

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



**DESIGN OF WASTEWATER COLLECTION SYSTEM FOR  
TAFFOUH TOWN**

**BY**

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

**SUPERVISED BY**

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**HEBRON- WEST BANK**

**PALESTINE**

**MAY - 2012**

# **CERTIFICATION**

**Palestine Polytechnic University**

(PPU)

**Hebron- Palestine**

The Senior Project Entitled:

## **DESIGN OF WASTEWATER COLLECTION SYSTEM FOR TAFFOUH TOWN**

Prepared By:

**SHAHD KAFFESHAH**

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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**

**May - 2012**

## 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 the love and 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 “Eng. Yousef Al-Jabari”, and Taffouh 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 TAFFOUH TOWN**

Prepared By:

**SHAHD KAFFESHAH**

**WALA` AL-NATSHEH**

**SUPERVISED BY**

**Eng. SAMAH AL-JABARI**

The disposal of raw wastewater without treatment creates major potential health and environmental problems. In the Hebron rural areas, the sewage facilities do not exist. 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.

Taffouh like other towns in Hebron district has no wastewater collection system. People are using cesspits, latrines and septic tanks. These latrines and cesspits are deteriorating and they are in very bad condition, adding to this the increasing in water consumption and consequently increasing in wastewater production, resulting in over flows from the cesspits and excessive recharges of ground water in Taffouh town. For all these reasons, this study is conducted to design wastewater collection system for Taffouh town of the Hebron district.

The present study considered the annual population growth and their water consumption for the coming 25 years that will be the design period, along with the commercial and

industrial development in the area. The necessary hydraulic calculation needed for the design of the main trunks was carried out by simple calculation.

The study shows numbers of important conclusions. Wastewater disposal in Taffouh town causes problems to people; subsequently there is a big need for design and construction of wastewater collection system. Gravity flow sanitary sewer was proposed for Taffouh to minimize the cost of construction and excavations. The proposed wastewater collection system for Taffouh town covers most of the areas of Taffouh.

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## **CHAPTER ONE**

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## **DESIGN TABLES ( FROM SEWERCAD )**

## **1.1 General**

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.

Taffouh 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 Taffouh have been conducted.

## **1.2 Problem Definition**

The accelerated expansion and development of Taffouh 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 Taffouh. 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 Wastewater Collection System For Taffouh 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, sewerage materials, design of the wastewater flows and loadings and prepare all engineering design drawings and details for the sanitary system network and disposal methods.

### **1.4 Methodology**

1. Site visits to Taffouh town and municipality.
2. All needed maps and the previous studies that contain different information about Taffouh 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 were carried out.
6. Finalizing the project which contains the report, the needed maps and drawings, and the bill of quantities.

### 1.5 Phases Of The Project

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

Title	Duration									
	09/11	10/11	11/11	12/11	01/12	02/12	03/12	04/12	05/12	
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										

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 2036.

### **1.5.2 Second Phase: - Preparing Layout For Wastewater Collection System And Collect The Amount Of Wastewater**

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

This phase includes the following tasks:

1. Draw the layout of wastewater collection system and compare it with the real situation in Taffouh 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 2036.

### **1.5.3 Third Phase: - Preparing Layout For Wastewater Collection System**

In this phase the necessary hydraulic calculations needed for the design of main trunks was 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 was 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.

## **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.

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

## **2.1 General**

In this chapter, the basic data of Taffouh 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**

Taffouh is the second oldest town after Jericho, it is situated 8 Km to the west of Hebron, as shown on the project location maps Figure (2.1) and (2.2); the average elevation of the town is 800 m above sea level. The present administrative area of the town is about 20300 donum. The total population within the municipal administrative borders was estimated to be around 13000 persons in the year 2006.

The topography within the town is mountainous and rugged, and it is surrounded by two wadis. This is illustrated on Figure (2.3), which shows the topography of the project area.

The ground elevations within this area range from 850 m with respect to sea level in center of the town, to around 650 m in the east part of the town .

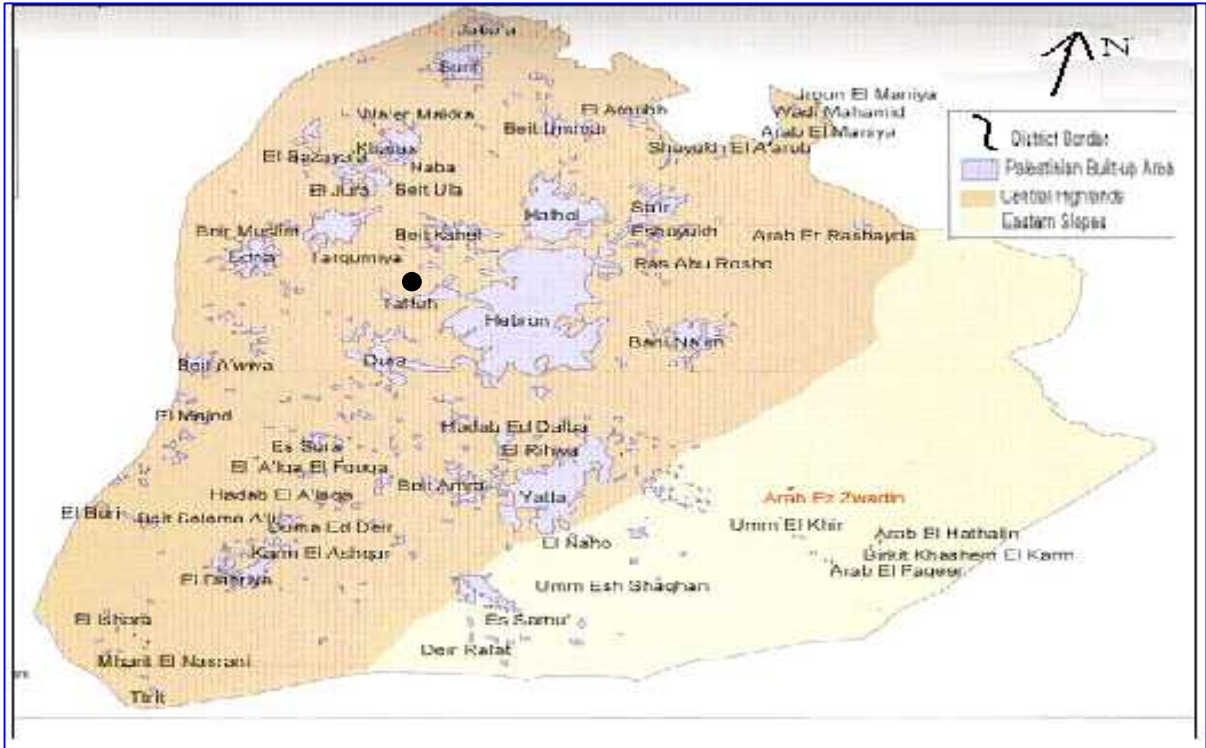


Figure (2.1) Taffouh map



Figure (2.2) Location map



## **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 Taffouh 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 average annual rainfall in Taffouh town is about 457 mm. Rainfall occurs between October and May while it rarely rains in the summer season from June to September. The monthly rainfall of Taffouh town is shown in Table (2.1).

### **2.3.2 Temperature**

The temperature is characterized by considerable variation between summer and winter times. The mean temperature values at Taffouh town are given in Table (2.1).

The following minimum and maximum values were shown:

- The mean maximum temperature: 20 °C
- The mean minimum temperature: 11 °C

### 2.3.3 Relative Humidity

The relative humidity in Taffouh town varies between 25-75 %. The relative humidity of Taffouh town is shown in Table (2.1).

Month	Rainfall (mm)	Maximum Temperature (°C)	Minimum Temperature (°C)	Relative Humidity (%)
September	0.0	10.25	3.96	74.19
October	11.75	11.58	4.70	72.22
November	51.83	14.57	6.46	65.96
December	142.57	19.59	9.93	54.62
January	145.93	23.63	13.23	48.25
February	88.5	25.90	15.77	51.03
March	37.35	27.16	17.04	56.77
April	17.5	27.23	16.96	59.88
May	4.5	25.97	15.94	61.66
June	0.0	23.18	14.02	58.89
July	0.0	17.50	9.90	64.07
August	0.0	12.09	5.62	72.69

Table (2.1): Meteorological Conditions At Taffouh Town Weather Station for (2000-2005)  
[Meteorological Station Of Hebron City].

## **2.4 Water supply**

Most of the water supply to Taffouh town comes from WBWD (West Bank Water Department). This connection was constructed in 1994, and the connection point is located at AL- Jaladeh Crossroads (Square) - Hebron.

The total water supply to Taffouh town was 170000 m<sup>3</sup>/year from the connection point.

The average of supplying water is about 3 days per week at about 5 hours a day. This improves in winter and becomes worse in summer.

Taffouh town has only one reservoir in its water system, which located in AL-Hiwarrarah. The reservoir is filled from the supplying pipeline whose diameter is 4 inches from (WBWD).

## **2.5 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 in Taffouh town, like many places in Palestine, because the town is considered to be unsewered area, using cesspits 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 for Taffouh town.

## **2.6 Water Consumption**

According to the water consumption data obtained from the previous studies and Taffouh municipality, the water consumption is 70 liters/per capita per day.

## **2.7 Wastewater Quantity**

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



## **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.

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].

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 or ultra polyvinyl 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.

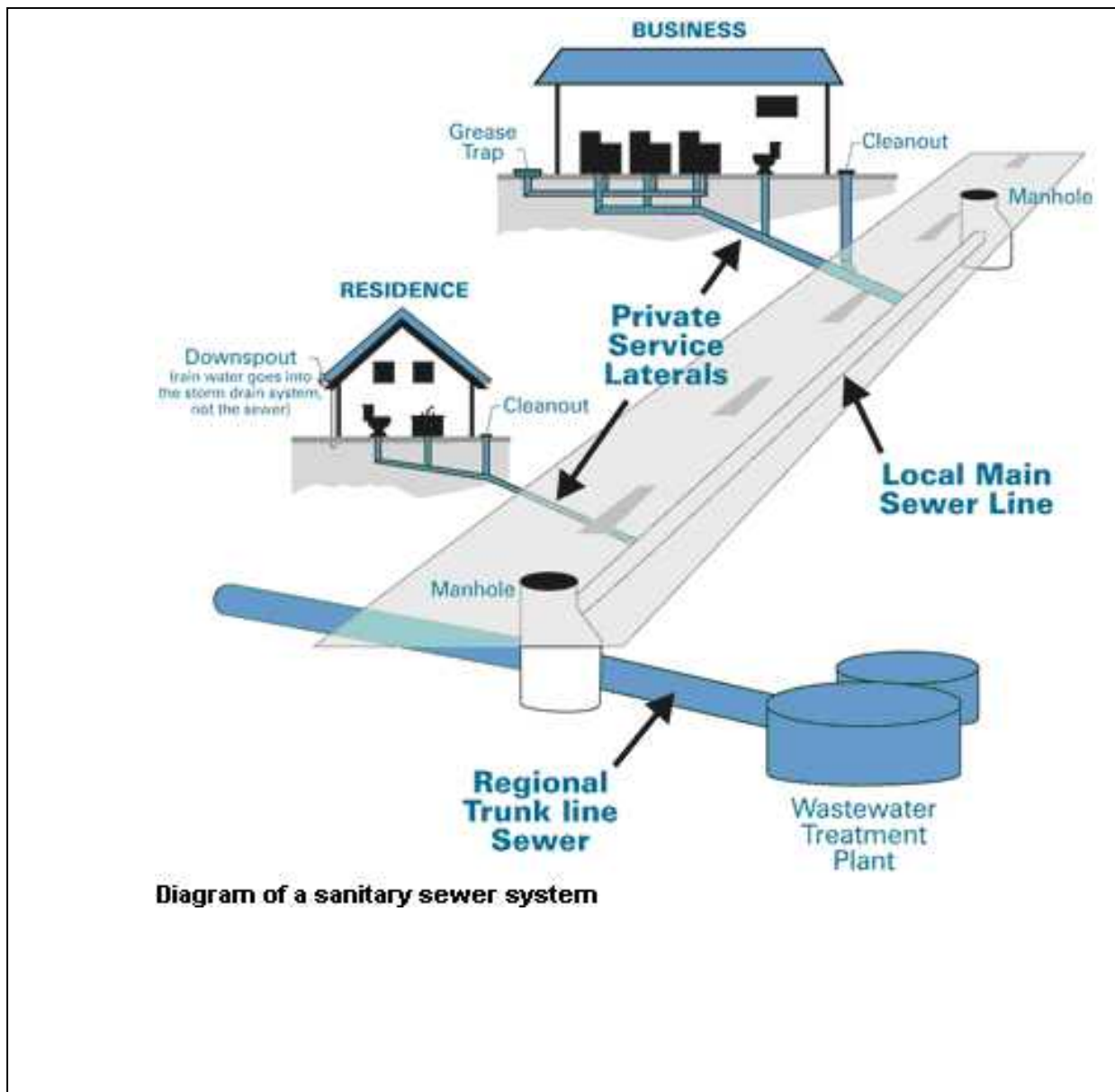


Figure (3.1): Types Of Sewers Used In Wastewater Collection System

### **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 to 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 30-50 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 30-50

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**

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 [Hammer,1977].

### **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 [Qasim,1985].

### **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 [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].

#### **3.4.4 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 [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 large and less efficient than vaned designs [Mc Ghee, 1991].

### **3.5 HYDROLICS 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 [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's formula:

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

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;  $C = \frac{100\sqrt{R}}{m + \sqrt{R}}$ ,

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 :

$$H = L \cdot V^2 / (D \cdot 2g) \quad (3.2)$$

Where H: the pressure head loss ( mwc ).

L: the length of pipe (m).

D: the diameter of pipe (m).

: 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:

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

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

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

- For circular pipe flowing full,  $R = (D/4)$ .
- For open channel flowing full,  $R = [(b \cdot d) / (b + 2d)]$ .

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

- **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:

$$Pf = 1.5 + 2.5 / q \quad (3.4)$$

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 Filled 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 [Qasim,1985,peavey,1985]:

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.

### **3.6.2 Preliminary 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 [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, 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 [Qasim, 1985]:

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 [Viessman,1985].

### **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 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 Four.

**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  $n = 0.01$ . 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	30	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.

**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, 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:

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

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 (3.2). Hydraulic elements of circular pipes under partially-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) will be shown in the design calculation in chapter five [Qasim, 1985].

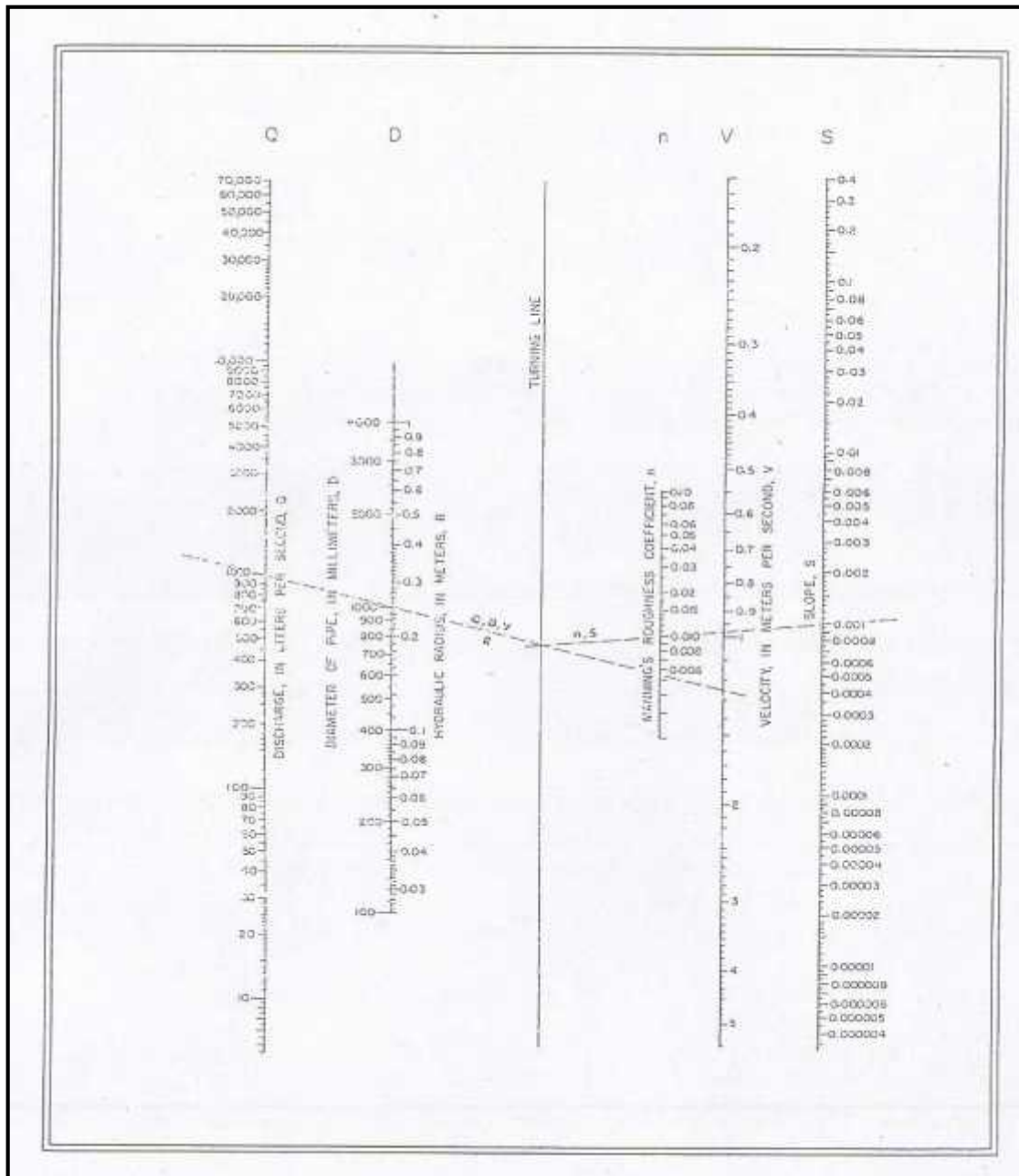


Figure (3.2) Nomograph for solution of manning formula

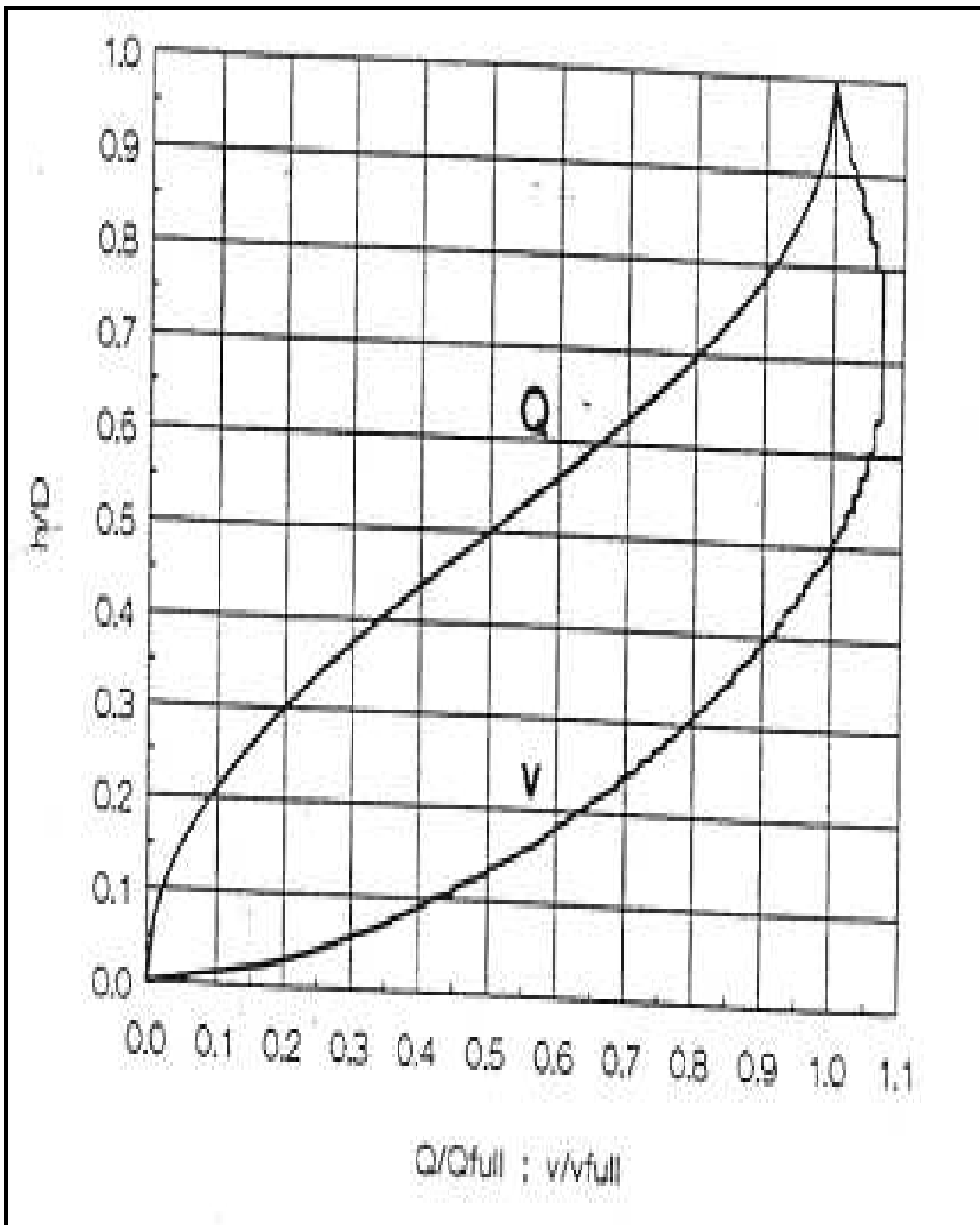


Figure (3.3) Hydraulic properties of circular sewer

## **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 [Viesman, 1985].

### **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 [Qasim,1985].

#### **- 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.

### **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.

## **4.1 General**

In this project, design of wastewater collection system for Taffouh town is made, and develop a future plans for construction of the collection system, corresponding to the vision of Taffouh 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 Taffouh, 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 of Taffouh town is 13000 inhabitants.

#### **4.2.2 Population Forecast**

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

To calculate the population at the end of the design period (year 2036), a geometric increase is assumed, represented by the following equation:

$$P = P_0 (1+R)^n \quad (4.1)$$

Where, P is the future population, P<sub>0</sub> is the present population, R is the annual population growth rate, and n is the period of projection.

#### **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 Taffouh 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 sewerred, 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 Taffouh, 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 Taffouh town, the lowest point is in Alfara'ah.



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 Taffouh town is illustrated in Figure (4.2), and Figure (4.3).

Two main trunks, four submain lines, and four lateral lines 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 constraints. 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 L3) 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 150L/c.day.
3. For current population = 22832 capita.
4. For future population : using the formula  $P = P (1+R)^n$  , Where P is a current population
5. For population growth rate 3.5 %.
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 :

$$Pf = 1.5 + (2.5/ q).$$



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 (4.1) , and sewer design tables are presented in tables (4.2) and (4.3) . The data in sewer design tables are calculated as follow:

- From manhole # 1 to manhole # 2 .
- Sewer length = 50 m.
- Density person for this area = 44.26 c/donum .
- Unit sewage =  $0.007 \text{ m}^3/\text{c.day} * 80\% * 44.26 \text{ c/donum} = 5.30 \text{ m}^3/\text{d.donm} .$
- Partial sewerred area =  $2.75 \text{ m}^2 .$

- Cumulative sewered area =  $2.75 \text{ m}^2$  .
- $Q_{\text{average}} = \text{cumulative sewered area} * \text{unit sewage} = 2.75 \text{ m}^2 * 5.30 \text{ m}^3/\text{d.donm} = 14.60 \text{ m}^3/\text{day}$
- Peak factor  $Pf = 1.5 + (2.5/ q) = 1.5 + (2.5/ 14.60) = 2.15$  .
- $Q_{\text{maximum}} = Q_{\text{average}} * Pf = 14.60 \text{ m}^3/\text{day} * 2.15 = 31.46 \text{ m}^3/\text{day}$  .
- Infiltration = 10% of  $Q_{\text{average}} = 10\% * 14.60 = 1.46 \text{ m}^3/\text{day}$  .
- Total flow =  $Q_{\text{maximum}} + \text{Infiltration} = 31.46 \text{ m}^3/\text{day} + 1.46 \text{ m}^3/\text{day} = 32.92 \text{ m}^3/\text{day}$ .
- Ground elevation for manhole # 1 = 870 m , and for manhole # 2 = 865.5 m .
- Structure diameter for manholes = 1.2 m .
- Flow velocity = 0.9 m/s .

The calculation and design tables for the wastewater collection system of Taffouh town are shown in Appendix A and B .

The profiles of this sewer and all sewers are shown in Appendix C.





## 4.5 SewerCAD Program Works:

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

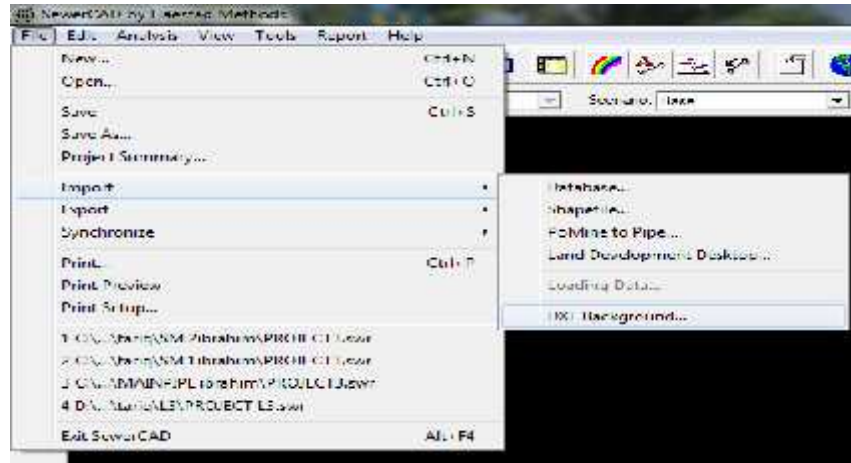


Figure (4.5) Importing DXF File

- Specify file location and then press open, figure (4.6) below shows this step. Figure (4.7) shows a line example.



Figure (4.6): Opening The DXF File.

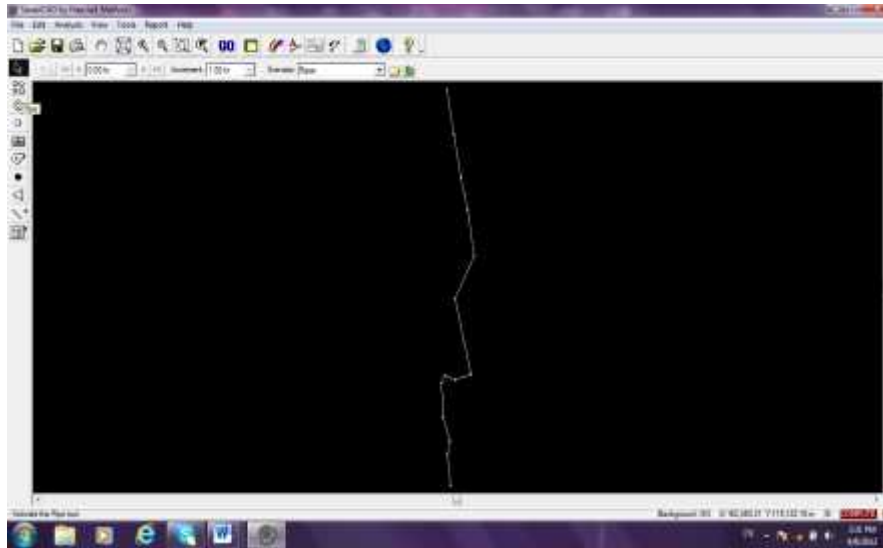


Figure (4.7): Line Example

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

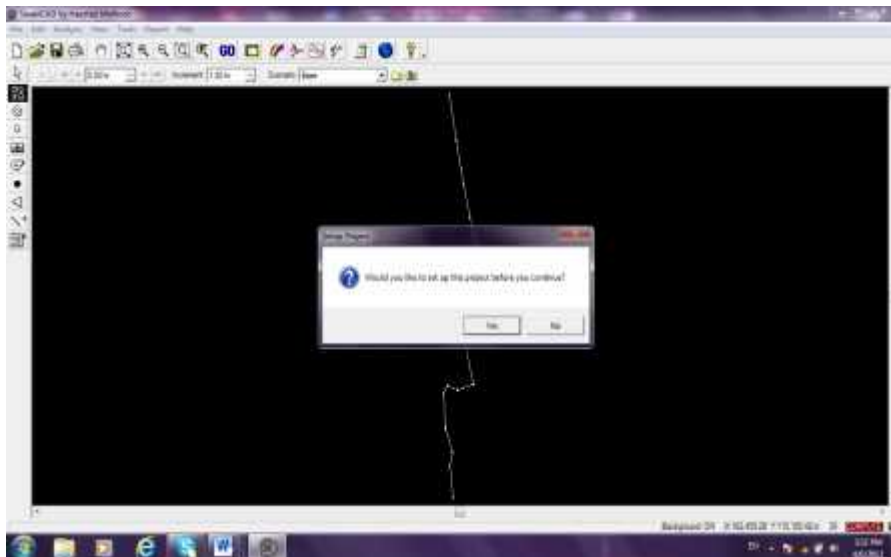


Figure (4.8): Creating Project

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

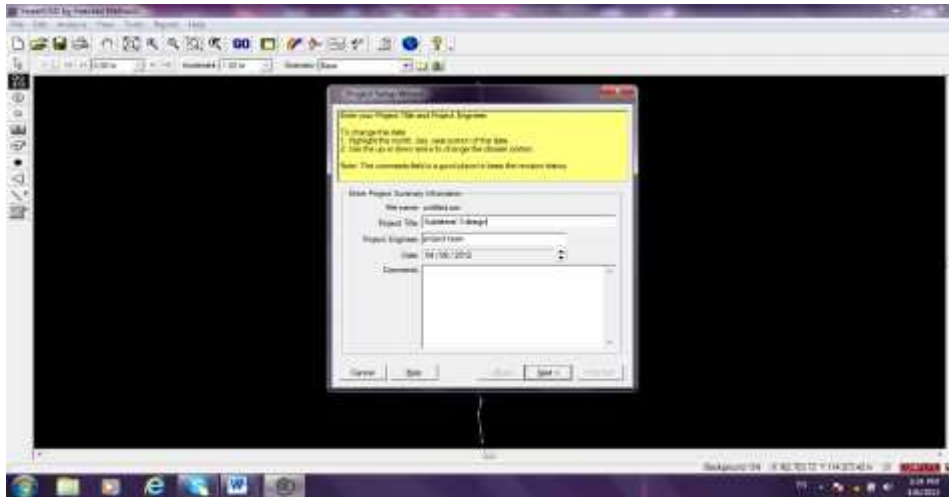


Figure (4.9): Defining The Project

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

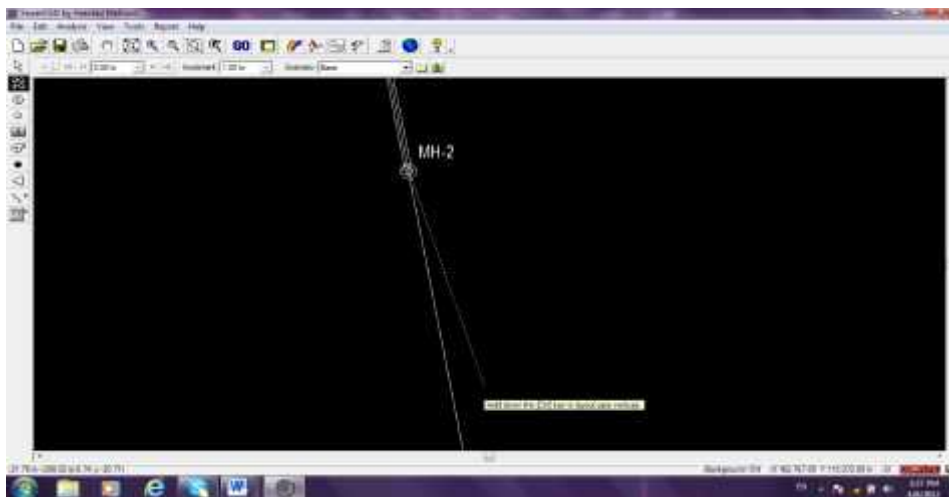


Figure (4.10) Creating a pipe network.

- 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.

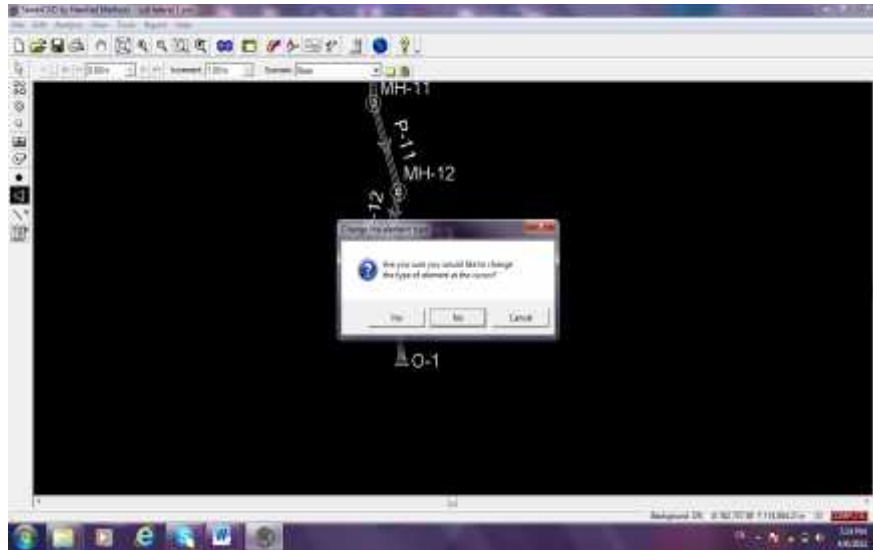


Figure (4.11): Creating Outlet

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

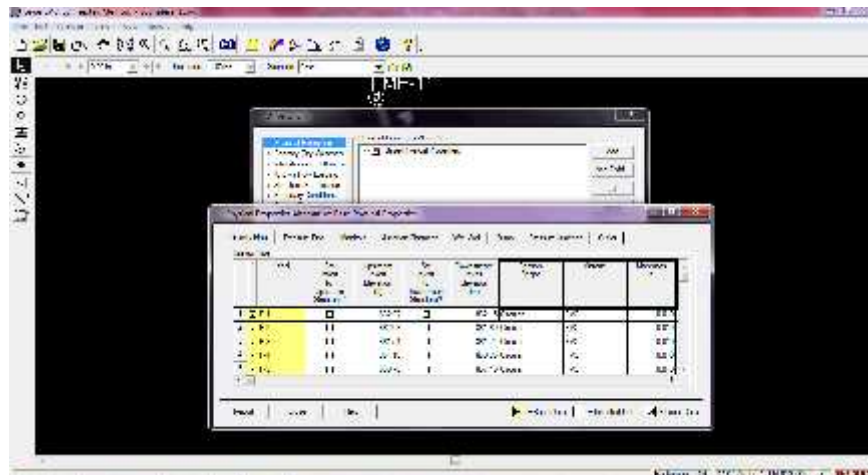


Figure (4.12): Editing Design Parameters – Part I

- 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.

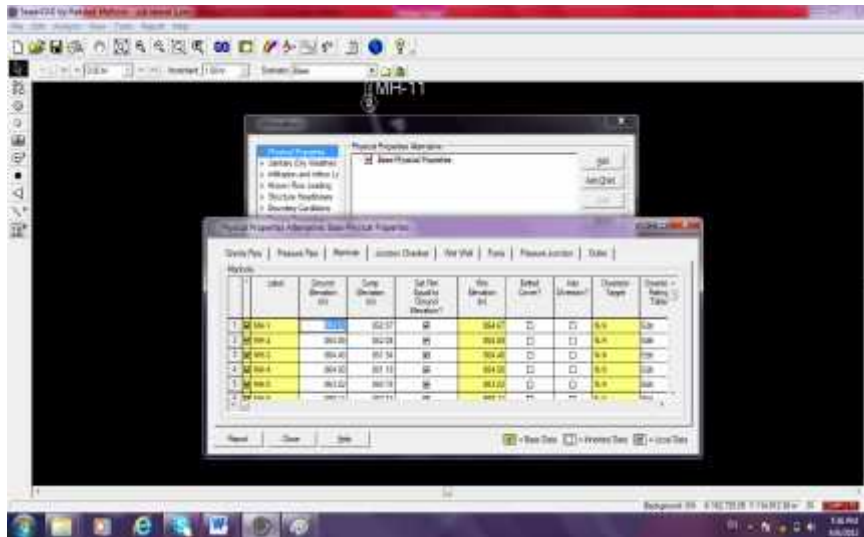


Figure (4.13): Editing Design Parameters– Part2

- 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.

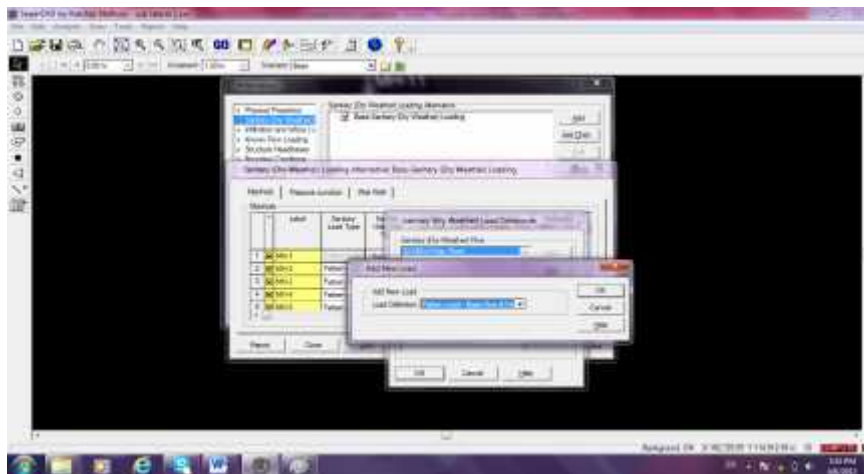


Figure (4.14): Editing Design Parameters– Part3

- 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.

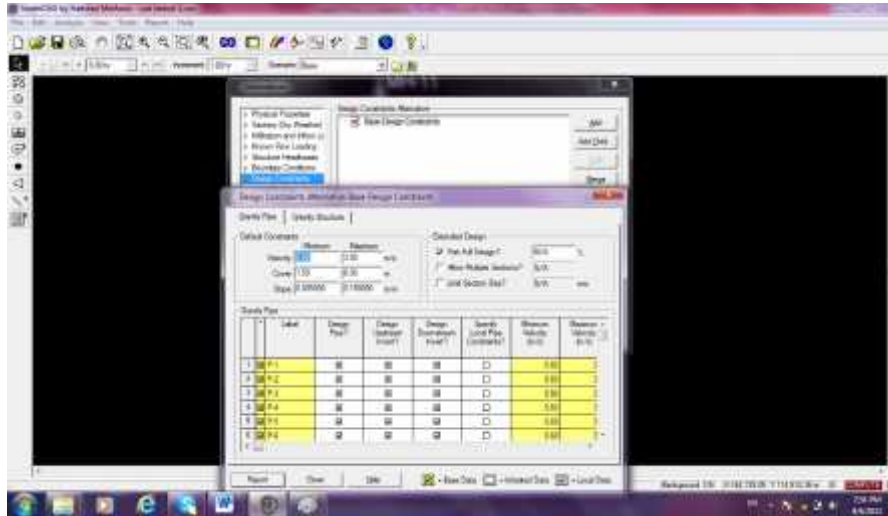


Figure (4.15): Editing Design Parameters– Part4

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

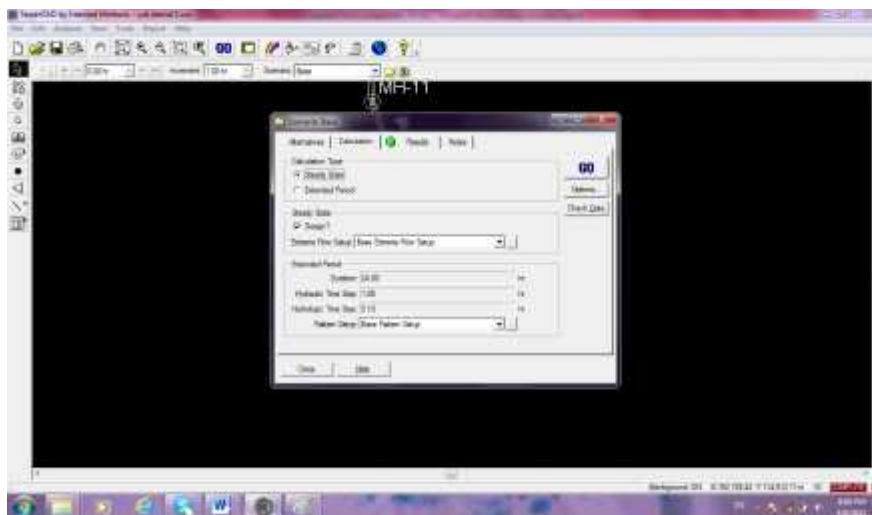


Figure (4.16): Checking The Design

- 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 messages 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. We can get the required tables by pressing tabular report button see figure (4.17), and then choose gravity pipe report and gravity node report.

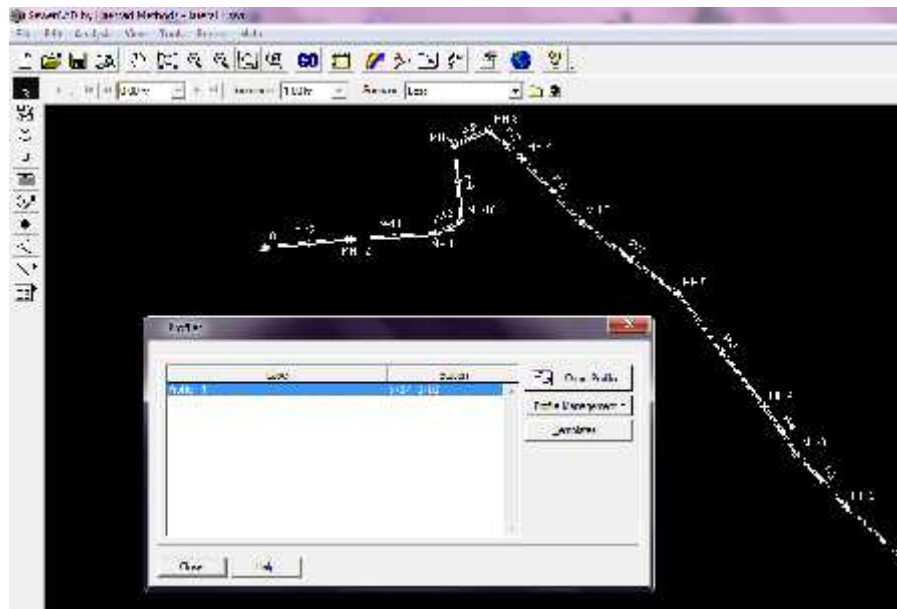


Figure (4.17): Creating Profile



## BILL OF QUANTITY

### 5.1 BILL OF QUANTITY FOR 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	11697				
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	804.5				
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	2239.5				

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	40				
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	2258				
<b>Sub-Total</b>							
<b>B</b>	<b>PIPE WORK</b>						
B1	Supplying, storing and installing of uPVC	LM	17039				
<b>Sub-Total</b>							
<b>C</b>	<b>PIPE BEDDING AND BACKFILLING</b> <b>Dimension and material</b>						
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	11697				

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	804.5				
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	2239.5				
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	40				
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	2258				
<b>Sub-Total</b>							
<b>D</b>	<b>MANHOLES, Details according to the drawing</b>						

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	241				
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	179				
<b>Sub-Total</b>							
<b>E</b>	<b>Concrete Surround</b>						
E1	Supplying and installing of reinforced concrete (B 200) protection concrete encasement for sewer pipe.	LM	17039				
<b>Sub-Total</b>							
<b>F</b>	<b>Air And Water Leakage Test</b>						

F1	Air leakage test for sewer pipe lines 8,10,12,15 and 18 inch according to specifications, including for all temporary works.	LM	17039				
F2	Water leakage tests for manholes, depth up to 1.00 meter according to specifications.	NR	241				
F3	Water leakage test for manholes , depth up to 2.5 meter according to specification	NR	179				
<b>Sub-Total</b>							
<b>G</b>	<b>Survey work</b>						
G1	Topographical survey required for shop drawings and as built DWGS using absolute Elev. And coordinate system	LM	17039				

## CONCLUSIONS

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

1. Taffouh town like other towns in Palestine has no sewage facilities. The people are using latrines, cesspits and septic tanks. The wastewater has been seeping into the ground through the over flow of the deteriorated cesspits and latrines, causing series environmental and health problems.
2. The present population of Taffouh town is around 22832 person. Prediction of the future population of Taffouh town is very different due the political uncertainties. The rate of population growth is taken as 3.5%.
3. Restrictions on the Palestinian use of the annual ground water resources of the West Bank led to limited quantities of water supplied to Taffouh town and due to this condition the average consumption of water in the town in general is low (70 l/c.d) and does not represent the present actual demand of water. The future water consumption is estimated to be 150 l/c.d.
4. The proposed wastewater collection system for Taffouh town covers most of the areas of Taffouh except some small areas which is closed by Israelis Military orders.
5. According to the wastewater collection system design , the number of sewer lines is ten lines , two main trunks , four submains and four laterals.
6. The diameter of pipes in the system vary between ( 200- 450 ) mm.
7. In the design of the wastewater collection system, the slope of sewers followed the slope of ground to decrease the cost of construction the sewers, and due to this condition many drop manholes are seen in the sewer profiles.

8. The depth of sewer pipes in collection system are kept between (1.5 – 5) m below the base of ground floor just to minimize the cost of excavation.
9. The maximum depth of flow in sewer taken as 0.5 of the sewer diameter to be capable to receive any unexpected infiltration from the storm water.
10. The flow in proposed wastewater collection system is going by gravity. No pumping station was suggested in the town area.

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