept under pressure, can be compared with a water distribution system. Sewage from an individual house connection, which is collected in manhole on the site of the premises, is pumped into the pressure system. There are no requirements with regard to the gradients of the sewers.

3.3.3 Vacuum Type System

Collecting wastewater only in an airtight system. A vacuum of 5-7 m is maintained in the system for the collection and transportation of the wastewater. There is no special requirement for the gradients of the sewers.

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 90-180 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 90-180 m depending on the size of sewer and available size of sewer cleaning equipment (Qasim,1985).

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

Adrop 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.

3.4.2 House Connections

The house sewers are generally 10-15 cm in diameter and constructed on a slop of 0.02 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 (Qasim, 1985).

3.4.3 Inlets

Inlets are structures through which storm water enters the sewers. Their design and location require consideration of how far water will be permitted to extend into the

Street under various conditions. The permissible depth of water in the gutter is limited to 150 mm on residential streets and to that depth, which will leave two lanes, clear of standing water on arterials and one lane on major streets (Mc Ghee, 1991).

3.4.4 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 (Mc Ghee, 1991).

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 (Mc Ghee, 1991).

3.4.5 Sewer Outlets and Outfalls

Storm water and treated wastewater may be discharged to surface drainage or to bodies of water such as lakes, estuaries, or the ocean. Outlets to small streams are similar to the outlets of high way culverts, consisting of simple concrete headwall and apron to prevent erosion. Some wastewater treatment plants are located at elevations, which might be flooded. Present regulations require that sewage treatment works be protected against a 100-year flood, which may require levees around low-lying installations and pumping of the treated flow when stream levels are high. Gravity discharge line in such circumstances must be protected by flap gates or other automatically closed valves, which will prevent the stream flow from backing up into the plant (Mc Ghee, 1991).

Sewers discharging into large bodies of water are usually extended beyond the banks into fairly deep water where dispersion and diffusion will aid in mixing the discharge with the surrounding water. The outfall lines are constructed of either iron or reinforced concrete and may be placed from barges or joined by divers. Iron is generally preferred for outfall 610 mm in diameter or less. In bodies of water which are sufficiently large to permit heavy wave action. The outfall may be protected by being placed in a dredged trench or by being supported on pile bents. Subsurface discharges normally employ multiple outlets to aid in distribution and dilution of the wastewater (Mc Ghee, 1991).

3.4.6 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 one 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 elevation of the treatment plant (Mc Ghee, 1991).

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 larger and less efficient than vaned designs (Mc Ghee, 1991).

Sewage pumping stations within the collection system include a wet well, which serves to equalize the incoming flow, which is always variable. Although pumps that can operate at variable speed are available, their cost and the complexity of their control systems generally make them an expensive alternative. Ordinary constant-speed pumps with standard motors should not be turned on and off too frequently since this can cause them to overheat. In small pumping stations there may be only two pumps, each of which must be able to deliver the maximum anticipated flow. Lower flows are allowed to accumulate in the wet well until a sufficient volume has been accumulated to run the pump for about 2 min. The wet well may also be sized to ensure that the pump will not start more often than once in about 5 minutes. The specific values of running time and cycle time depends upon the characteristics of the motor used and must be obtained from the manufacturers (Mc Ghee, 1991).

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 a sewer remains constant (Metcalf,1982).

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 formula: Using the Chezy equation, the velocity of flow in sewers can be determined according to

$$V = C\sqrt{RS} \tag{3.1}$$

Where V is the velocity of flow, C is the Chezy coefficient ($C = 100\, R/(m+ \sqrt{R})$, where m = 0.35 for concrete pipe or 0.25 for vitrified clay pipe), R is the hydraulic radius, and S is the slope of the sewer 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

$$H = \lambda\, L*V^2/(D*2g) \tag{3.2}$$

Where H is the pressure head loss in mwc, L is the length of pipe, D is the diameter of pipe, λ is the dimensionless friction factor generally varying between 0.02-0.075.

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. Head loss, according to Manning's equation is given by

$$V = 1/n\, R^{2/3}\, S^{1/2} \tag{3.3}$$

Where n is the Manning coefficient (1/n = 75 $m/s^{1/3}$), R is the hydraulic radius = area /wetted perimeter (circular pipe flowing full, R= D/4).
Coefficient of roughness depends on the material and age of the conduit. Commonly used values of n for different materials are given in Table 3.1.

Table 3.1:Common Values of Roughness Coefficient Used in the Manning Equation

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

3.5.3 Hydraulics of Partially Filled Sections

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 sewerage 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 (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.

3.6.1 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 generally a part of the area wide waste management plan.

3.6.2 Preliminary Investigations

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 (Qasim, 1985).

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.

3.6.3 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 (Qasim, 1985):

1. Select the site for 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. Sewers should not be located near water mains. State and local regulations must be consulted for appropriate separation distance between the sewers and water lines.

8. 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.

3.6.4 Selection of Design Parameters

Many design factors must be investigated before sewer design can be completed. Factors such as design period; peak, average, and minimum flows; 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 a design period of 25-50 years or more.

2. **Design Population:** Population projections must be made for the population at the end of the design year. Discussion on population projection can be found in chapter four.

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

4. **Minimum Size:** As mentioned earlier, minimum sewer size recommended is 20 cm (8 in). Many countries allow 15 cm (6 in) 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. In depressed sewers self-cleaning velocities of 1.0 m/s must be developed to prevent accumulation of solids. 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 causes serious pipe corrosion. Methane gas has 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.

Table 3.2: Minimum Recommended Slopes of Sanitary Sewer.

slope	**Diameter**	
mm	**mm**	**inch**
0.006	150	6
0.004	200	8
0.0028	250	10
0.0022	310	12
0.0017	360	14
0.0015	380	15
0.0014	410	16
0.0012	460	18
0.0008	610	24
0.00067	690	27
0.00058	760	30
0.00046	910	36
0.00038	1050	42
0.00032	1200	48
0.00026	1370	54

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 connections, inlets, inverted siphons, outlets and outfall, and others. These are discussed briefly in section 3.4. Appropriate sewer appurtenances must be selected in design of sanitary sewers. Manholes for small sewers are generally 1.2 m in diameter. For larger sewers larger manhole bases are provided. The maximum spacing of manholes is 90-180 m.

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 in various forms is expressed below:

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

$$Q = (0.312\ /n)\ D^{8/3}\ S^{1/2} \quad \text{(circular pipe flowing full)} \qquad (3.4)$$

Where Q is the flow rate.

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 3.2. Hydraulic elements of circular pipes under part-full flow conditions are provided in Figure 3.3. It may be noted that the value of n decreases with the depth of flows Figure 3.2. 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 3.2 and 3.3 are shown in the design calculation in chapter four (Qasim, 1985).

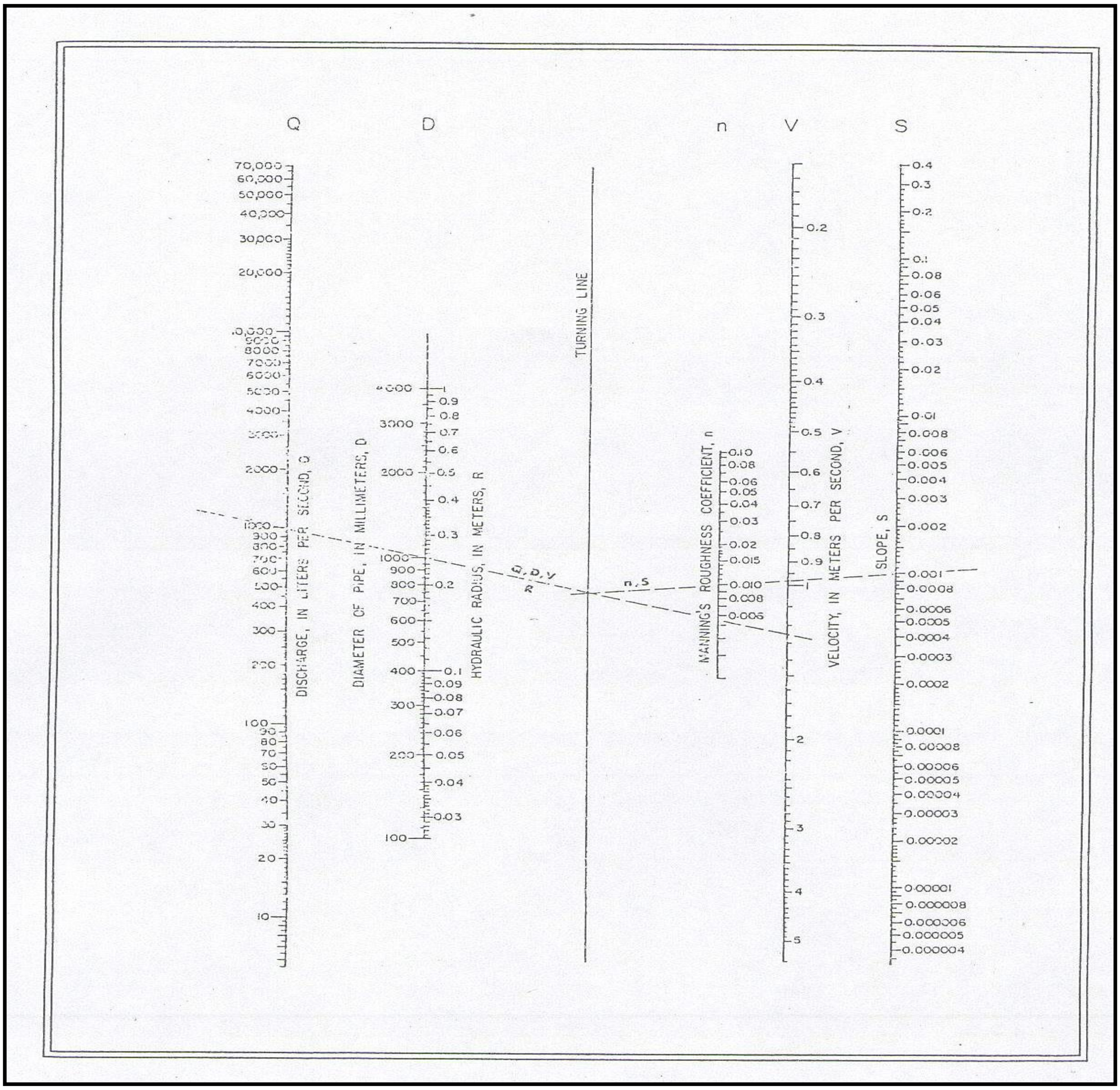


Figure (3.2) Nomograph for solution of manning formula

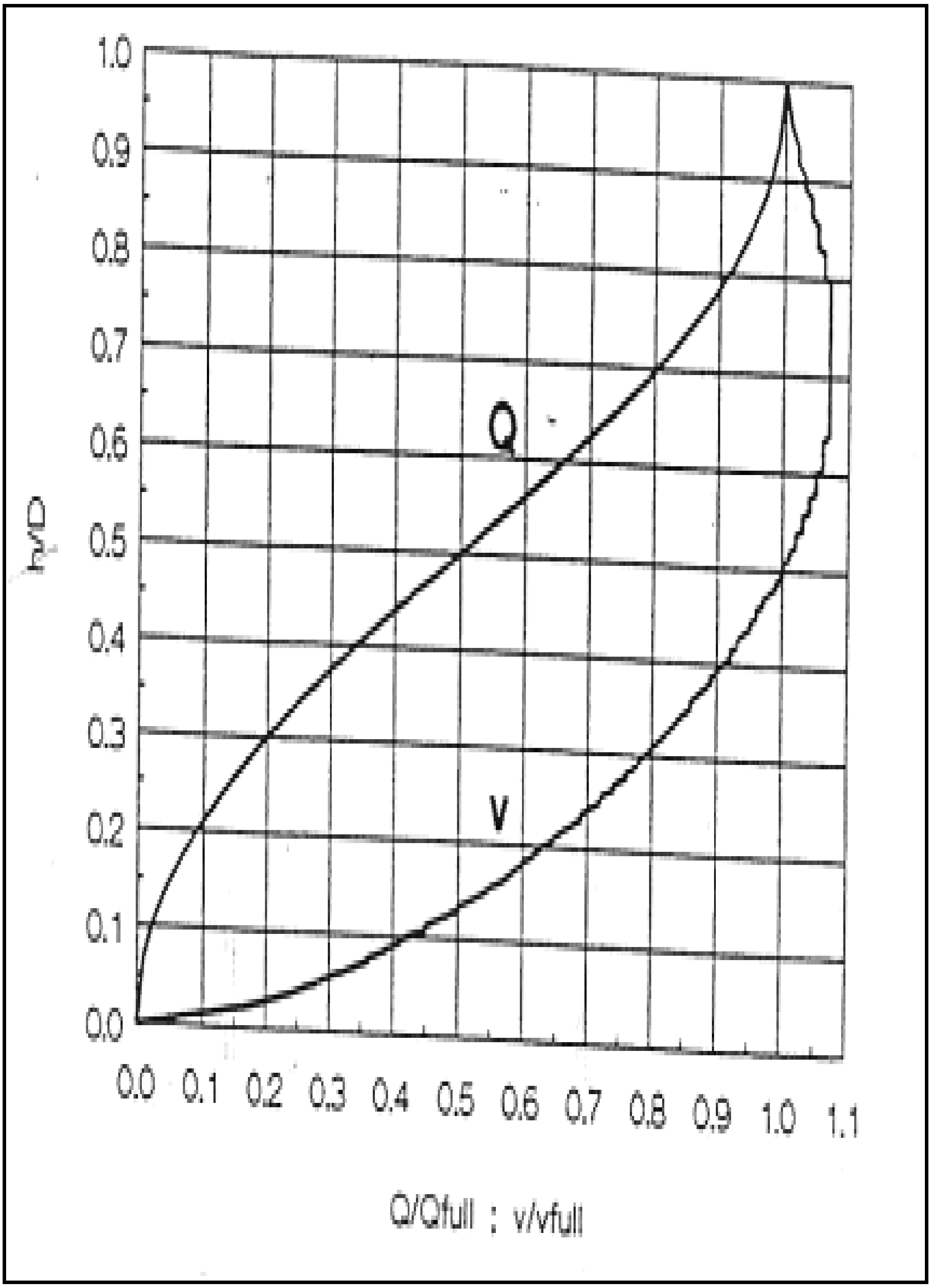


Figure (3.3) Hydraulic properties of circular sewer

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.

3.6.5 Construction Consideration

1. **Construction Materials:** As mention 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. Joints and Infiltration: The method of making joints should be fully covered in the specifications. Joints should be designed to make sewers water-tight, root-resistant, flexible, and durable. A leakage test should be specified. The leakage shall not exceed 0.5 m^3 per day per cm of pipe diameter per Km. It has been experimentally demonstrated that joints made from rubber gasket and hot-poured bituminous material produced almost no infiltration, whereas cement mortar joints cause excessive infiltration.

3. Sewer Construction: Sewer construction involves excavation, sheeting and bracing of trenches, pipe installation, and backfilling. Each of these construction steps is discussed briefly below (Qasim,1985).

- **Excavation**: After the sewer alignment is marked on the ground, the trench excavation being. Machinery such as backhoe, clamshell, dragline, front-end loader or other specialized equipment is used. Hand excavation may be possible only for short distances. Hard rocks may be broken by drilling; explosives may also be used where situations permit.
- **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 sides. Bracing is placing crosspieces extending from one side of 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 boards, 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 specifications.

- **Backfilling:** The trenches are filled immediately after the pipes are laid. The fill should be carefully compacted in layers of 15 cm deep around, under the over the pipe. After completion of the filling, the surface is then finished.

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, slop, pipe size and type, and location of special structures and the appurtenances.

3.6.7 Preparation of Contract Drawings and Specifications

It is important that the detailed drawings be prepared and specifications completed before the bide 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 laying, jointing, appurtenances, and acceptance tests (Qasim, 1985).

3.7 INFORMATION CHECKLIST FOR THE DESIGN OF SANITARY SEWER

Design of sanitary sewers involves preliminary investigations, a detailed field survey, design calculations, and field drawings. The design engineer should be familiar with the service area, the local and state design criteria, and the design procedures. Adherence to a carefully planned sequence of activities to develop sewer design minimizes project delays and expenditures. A checklist of design activities is presented below. These activities are listed somewhat in their order of performance.

However, in many cases separate tasks can be performed concurrently or even out of the order given below.

1. Develop a sewer plan showing existing and proposed streets and sewers, topographic features with contour of 0.5 m, elevations of street intersections, and location of permanent structures and existing utility lines. Mark the proposed sewer lines and tentative slopes.

2- Locate manholes and number them in accordance with a convenient numbering system.

3- Prepare vertical profile showing ground surface, manhole location, and elevation at the surface of each manhole.

4- Determine total land surface area that will be eventually served by different sewer lines.

5- Determine expected saturation population densities and average per capita wastewater flow rate.

6- Estimate peak design flow, peak, average, and minimum initial flows.

7- Reviews design equations and develop hydraulic properties of the conduits.

8- Obtain state standards, sewer codes, or any design and maintenance criteria established by the concerned regulatory agencies.

SUMMARY

In this chapter, municipal sewage collection systems in general have been described. The various types of wastewater collection systems have been narrated. Some literature on the sewer appurtenances has been reviewed. The flow equations of sewer pipes have been brought out. The design and construction of community sewage system has been briefly discussed. Finally the information checklist for the design of sanitary sewers has been pointed out.

CHAPTER FOUR

4 ANALYSIS AND DESIGN

4.1General

In this project, design of wastewater collection system for Dora city will be made, and develop a future plans for construction of the collection system, corresponding to the vision of Dora 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 city of Dora, as well as other Palestinian cities and villages, there is great uncertainty in the political and economical future. The final results of this census show that the total population of Dora is 27600 inhabitants Based on information obtained from Dora municipality.

4.2.2 Population Forecast

The rate of 3.6% per year was used for the future growth of the population of Dora city.[12]

To calculate the population at the end of the design period (year 2039), a geometric increase is assumed, represented by the following equation:

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

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 population projection up to the design horizon of 2039 is shown in table 4.1

Table 4.1:- Population forecasts for Dora city

YEAR	2014	2024	2034	2039
POPULATION	27600	39311	55990	66820

4.2.3 Population Density

In our project the population densities on the city structure plan, which serves for issuing buildings permit. The data obtained for population density from Dora 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 Dora 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 Dora city, there are two points of the first towards Al-Fawwar and the second point towards towards the west .
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 located so as to provide access for maintenance and thus are ordinarily placed in streets or other rights-of-way.

6. 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.
7. 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.
8. The pumping is avoided across drainage boundaries. Pumping stations are costly and add maintenance problems.

The final layout of wastewater collection system of Dora city is illustrated in Figure (4.2), and Figure (4.3).

four main trunks and three sub-main are located on the layout.

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 main sanitary sewer for the area to outfall (line D) shown in Figure (4.4). The following data will be collected and analyzed.

1. For current water consumption uses 70L/c.day.
2. For future water consumption uses 120L/c.day.
3. For current population
4. For future population : using the equation (4.1) .
5. For population growth rate 3.6 %.
6. For design period use 25 years as a design period.
7. The wastewater calculates as 80% of the water consumption.
8. For infiltration allowance use 10% of the domestic sewerage flow.
9. Peaking factor depending on the formula :

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

Where q = average industrial sewage flow.

10. For the hydraulic design equation use the Manning equation with an n value of 0.01. To simplify the computations, we use the tables.
11. Minimum pipe size: The building code specifies 200 mm (8 in) as the smallest pipe size permissible for this situation.
12. Minimum velocity: To prevent the deposition of solids at low wastewater flows, use minimum velocity of 0.6 m/s during the peak flow conditions.
13. Minimum cover (minimum depth of cover over the top of sewer). The minimum depth

of cover is 1.5 m.

Solution :-

1. Lay out the sewer. Draw a line to represent the proposed sewer Figure (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 of Q for the sanitary sewer are presented in Table (4.2) , The data in the table are calculated as follow:
4. The entries in columns 1 and 2 are used to identify the line numbers and street sewer name.
5. The entries in columns 3 through 5 are used to identify the sewer manholes, their numbers and the spacing between each two manholes.
6. The entries in column 6 used to identify unit sewage. Unit sewage = 80% multiplied by the current consumption density divided area in dounm.
7. The entries in columns 7 and 8 are used tributary area, column 7 used incremental area, column 8 used total area in dounm.
8. To calculate municipal maximum flow rates columns 9, 10, are used. Column9 is municipal average sewage flow (unit sewage *total area), the peak factor column 10 is calculated using equation 3.2 as: $P_f = 1.5 + 2.5/ \sqrt{q}$, where q = Average industrial sewage flow (Column 9).
9. Column 11 used to calculate the Q max ,the value of it comes from multiply column 10* column 9. Column 12 calculate the infiltration which equal to 10% $fQ_{average}$ (10% * column 9). Column 13 and column 15 used to show the maximum flow design which is come from column 11+ column 1

The calculation and design tables for the wastewater collection system of Dora city are shown in Appendix A .

We will use Bently Sewer CAD Program in design, The following pages show how to use the program.

4.5 Bently Sewer CAD Program Works:

- Open Bently Sewer CAD, select create new project , figure (4.5) below shows this step.

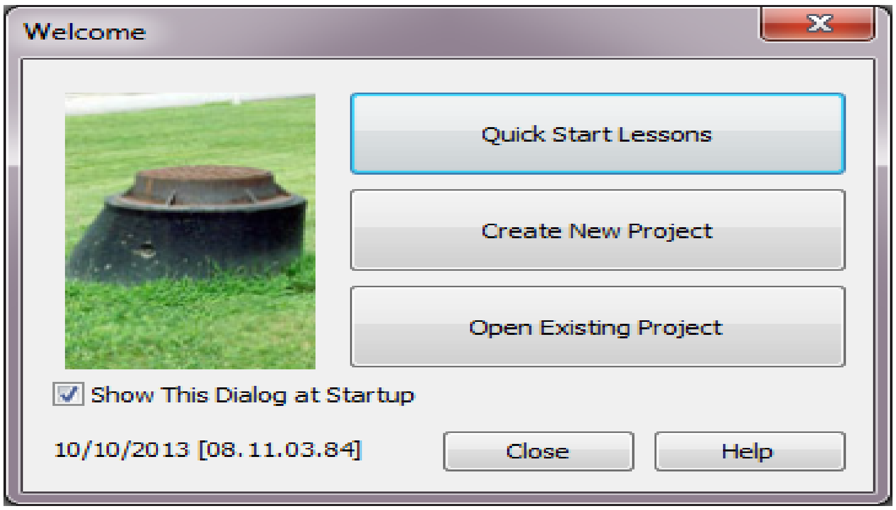


Figure (4.5) create new project

- View →background layers → New → file, figure (4.6) below shows this step.

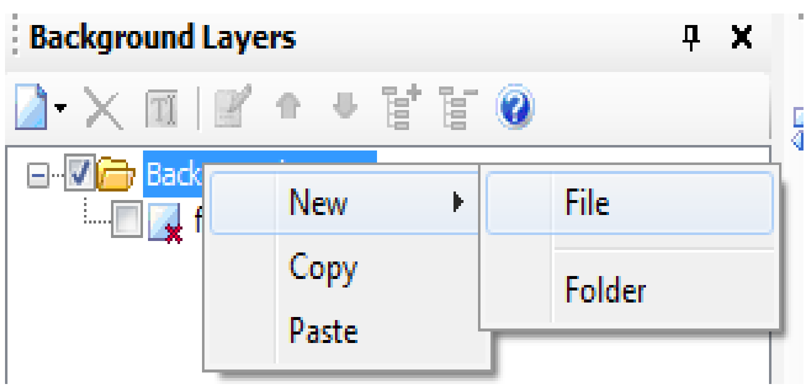


Figure (4.6) Importing DXF File

- Specify file location and then press open, figure (4.7) below shows this step.

  Figure (4.8) shows a line example.

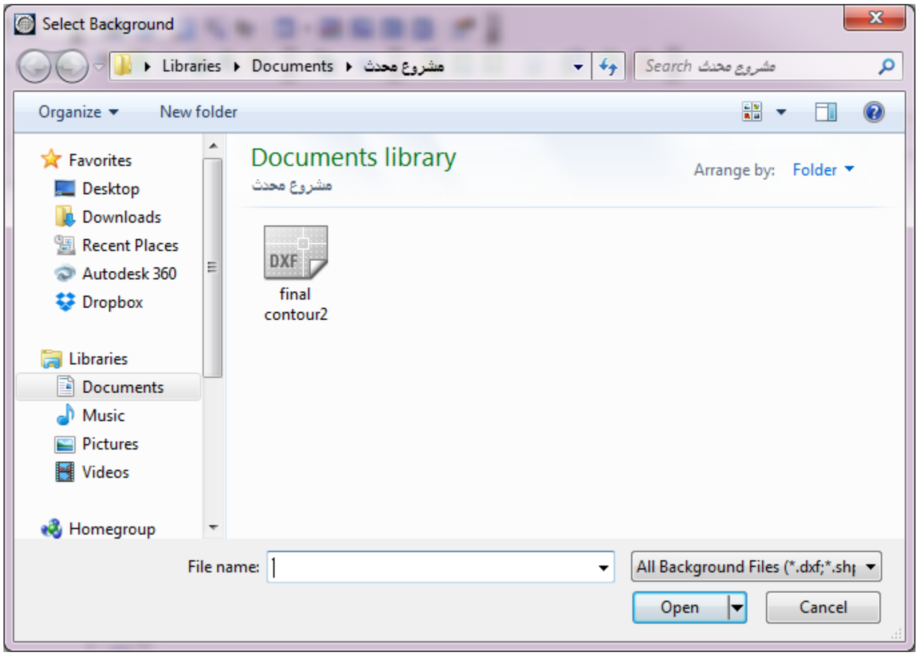


Figure (4.7): Opening the DXF file.

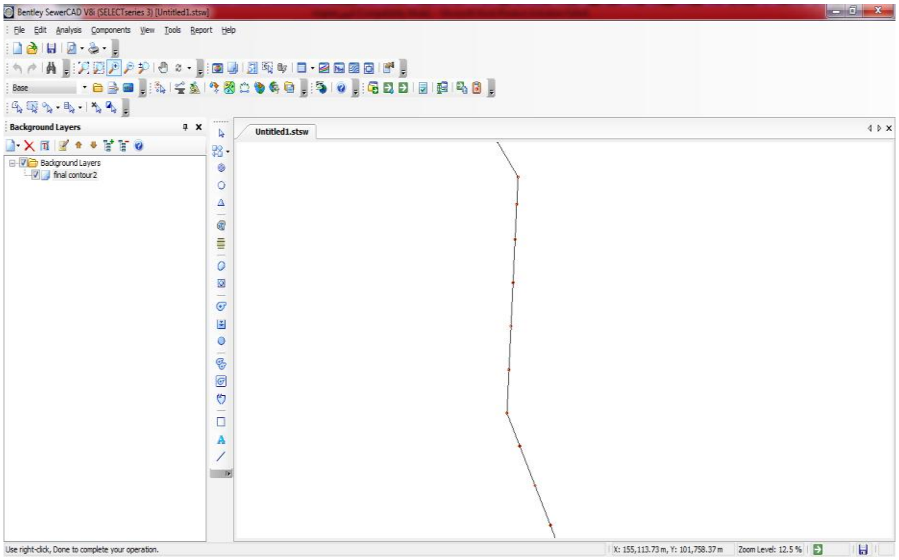


Figure (4.8) : Line Example

- Press conduit icon and connect between manholes, figure (4.9) below shows this step, figure (4.10) shows the result .

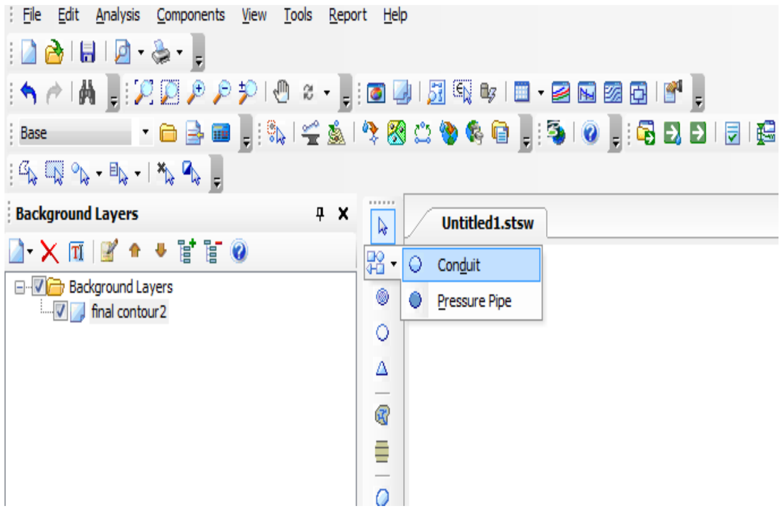


Figure (4.9): Creating a pipe network.

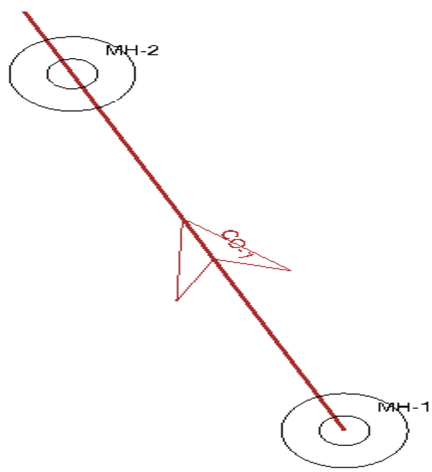


figure (4.10) : pipe network

- Tools →TRex ,here we Editing coordinate(x,y,z) fo each manhole by import 3D contour file , figure (4.11) show this step, figure(4.12)show the manhole coordinate.

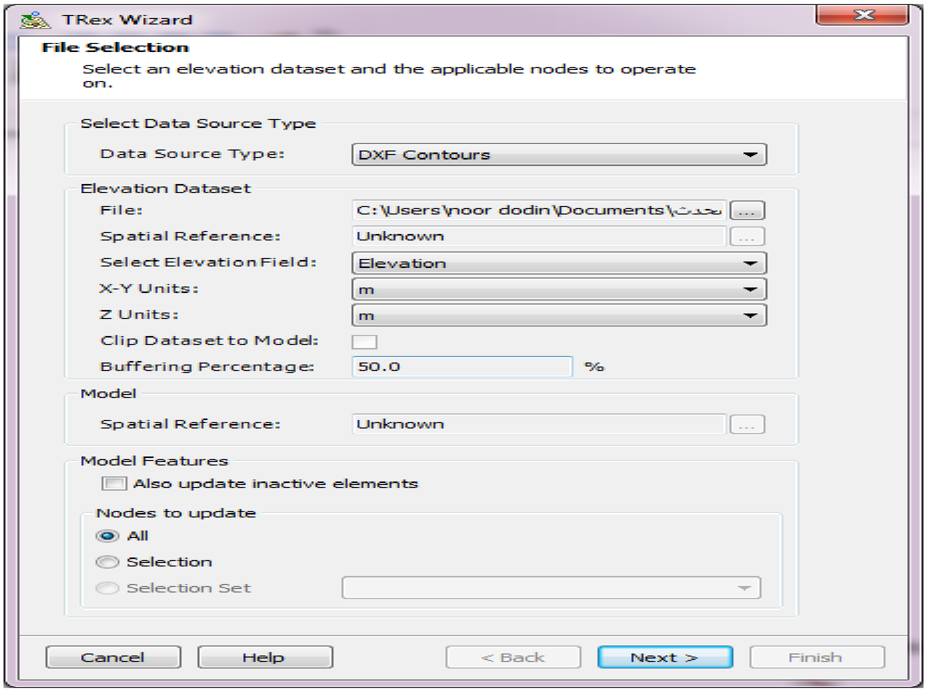
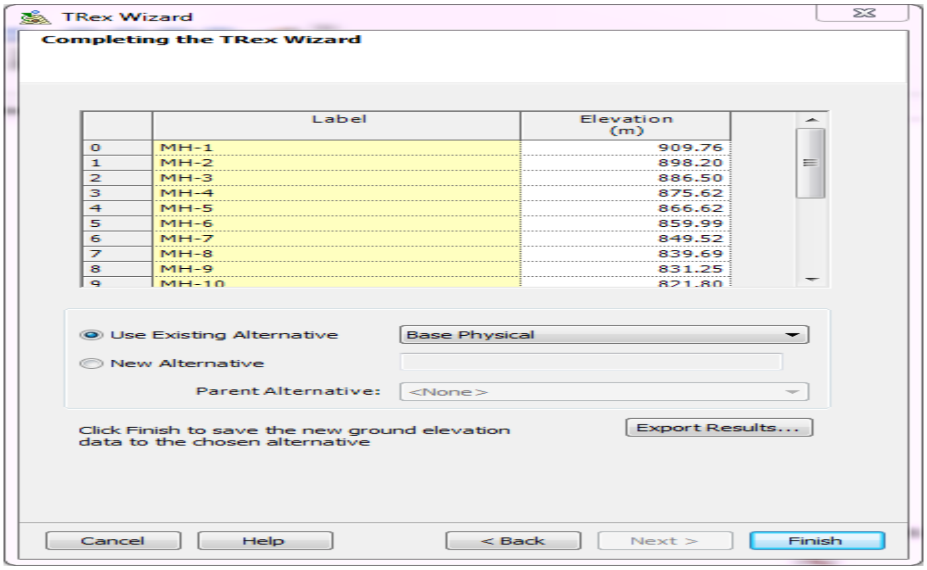


figure (4.11) : Import 3D contour



figure(4.12) : Editing manhole coordinate.

- Tools →sanitary load control center, here we change the load definition to (sanitary pattern load) and Enter the the Base flow, figure (4.13) show this step.

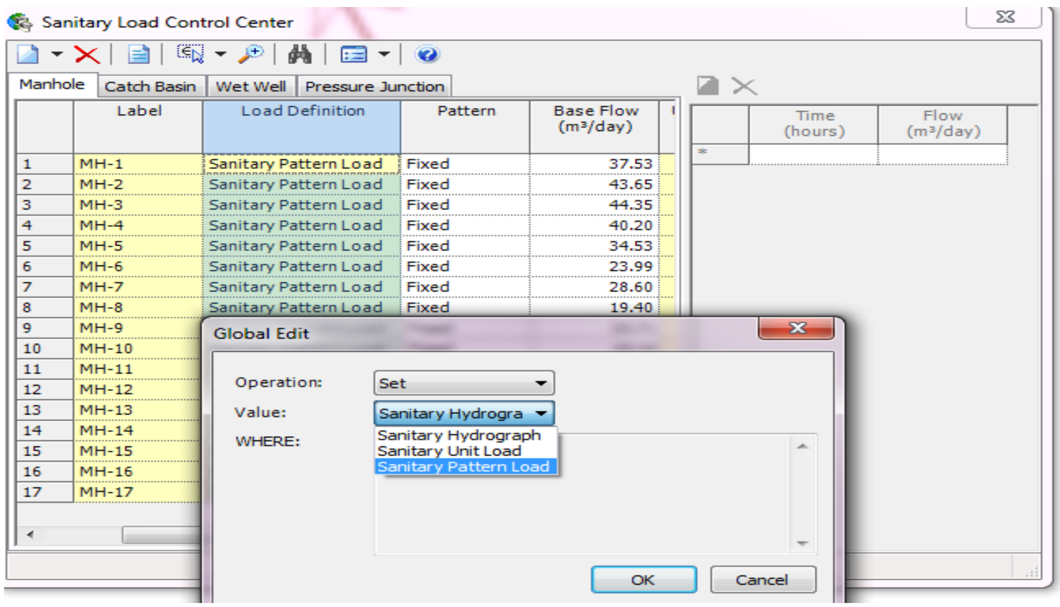


figure (4.13) : Editing Base flow

- In this step we Editing required data in the table of (manhole ,conduit,out fall) like length of conduit,diameter of manhole(1200mm),type of conduit(circuler)and its material(PVC) and other , figure (4.14) Show this step.

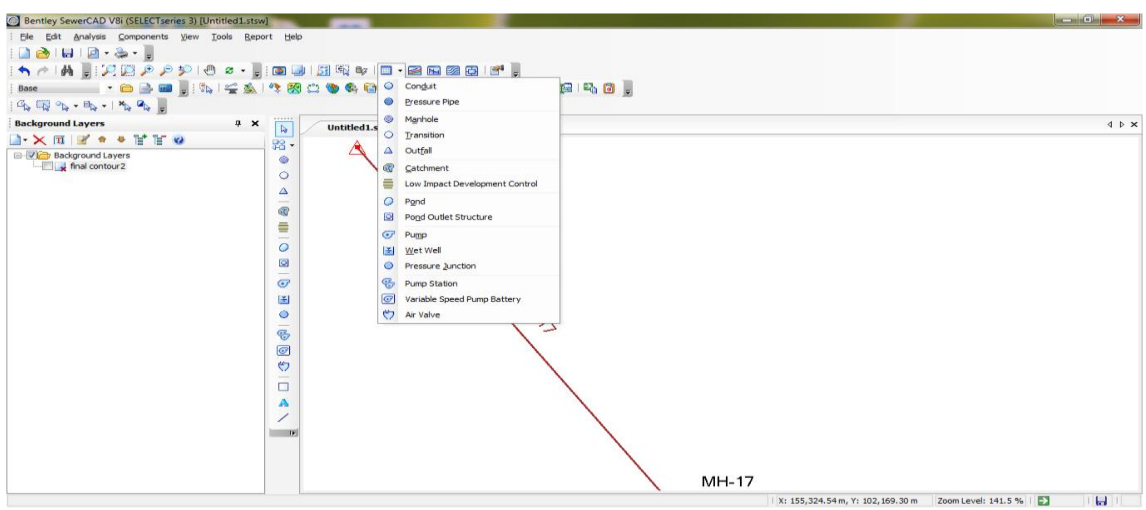


figure (4.14): Editing required data for design

- component →Defualt design constraints, here we Editing the design Parameters(velocity,cover,slope), figure (4.15) Show this step.

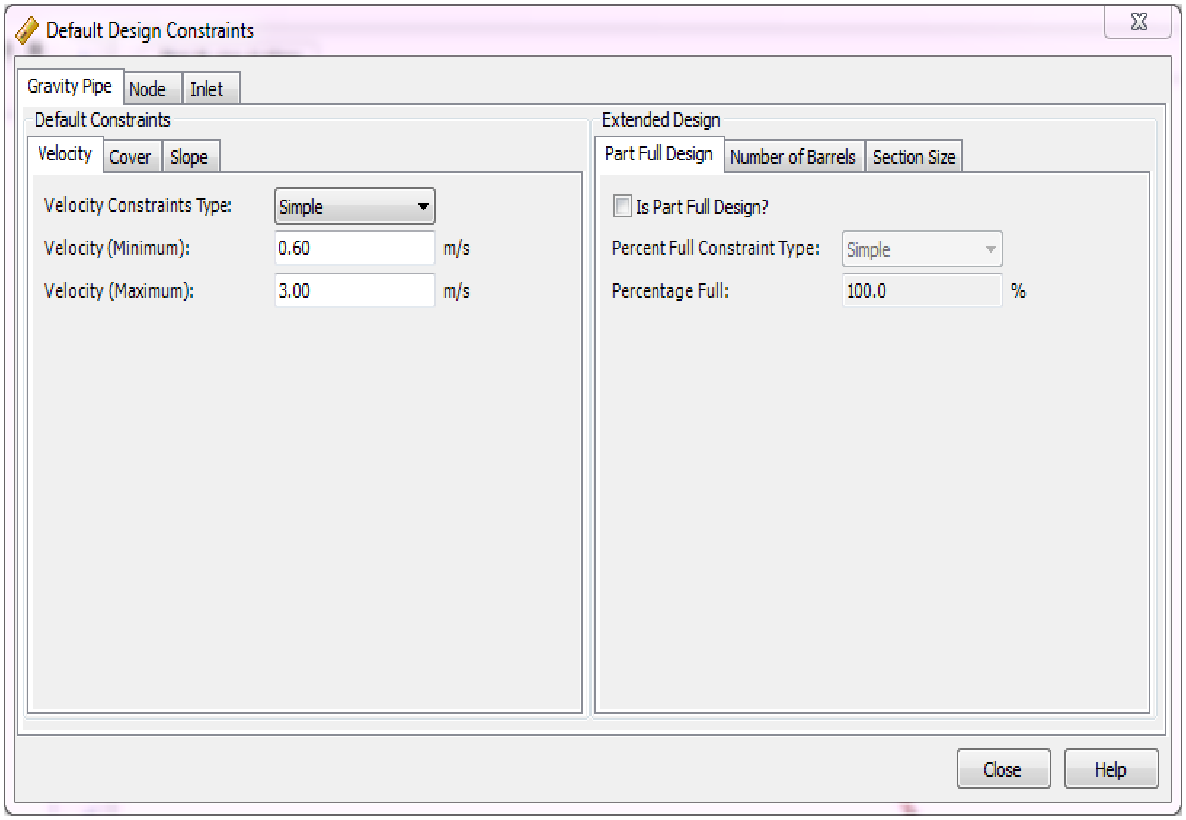


figure (4.15) : Editing Design Parameters – Part1

- Analyse →calculation options→Base calculation options→calculation options→Design, here we change the calculation type from Analyse to design, figure (4.16) Show this step.

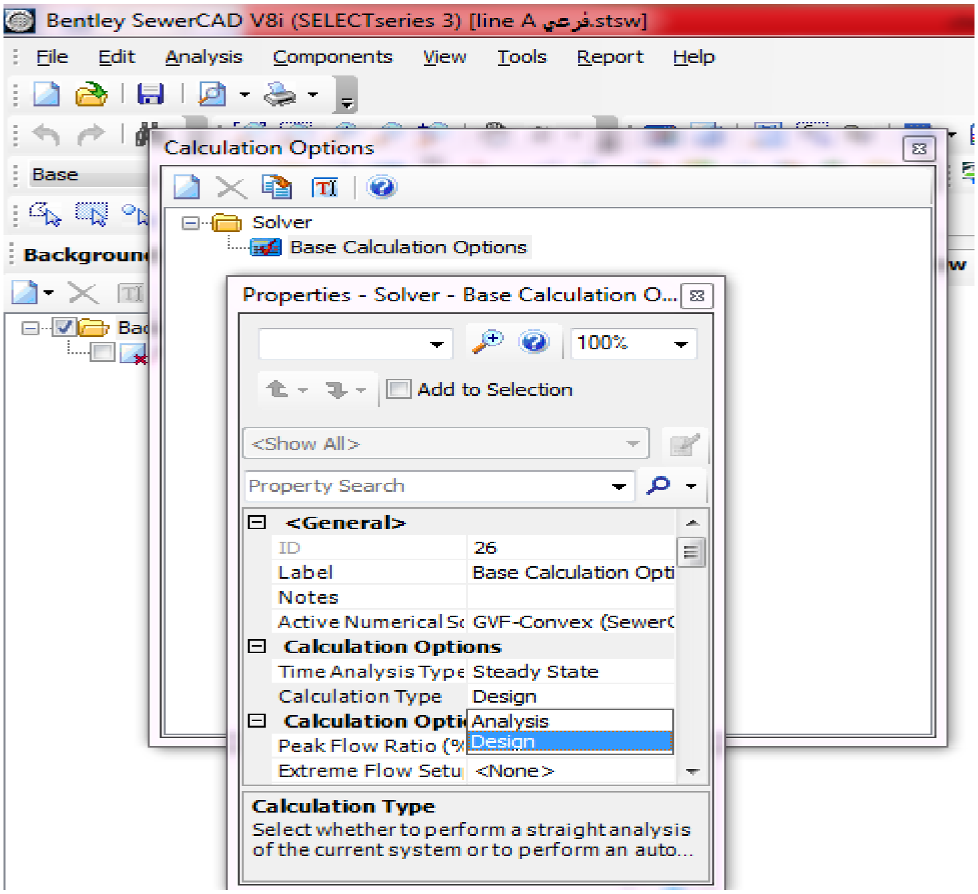


figure (4.16) : Editing Design Parameters – Part2

- Last step press save, press compute button to start 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. figure (4.17) below shows the step.

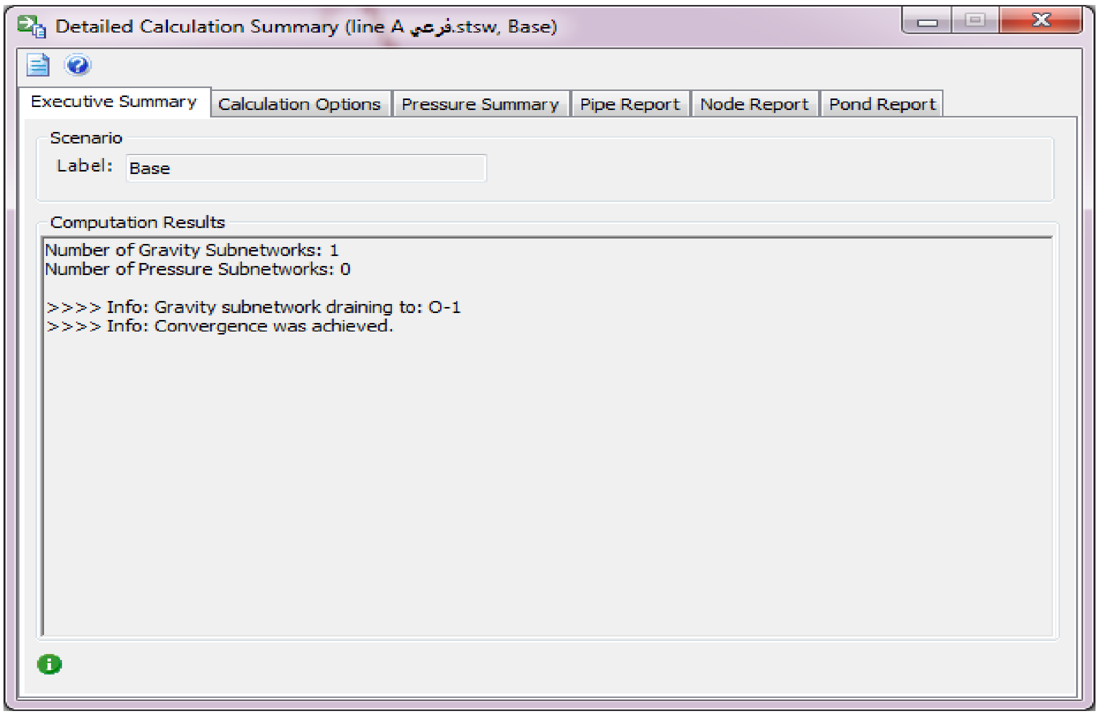


Figure (4.17): Checking The Design

- 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 (4.18), here we should put the scale of the profile.

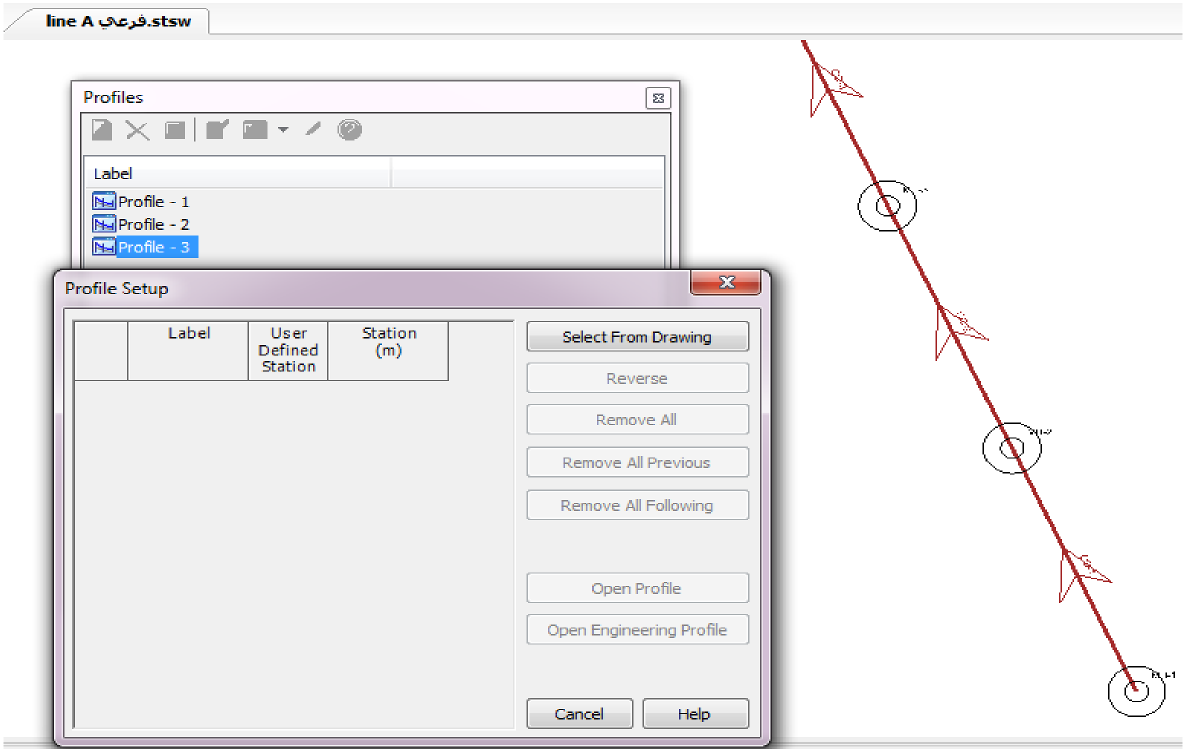


Figure (4.18): Creating Profile

- 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.

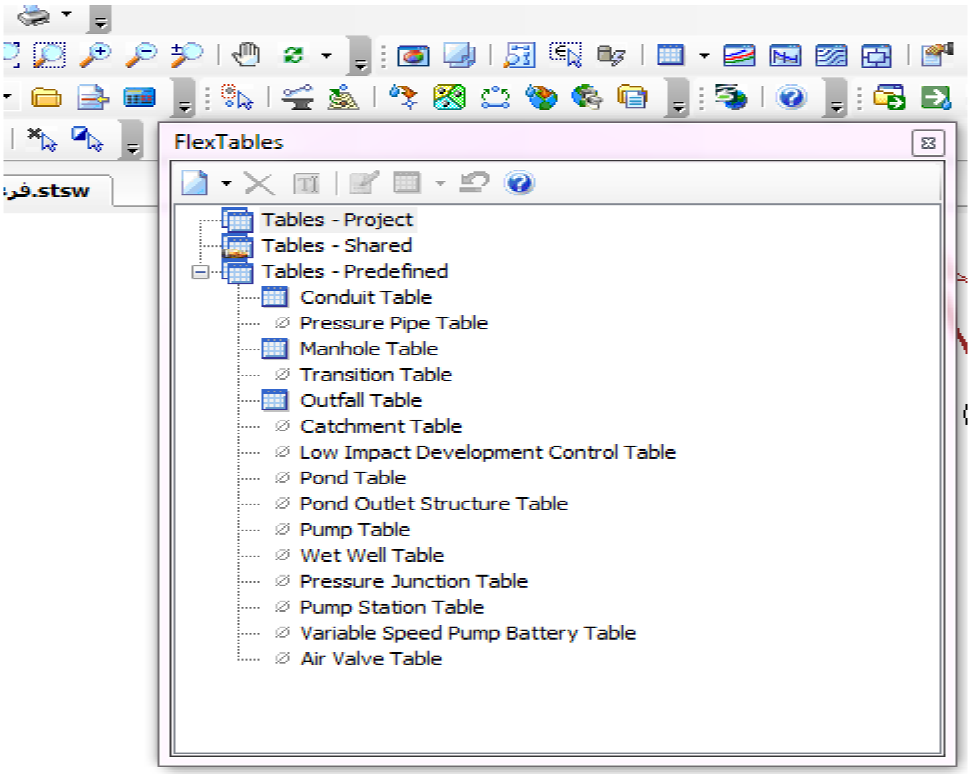


Figure (4.19): Creating Tables

Table 4.4 show the calculations for line A1 and figure 4.20 show the profile for same line. Calculation and drawings for all other lines are shown in (Appendix B) and the profiles for all lines are shown in (Appendix C).

CHAPTER FIVE

5 BILL OF QUANTITES

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	12166				
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	1673				
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	300				
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	880				

Sub-Total							
B	**PIPE WORK**						
B1	Supplying, storing and installing of PVC	LM	15019				
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 1.5 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	12166				
C2	Supplying and embedment of sand for one pipe diameter 10 inch, depth up to 1.5 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	1673				
C3	Supplying and embedment of sand for one pipe diameter 12 inch, depth up to 1.5 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	300				

C4	Supplying and embedment of sand for one pipe diameter 15 inch, depth up to 1.5 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	880				
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 1.5m.	NR	300				
D2	Supplying and installing of precasted manhole including excavation pipe connection, epoxytar coating, 25-ton cast iron cover and backfill, size 1200mm, depth up to 2.5m.	NR	31				
Sub-Total							
E	**Concrete Surround**						
E1	Suppying and installing of reinforced concrete (B 200) protection concrete encasement for sewer pipe.	LM	15019				
Sub-Total							
F	**Air And Water Leakage Test**						

F1	Air leakage test for sewer pipe lines 8,10,12 and 15 inch according to specifications, including for all temporary works.	LM	15019				
F2	Water leakage tests for manholes, depth up to 1.5 meter according to specifications.	NR	300				
F3	Water leakage test for manholes , depth up to 2.5 meter according to specification	NR	31				
Sub-Total							
G	**Survey work**						
G1	Topographical survey required for shop drawings and as built DWGS using absolute Elev. And coordinate system	LM	15019				

CHAPTER SIX

6 CONCLUSION

In this project, the trial is made to design waste water collection system for Dora City 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. Dora like other city 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 Dora covers most of the areas of the City.

3. The present water consumption of Dora is 70 L/c.day and the future water consumption is estimated to be 120 L/c.day depending on 3.4 % increase use rate.

4. The collection system is consisting of 6 sewer lines.

5. All lines in the collection system will be design by gravity.

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APPENDIX A

CALCULATION TABLES

APPENDIX B

DESIGN TABLES(FROM Bently SEWERCAD)

APPENDIX C

MAP & PROFILES FOR PIPES