Palestine Polytechnic University
College of Engineering
Civil Engineering Department

Design of Wastewater Collection System for Bani Naim Town

Project Team:

Anas Qawasmi **Hammam Abu Talib**

Supervisor:

Dr. Samah Al-Jabari

This project submitted to the College of Engineering in Partial Fulfillment of Requirements of the Bachelor Degree in Surveying and geomatics engineering

H e b r o n - P a l e s t i n e

Jul, 2023

جامعة بوليتكنك فلسطين
كلية الهندسة
دائرة الهندسة المدنية

تصميم نظام تجميع مياه الصرف الصحي لبلدة بني نعيم

فريق العمل:

همام أبو طالب أنس القواسمة

المشرف:

د. سماح الجعبري

بناء على توجيهات الأستاذ المشرف وبموافقة جميع أعضاء اللجنة الممتحنة تم تقديم هذا المشروع الى دائرة الهندسة المدنية

في كلية الهندسة للوفاء الجزئي بمتطلبات الحصول على درجة البكالوريوس.

توقيع مشرف المشروع	توقيع رئيس الدائرة
....	....

Abstract

Design of Wastewater Collection System for Bani Naim Town

Submitted by:

Anas Qawasmi | Hammam Abu Talib

Supervisor:

Dr. Samah Al-Jabari

Bani Naim Town currently lacks of a wastewater collection and treatment systems, the wastewater in the town is collected in a cesspits and wastewater trucks. This condition creates many potential health, environmental, and social risks for the town. This project presents a design for a wastewater collection system for Bani Naim Town. A comprehensive assessment of the current situation of the town and description of area as well as the detailed data and information needed for the design. This report contains the full design for a complete collection system covers all the town with main, sub-main and lateral sewers. The project also discussed the possibility of using pumps and will proposed the most suitable place for the treatment plants. The designed collection system be linked to treatment plants for recycling and use in agricultural and industrial applications.

الملخص

تصميم نظام تجميع مياه الصرف الصحي لبلدة بني نعيم

فريق العمل:

همام أبو طالب   أنس القواسمة

المشرف:

د. سماح الجعبري

تفتقر بلدة بني نعيم حاليًا إلى نظام تجميع ومعالجة مياه الصرف الصحي، حيث يتم تجميع مياه الصرف الصحي في البلدة في حفر امتصاصية وشاحنات الصرف الصحي. تخلق هذه الحالة العديد من المخاطر الصحية والبيئية والاجتماعية المحتملة على المدينة. يقدم هذا المشروع تصميماً لنظام تجميع مياه الصرف الصحي في بلدة بني نعيم. تقييم شامل للوضع الحالي للمدينة ووصف المنطقة وكذلك البيانات التفصيلية والمعلومات اللازمة للتصميم. يحتوي التقرير النهائي على التصميم الكامل لنظام تجميع كامل يغطي جميع البلدة بخطوط تصريف المياه العادمة الرئيسية والفرعية والجانبية. يناقش المشروع أيضًا إمكانية استخدام المضخات ويقترح المكان الأنسب لمحطات المعالجة. سيتم ربط نظام الجمع الذي سوف يتم تصميمه بمحطات المعالجة لإعادة التدوير والاستخدام في التطبيقات الزراعية والصناعية.

DEDICATION

To our true source of hope …

to the people who keep us going through struggles and hardships …

your encouragement and continuous support are only matched by your big hearts and pure souls

To our families …

To our dearest friends …

To everyone who carries love in his heart for us …

Thank you from the depths of our hearts.

ACKNOWLEDGEMENT

We would like to give our sincere thanks and gratitude to Palestine Polytechnic University, represented by the university administrate, and to the faculty of engineer members and civil engineering department teacher and lecturer, and our thanks especial go to Dr. Samah Al-Jabari, who supervised this project, gave us a massive amount of advice and encouragement.

We extend our sincere thanks to the municipality of Bani Naim, represented by Engineer Muhammad Manasrah and Engineer Taha Manasrah for their continuous support during the work of the project. Finally, we salute Labeeb & Suhaib Library for its professional work in producing plans and project reports.

Project Team

Table of Content

List of Tables

List of Figures

Chapter (1) : Introduction

1.1 General

1.2 Problem Definition

1.3 Project Objectives

1.4 Phases of Project

1.5 Organization of the Study

1.6 summary

1.1 General

One in nine people lack access to clean drinking water, and over 2.5 million people live without adequate sanitation facilities. The use of traditional methods of waste water disposal, such as cesspools and waste water vehicles, has numerous negative effects on society and the environment in which they are used. This issue is one of the most common problems in developing countries with weak infrastructure. So, point-of-use water and sanitation technologies reduce the number of deaths caused by waterborne disease [1].

Infrastructure can be defined as the physical components of interconnected systems that provide the necessities goods and services necessities to enable, sustain or improve conditions for community life or to achieve the services or facilities necessary to attracting investments and grown the economy in order to achieve progress and prosperity. The lack of adequate infrastructure can negatively affect the region's economy, its productivity, and competitiveness. Wastewater collection systems are considered one of the most important branches of the infrastructure due to their role in preserving the environment and the health of citizens [2].

A wastewater collection system is a network of pipes, manholes, and other infrastructure that is used to collect and transport wastewater from homes, businesses, and other buildings to a treatment facility. The collection system is an essential part of a country's infrastructure, as it helps to protect public health and the environment by removing hazardous materials and pollutants from the wastewater before it is released back into the environment [3].

The collection system typically consists of a series of pipes that are connected to buildings and other structures, which collect the wastewater and transport it through the system. The pipes may be made of various materials, including concrete, clay, plastic, or metal, and they are typically buried underground to protect them from damage. Manholes, which are typically located at regular intervals along the pipe network, allow access to the pipes for maintenance and repairs [3].

The collection system also includes a number of other components, such as pump stations, lift stations, and treatment plants, which help to move the wastewater through the system and treat it before it is released back into the environment. The size and complexity of a wastewater collection system can vary greatly depending on the size of the community and the volume of wastewater that needs to be treated [3].

Wastewater management is a significant challenge in Palestine, as the country has a limited supply of water resources and a growing population. Many communities in Palestine rely on waste water trucks and cesspits for sewage disposal, which can lead to contamination of surface and ground water if they are not properly maintained. In addition, many wastewater treatment plants in Palestine are outdated and do not have the capacity to adequately treat the wastewater produced by the growing population [4].

As a result, untreated or partially treated wastewater is often discharged into the environment, posing a risk to public health and the environment. There are efforts made by the government and municipalities to address this issue, despite the fact that a large percentage of areas lack modern wastewater collection systems. The Palestinian cities that contain wastewater collection systems represent only about 33 % [4] .

Bani Naim Town is one of the areas that still uses traditional methods of waste water disposal through the use of cesspits and waste water trucks that dispose of waste water in valleys and remote areas. In light of the increase in population density in the town and the deterioration of the cesspits and the impact of the soil and groundwater on it, the design of a waste water collection system for the town has become an urgent and necessary matter. Therefore, this project aims to design a waste water collection system and link it to treatment plant for Bani Naim Town.

1.2 Problem Definition

The rapid expansion and development of Bani Naim has increased water consumption and thus the generation of large amounts of wastewater from various sources such as residential areas, commercial establishments, and various industries. Moreover, in some areas, wastewater flows directly into the wadis through open drains in different routes causing serious environmental and health problems such as the spread of diseases and stinking smells. The lack of a waste water collection system and the common use of cesspits in the area has led to wastewater seeping into the ground in a remote area of the town, causing pollution of the groundwater.

These bad conditions and the lack of wastewater collection system Increase the environmental and health problem. Wastewater collection system becomes an urgent necessity to solve all the above problems. This study will contribute to solving this problem by evaluating and designing the aforementioned wastewater collection system, taking into account population growth, their water consumption, and industrial and commercial development in the region.

1.3 Project Objectives

The overall goal of this project is to design the wastewater collection system for Bani Naim Town and the sub purposes of this project can be categorized as follows:

1. A study of the current situation of Bani Naim Town with regard to wastewater disposal and the amount of damage that the Town suffers from this problem
2. Determine the design parameters related to the population and the project area, such as population growth rate, water consumption per capita, etc
3. Determine the areas targeted by the design and divide them into drainage basins according to the topographic nature of the land.
4. Design of a proposed wastewater collection system that includes the design of main and sub-main sewage, drainage sites, water dividers, water catchment areas, and proposed pumping stations.

5. Preparing maps and graphs of the collection system sewages, and then preparing schedules of quantities and specifications for the pipes according to the existing parameters and results.
6. The system will be connected to a main treatment plant proposed by the Joint Services Council for Water and sewage - North Hebron, in order to benefit from the treated wastewater in industrial and agricultural applications.

1.4 Phases of Project

The project consists of four phases, designed to be completed according to them with the schedule shown below. A description of each of the four phases of the project and the tasks involved are given below: -

Table (1.1): Phases of the Project With its Expected Duration in the Academic year 2022-2023

Title	**Duration Academic year 2022-2023**							
Month/year	**9/22**	**10/22**	**11/22**	**12/22**	**2/22**	**3/22**	**4/22**	**5/22**
Data Collection and Survey								
Fieldwork								
Analysis and Design								
Writing and Preparing the Report								

1.4.1 First phase: Data Collection and Survey

During this phase, available Data and information was collected from many sources and several field visits were conducted. This phase includes the following activities :-

- All necessary maps and plans, such as water and road networks, arial and topographic maps etc.
- Metrological and hydrological data were collected from Palestinian Meteorological Authority and from the municipality of Bani Naim
- Obtaining all necessary surveying data for the project, such as aerial photographs, contour lines, structural and surveying plans, etc.
- Collecting all need data and information about Bani Naim Town from reports studies such as number of populations, water consumption growth rate

1.4.2 Second phase: Fieldwork

The fieldwork phase of the project includes several elements, which are: -

- Visit the municipality of Bani Naim to collect information and data.
- Conducting a field examination of the directions of the main and secondary lines of the network during the design phase of the proposed wastewater collection system.
- Checking the locations of the proposed pumping stations on the ground in order to assess the suitability of the site for the construction of the pumping station.

1.4.3 Third phase: Analysis and Design

At this stage, the layout has been prepared and put into its final form, after which the wastewater quantities are determined the hydraulic calculation necessary for the design of the main sewages was carried out. This stage includes the following tasks:

- Draw the network diagram and compare it with the real situation in the Town of Bani Naim and then make the adjustment and the last drawing of the final layout, this task is the most outstanding.
- Evaluation of contour maps and their matching with actual ground levels
- Construction of watersheds, sub-catchments, and sewer paths.
- Establish design standards and conduct the required hydraulic towing for sewage mathematical calculations.
- preparing tables of bill of quantities
- Preparing the various drawings needed for the designed water courses.

1.4.4 Fourth phase: Writing and Preparing the Report

This stage will be continuous throughout the project period, in which a comprehensive report will be prepared for all the objectives. Final report will be prepared and submitted to the department of civil Engineering at Palestine Polytechnic University, and this will be done next semester.

1.5 Organization of the Study

The study report was prepared in accordance with the objectives and work.

- ✓ **The first chapter (Introduction):** presents an introduction to the infrastructure and wastewater collection systems then the state of wastewater and how to dispose of it in Palestine and Bani Naim Town in general, additionally, to present the objectives of the project and the methodology that will be followed to achieve it.
- ✓ **The second chapter (Project Area)**: focusing on the study area which deals with Geographical location, Population, Water Supply and Distribution, landuse, roads.
- ✓ **The third chapter (Basics and Laws)**: the basics for design and the laws for calculations
- ✓ **The fourth chapter (Analysis and Design):** the calculation using for design outputs (tables, drawing)

- ✓ **The fifth chapter (Bill of Quantities):** which contents a table with all actions and quantities needs to implement the project
- ✓ **The sixth chapter (Conclusions and Recommendations):** important notes and comments made during the work on the project

1.6 Summary

In this chapter, general information was provided about the design of wastewater collection systems, the status of wastewater in Palestine in general, and the town of Bani Naim in particular, and the problems facing this town related to the disposal of wastewater, in addition to the above. The project objectives are defined, as well as the stages of work completed throughout the academic year and the methodology used in these stages

Chapter (2) : Project Area

2.1 General

2.2 Geographical Location and Natural Features

2.3 Annual Rainfall and Temperature

2.4 Population

2.5 Water Supply and Distribution

2.6 Wastewater Disposal

2.7 Treatment Plants

2.8 Economic Activities

2.9 Landuse

2.10 Roads

2.1 General

In this chapter, the basic information that pertains to the Town of Bani Naim, which is Geographical location, terrain, rainfall amounts, land use, population census of the region, economic situation, Treatment plants, roads, water network and waste water disposed.

Note: All information and data in this chapter were obtained from the municipality of Bani Naim Town

2.2 Geographical Location and Natural Features

Bani Naim Town is located 8 kilometers east of Hebron city, as shown in figure (2.1). The average elevation of the town is 951 m above sea level. The total area of Bani Naim lands is about 157000 dunums. The area of Bani Naim Town within the boundaries of the master plan is approximately 9557 dunums.

The topography of the Town is a mountainous area as shown in figure (2.2) & figure (2.3), which show the topography of the project area. Where the topography is represented within the boundaries of the master plan. The highest point in this region, located in the town center, reaches 975 meters above sea level. The lowest point is 840 m above sea level, located in the eastern part of the town. (The location of the two points is shown in figure (2.4)).

The lowest area in the project area is located in “Al-Masafer” with an elevation of 390 m above sea level as shown in figure (2.4). This area is proposed to use for the main treatment plant shown in the final layout in appendix (A).

Figure (2.1): Location of Bani Naim Town

Figure (2.2): Digital Elevation Model of Project Area

Figure (2.3): Digital Elevation Model of Bani Naim Town within the Boundaries of the Master Plan

Figure (2.4) : Contour Plan of Project Area

2.3 Population

Bani Naim Town is characterized by a high population density (as shown in figure (2.5)) and a high population growth rate of 2.4%. The total number of its population within the administrative boundaries of the town in 2017 was 20,554 people. However, the population of Bani Naim Town in 2022 is estimated to be 23,144, and the estimated population for 2025 is about 27,980. Table (2.2) shows the population census of Bani Naim town in the previous ten years and the expected census for the next ten years.

Table (2.1): The population census of Bani Naim town from (2012-2032).

Year	Population
2012	18,364
2013	18,763
2014	19,174
2015	19,610
2016	20,071
2017	20,554
2018	21048
2019	21553
2020	22070
2021	22600
2022	23143
2023	23699
2024	24268
2025	24850
2026	25447
2027	26058
2028	26683
2029	27324
2030	27980
2031	28652
2032	29340

Figure (2.5): Population Density of Bani Naim Town

2.4 Land Use

The land area of Bani Naim Town is about 157,000 dunums, and these lands are divided into several classifications based on the nature of the land and its intended use. It is very important to know the land classifications in the project area in order to design the wastewater collection system in the most effective way. Residential areas and streets are considered the most important classifications to take into account during the design process. Residential areas are the main target group for the project, and streets provide good solutions for laying sewage pipes without encountering problems such as trespassing on private property.

Other important classifications to consider include areas of high population density, such as the old town in the center of Bani Naim Town, where narrow streets and open areas make it difficult to construct sewage pipes (as shown in figure (2.6)). Agricultural areas must also be carefully considered during the implementation of collection system lines to avoid polluting the soil and groundwater. In addition, industrial and commercial areas that may have activities that could pose a threat to the safety of the system, such as quarries and construction sites, should be taken into account. (All classifications are within the boundaries of the master plan for Bani Naim town shown in figure (2.6)).

Figure (2.6): Landuse of Bani Naim Town

2.5 Wastewater Disposal

Bani Naim Town suffers from a real problem in the disposal and treatment of wastewater in the Town. Citizens use cesspits and sewage trucks to dispose of wastewater in valleys and uninhabited lands shown on figure (2.7). This results in many problems such as pollution of the environment and the spread of unpleasant odors, insects and diseases among the population, in addition to the pollution of groundwater, soil, wells and springs as a result of wastewater intrusion into them.

Figure (2.7): (A: Cesspits) & (B: wastewater flow in valley).

2.6 Water Supply and Distribution

Bani Naim Town was connected to the water network in 1980, and approximately 75% of the housing units are connected to the water network. Which the Town is supplied with water from the Palestinian Water Authority. Despite the existence of a water network in the town, some citizens use collection wells and water tanks as alternative sources for the water network, due to the presence of many problems in the water service in Bani Naim Town, including: -

1. Lack of water, especially in the summer months.
2. Water does not reach high areas, due to poor pumping.
3. The water tank is unable to meet the Town's need for water
4. leakage which is estimated to be around 25%

The water consumption in Bani Naim Town is 66 liters per capita per day, and the required amount of water for Bani Naim inhabitants is around 2222 m^3 excluding industrial and public uses. So, the water consumption for all uses in Bani Naim Town is estimated as 4200 m^3/day considering the future water demand as 150 liters per capita per day for all purposes including household, industrial, and public usage. Therefore, the quantity supplied to the Bani Naim Town is insufficient to meet the water demand, and for the same reason, the water is distributed to city inhabitants by rotation.

The water in Bani Naim Town is distributed by a network of steel pipelines. The distribution network consists of mostly steel pipes up to 250 mm (10 in) in diameter whereas a few pipes are High-Density Polyethylene pipes (HDPE). Most of these pipes are more than 25 years old, but in the last two years, some major strategic pipelines have been constructed to improve supplies to the existing distribution system. The total length of the existing pipes including house connections and Palestinian Water Authority's (PWA) transmission pipeline is 96.650 km.

2.7 Annual Rainfall and Temperature

Due to its geographical location near the Negev desert, Bani Naim Town experiences relatively small amounts of annual precipitation. However, according to data collected over the past thirteen years, Bani Naim Town typically experiences an average annual precipitation of 393 mm. The town also has an average summer temperature of 25 ℃ and an average winter temperature of 14 ℃, with an average relative humidity of 61%. The maximum annual precipitation during the past thirteen years occurred in 2020, with a total of 612 mm while the minimum annual precipitation during the same period occurred in 2011, with a total of 266.5 mm. (shown in table 2.1)

Table (2.2): The annual precipitation in Bani Naim Town.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Amount of rainfall **(mm)**	366	266.6	291	334	345	395.5	413	420	373	390	612	317	330

2.8 Treatment Plants

According to the treatment of wastewater disposal, the municipality of Bani Naim proposes to create three plants to treat and reuse the town's sewage. The first treatment plant will be built to serve agricultural uses, as shown in figure (2.8). The water will be transported by irrigation vehicles and treated for use in agriculture, which will treat 100 m^3 per day, while the second plant will be built to serve the main public utilities in the Town as shown in figure (2.9), which will treat 25 m^3 per day. The third treatment plant is the main plant that will treat wastewater for all targeted areas in Bani Naim Town and will be located in the layout plan.

Figure (2.9): Aerial Photo Showing the Location Second Treatment Plan

2.9 Economic Activities

The residents of Bani Naim depend for their livelihood on trade in the first place and industry in the stone and marble sector (Marble Company and Bani Naim Quarries), agriculture, and livestock.

Distribution of the workforce by economic activities as shown in figure (2.10):

- The trade sector, which constitutes 50% of the workforce.
- The Israeli labor market, which constitutes 20% of the workforce.
- The agricultural sector, which constitutes 19% of the workforce.
- The employee sector, which constitutes 5% of the workforce.
- The industry sector, which constitutes 5% of the workforce.
- The service sector, which constitutes 1% of the workforce

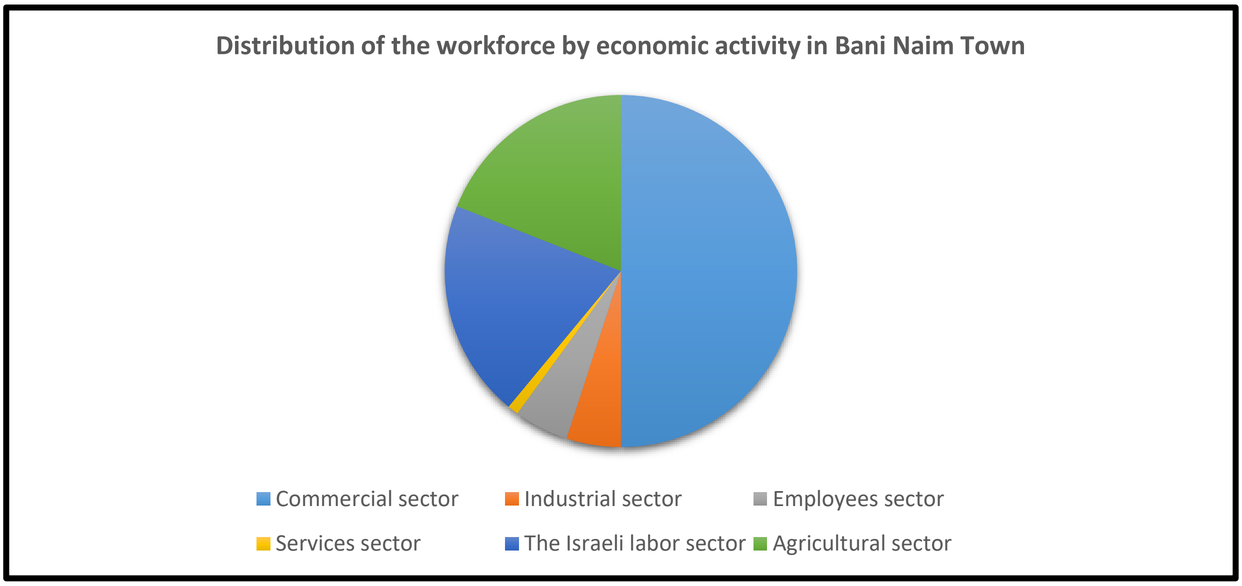


Figure (2.10): Diagram chart describes the distribution of the workforce by economic activities in Bani Naim Town

2.10 Roads

There are about 200 km of roads in Bani Naim Town, of which 60 km are paved roads in good condition, 20 km are paved roads in poor condition, and 120 km are unpaved roads as shown in Table (2.3) & figure (2.11).

Table (2.3): The condition of the roads and their lengths in Bani Naim Town.

The condition of the roads	Lengths of the roads (km)		
	Main roads	**internal roads**	**Agricultural roads**
Paved roads (good condition)	**30**	**20**	**10**
unpaved roads (bad condition)	**10**	**5**	**5**
unpaved roads	**-**	**20**	**100**
Total	**40**	**45**	**115**

Figure (2.11): Roads Classification in Bani Naim Town

2.11 Summary

In this chapter, we collected basic data about the study area in the town of Bani Naim, including its geographical location and topography. We also discussed the water network extensions in the town, land use and its most important classifications, economic activities of the population, treatment plants and the areas they serve, traditional methods of wastewater disposal in the town, population census data, annual rainfall amounts, and roads and their condition.

Chapter (3) : Basics and Lows

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, and (4) 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, and a typical layout of a municipal sewerage system is shown in Figure 3.2.

Figure (3.1): The types of sewers usually 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).

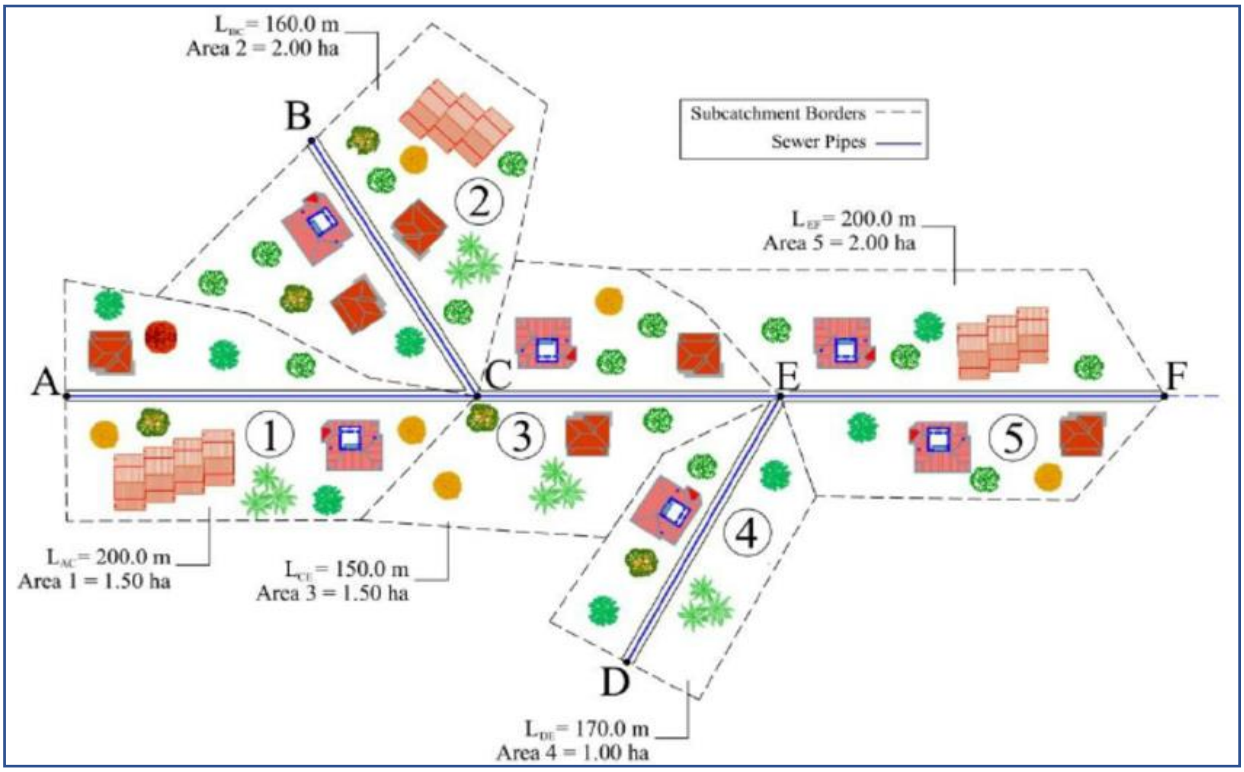


Figure (3.2): Typical layout of a municipal sewerage system.

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 3 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 50 m depending on the size of sewer and available size of sewer cleaning equipment.

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. Typical sewer and drop manholes are shown in Figure 3.3.

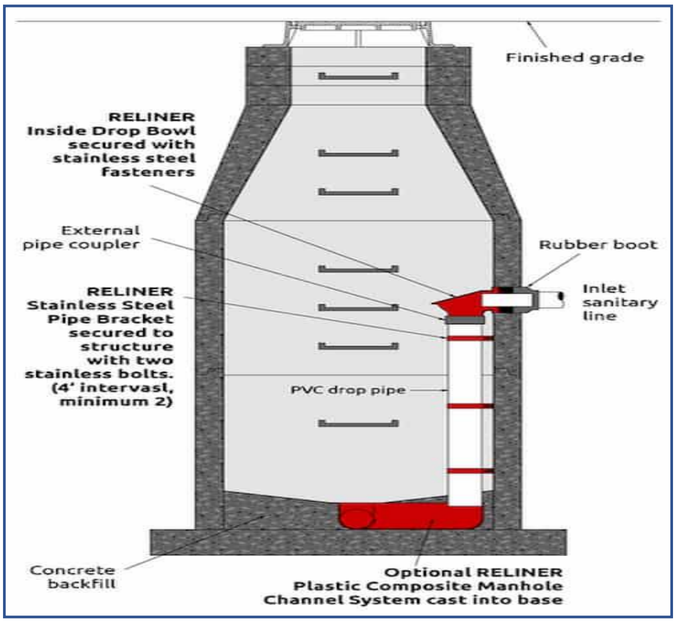


Figure (3.3): Typical sewer and drop manholes

3.4.2 House Connections

The house sewers are generally (4 in) 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.

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.

3.4.4 Sewer Outlets and Outfall

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.

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.

3.4.5 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.

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.

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.

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.

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

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

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. Comm-only 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 70% running full, that is means only 40 % to 70 % 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:

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.

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:

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.

Finally, these layout plans and profiles are revised after the field investigations and sewer designs are complete. A typical sewer layout and profile are shown in Figure 3.4 and figure 3.5.

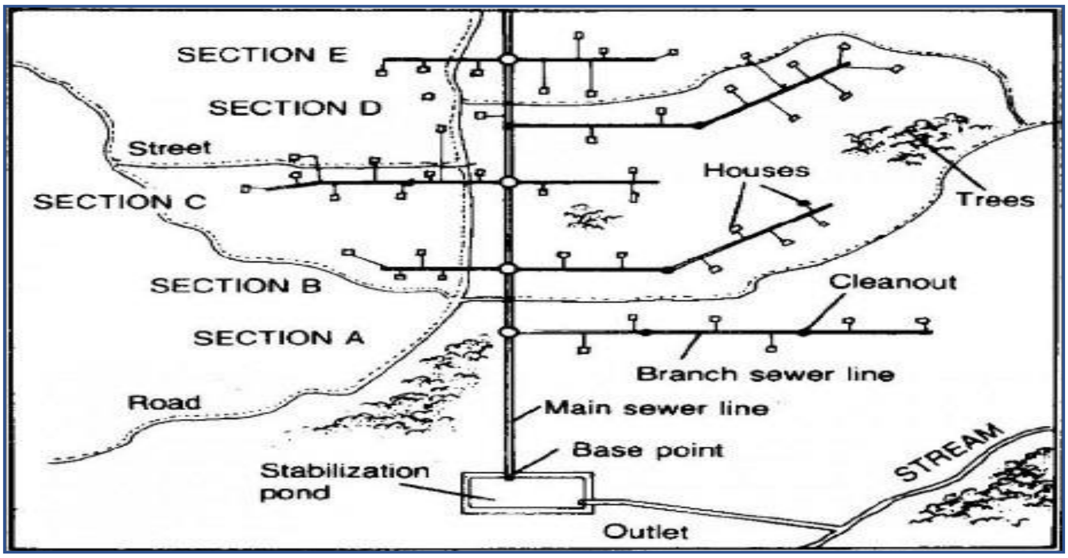


Figure (3.4): Typical sewer layout

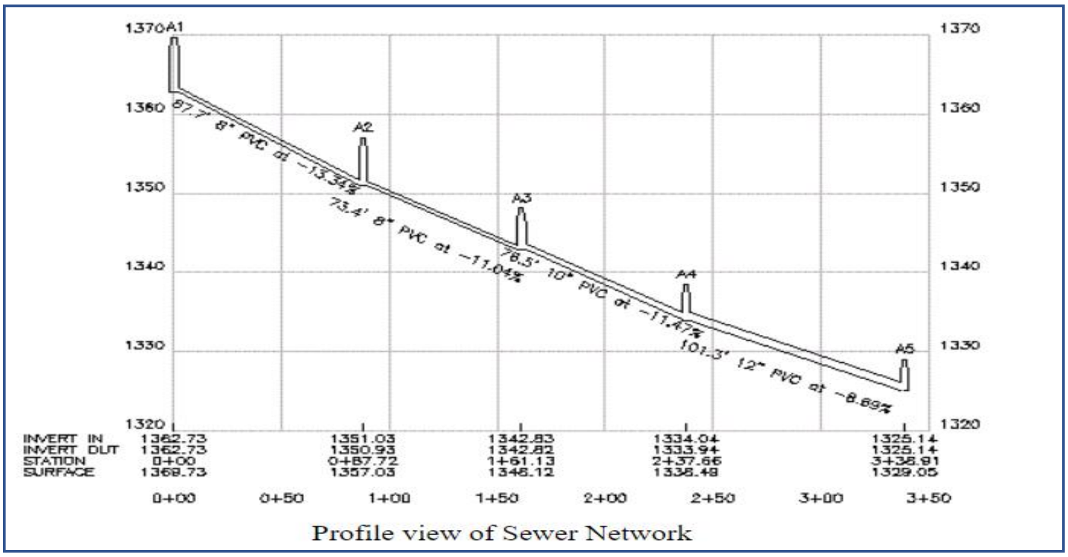


Figure (3.5): Typical sewer profile

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).
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 3.0 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 1.5 m below the ground surface. Depth epends 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 50 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:

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

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 3.6. Hydraulic elements of circular pipes under part-full flow conditions are provided in Figure 3.7. It may be noted that the value of n decreases with the depth of flows . 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 will be shown in the design calculation in chapter five.

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. Table 3.3 is typical of the way in which data can be organized to facilitate computations.

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 .

- **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.

3.7 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.

3.8 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 (4) : Analysis and Design

4.1 General

In this project, an attempt is made to evaluate and design wastewater collection system for Bani Naim Town, and develop a future plans for construction of the collection system, corresponding to population growth and the water consumption and subsequently the wastewater production from different sources in the future, in order to reduce the problem causes by the disposal of raw wastewater in the area. In this chapter, the layout of the system established will be presented followed by discussion of detailed design computations and the final design and specifications of the suggested wastewater collection system.

4.2 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, soil type, and the cellar or lowest floor elevation of all buildings to be drained. Where part of the drainage area to be served is undeveloped and proposed development plans are not yet available, care must be taken to provide adequate terminal manholes that can later be connected to the system constructed serving the area.

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

1. Obtain a topographic map of the area to be served.
2. Locate the drainage outlet. This is usually near the lowest point in the area and is often along a stream or drainage way. In Bani Naim area, the lowest point is in the southern part of the town where the meant authority will plan and design a treatment plant for the whole city of Hebron and some of their towns and villages.

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

4. 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.

5. 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 paralleling streams or channels.

6. Establish preliminary pipe sizes. Eight inches pipe size (usually the minimum allowable) can serve several hundred residences even at minimal grades.

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 number 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 for Bani Naim town is illustrated in Figures 4.1 and 4.2 and it appears more clearly in Appendix A.

Figure 0.1: The final layout of wastewater collection system for Bani Naim town

Figure (4.0.2): The final layout With Contour of wastewater collection system for Bani Naim town

4.3 Design Computations

The detailed design of sanitary sewers involves the selection of appropriate pipe sizes and slopes to transport the quantity of wastewater expected from the surrounding and upstream areas the next pipe in series, subject to the appropriate design constrains. The design computations and procedure for Bani Naim sanitary sewers is illustrated in the design example given below.

Design Example: Design a gravity flow sanitary sewer

Design a gravity flow trunk sanitary sewer for the area (part of Bani Naim town) shown in the accompanying Figure 4.3. The trunk sewer is to be laid along municipality street. As mentioned in chapter four, assume that the following design criteria have been developed and adopted based on an analysis of local conditions and codes.

1. For design period use 25 years as a design period.
2. For population growth use 2.4% .Depending on these values in the calculation of the population density (person/hectare).
3. For water consumption use 66 l/c.d. for the current use and 150 l/c.d. for the future use. The wastewater calculates as 80% of the water consumption.
4. . For infiltration allowance use 10% of the averag flow
5. Peaking factor depending on the formula: { $P_f = 1.5 + (2.5 /\sqrt{q})$ }
6. For the hydraulic design equation use the Manning equation with an n value of 0.013. To simplify the computations.
7. Minimum pipe size: The building code specifies 200 mm (8 in) as the smallest pipe permissible for this situation.
8. 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.
9. Minimum cover (minimum depth of cover over the top of the sewer). The minimum depth of cover is 1.5 m.

Figure (0.3): Sewer Line for the Design Example

Solution

1. Layout the sewer. Draw a line to represent the proposed sewer Figure (4.3).
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) .
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 bythe 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: $Pf = 1.5 + 2.5/\sqrt{q}$, 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% of Qaverage

(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 Bani Naim town are shown in Appendix B.

computation table depend on the factors that must be considered in arriving at the peak design flows

Table (4.1): The calculation table for the wastewater collection system of Bani Naim Town

Sanitary Sewer Design Computations

Sub-Main No. (6.2)

Line No	Location			Length	unit sewage	Tributary area		Flow Rates					Q max
	Street Sewer Name	Upper Mh No	Lower Mh No			Incremental	Total	Average	Peak Factor	Maximum	Infiltration	Total Maximum	
				m	m^3/d.dounm	dounm	dounm	m^3/day		m^3/day	m^3/day	m^3/day	m^3/day
1	2	3	4	5	6	7	8	9	10	11	12	14	15
1	Pipe No. 1	1	2	50	1.05009323	11.7	11.70	12.29	2.21	27.19	1.23	28.42	28.42
2	Pipe No. 2	2	3	50	1.05009323	16.2	27.90	29.30	1.96	57.48	2.93	60.41	31.99
3	Pipe No. 3	3	4	50	1.05009323	15.5	43.40	45.57	1.87	85.24	4.56	89.80	29.39
4	Pipe No. 4	4	5	50	1.05009323	14.8	58.20	61.12	1.82	111.22	6.11	117.33	27.53
5	Pipe No. 5	5	6	50	1.05009323	14.2	72.40	76.03	1.79	135.84	7.60	143.44	26.11
6	Pipe No. 6	6	7	50	1.05009323	14.1	86.50	90.83	1.76	160.08	9.08	169.16	25.72
7	Pipe No. 7	7	8	50	1.05009323	13.7	100.20	105.22	1.74	183.47	10.52	194.00	24.84
8	Pipe No. 8	8	9	50	1.05009323	13.6	113.80	119.50	1.73	206.58	11.95	218.53	24.53
9	Pipe No. 9	9	10	50	1.05009323	13.6	127.40	133.78	1.72	229.59	13.38	242.97	24.44
10	Pipe No. 10	10	11	50	1.05009323	13.5	140.90	147.96	1.71	252.35	14.80	267.14	24.18
11	Pipe No. 11	11	12	50	1.05009323	10.8	151.70	159.30	1.70	270.50	15.93	286.43	19.29
12	Pipe No. 12	12	13	10	1.05009323	9.2	160.90	168.96	1.69	285.94	16.90	302.83	16.40

Design Assamptions and data

1) Water comnsumption is	66	m3/d.d which	7) Minimum slope Smin =	0.50%		houses no	44
			8) Maximum slope Smax =	15%		pop.	1408
3) Infiltration is equal	10	% of the average industrial wastewater flow.	9) Maximum manhole spacing = 50	m		density	8.75077688
						unit sewage	1.050093226
4) Minimum pipe diameter=	200	mm	10) Minimum depth of sew	1.5	m		
5) Minimum velocity Vmin =	0.6	m/sec	11) Design depth of flow h/	0.5			
6) Maximum velocity Vmax =	3	m/sec	12) Maining coefficient n=	0.01			

4.4 SewerCAD Work Steps

SewerCAD is a software program for the design, analysis, and modeling of sewer systems.it enables engineers to create detailed 3D models of sewer systems, including pipes, manholes, and other components. The software also allows users to perform hydraulic and hydrological calculations, simulate flow conditions, and analyze the performance of various components within the system. The process of designing the sewer lines components in the project has been completed as shown in the following steps :

1. Import a DXF file to the program containing the locations of the manholes.

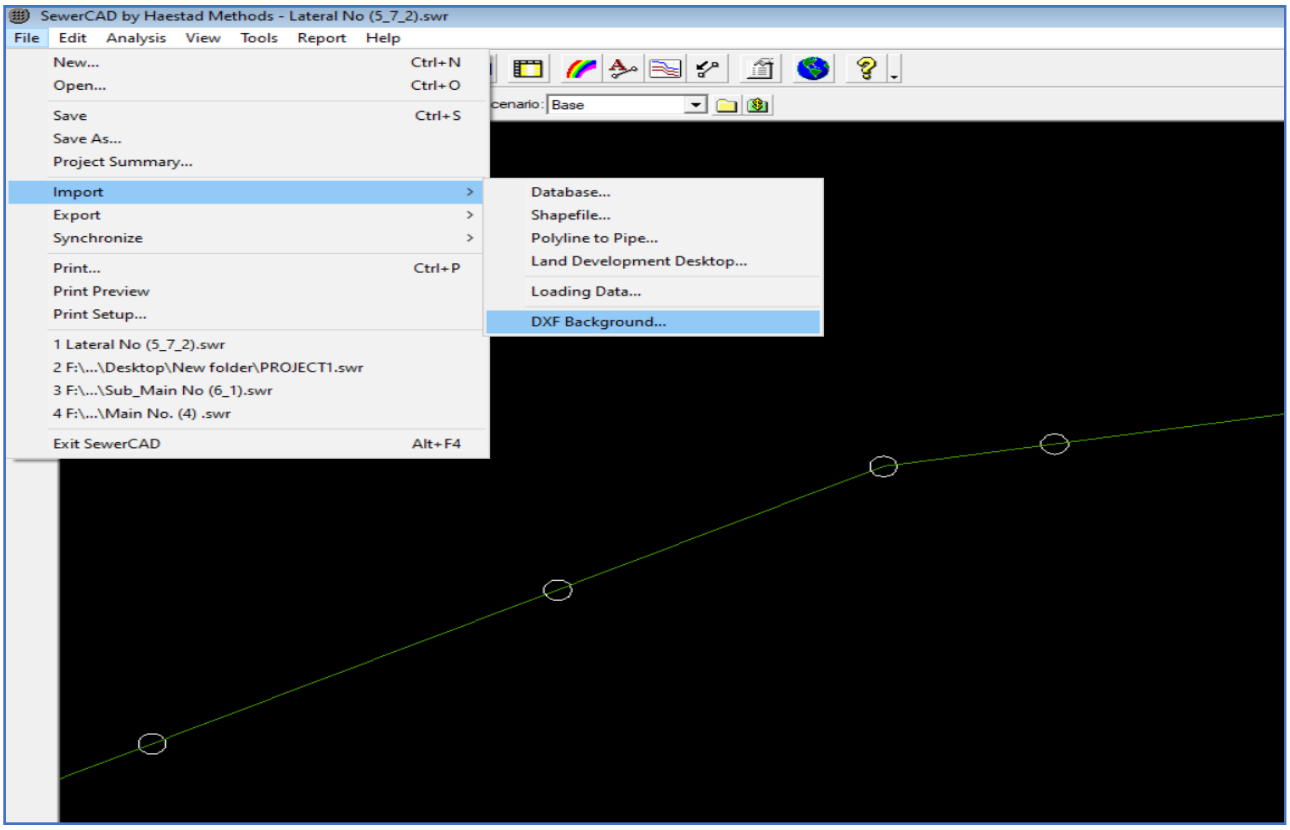


Figure (4.4): Step (1) : Importing a DXF file of manholes

2. Manholes are added to their specified locations, taking into account the direction of flow and the definition of the last manhole as a “Outlet”.

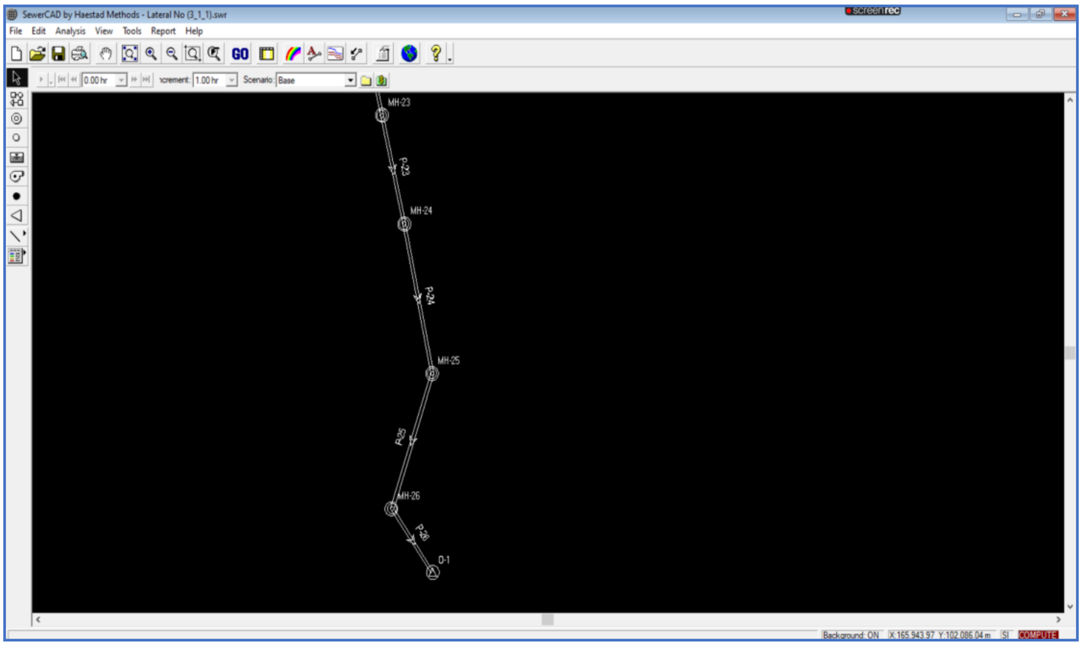


Figure (4.4): Step (2) : adding Manholes to their specified locations

3. From the Analysis menu >> Alternatives >> Physical Proparities >> Gravity Pipe, the default clip size is selected as 8 inches (200 mm).

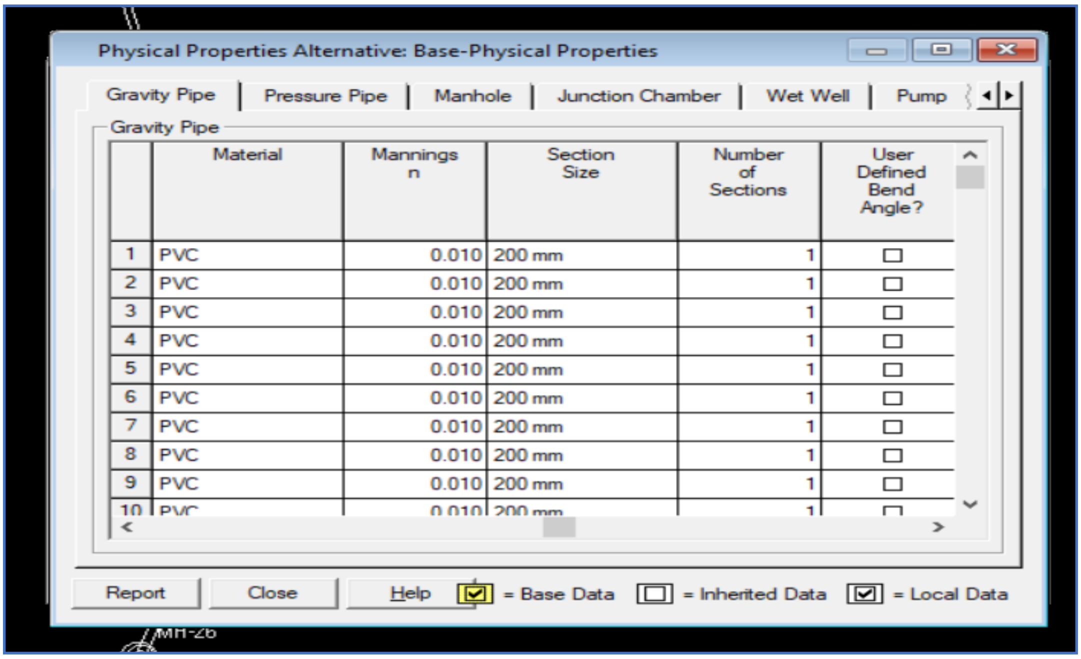
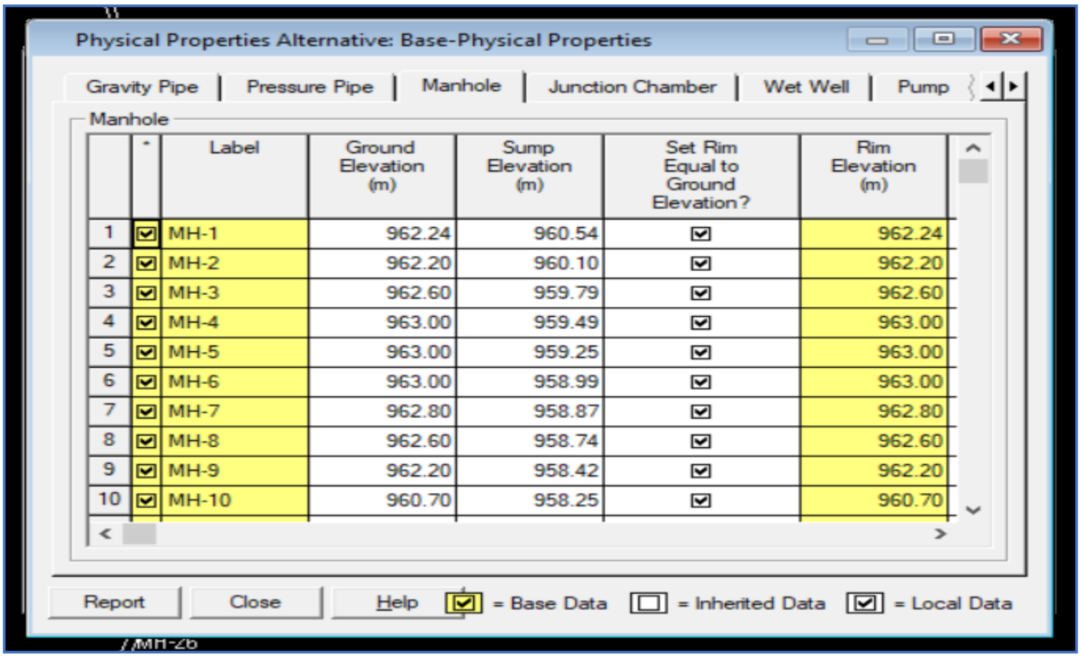


Figure (4.5): Step (3) : selecting section size

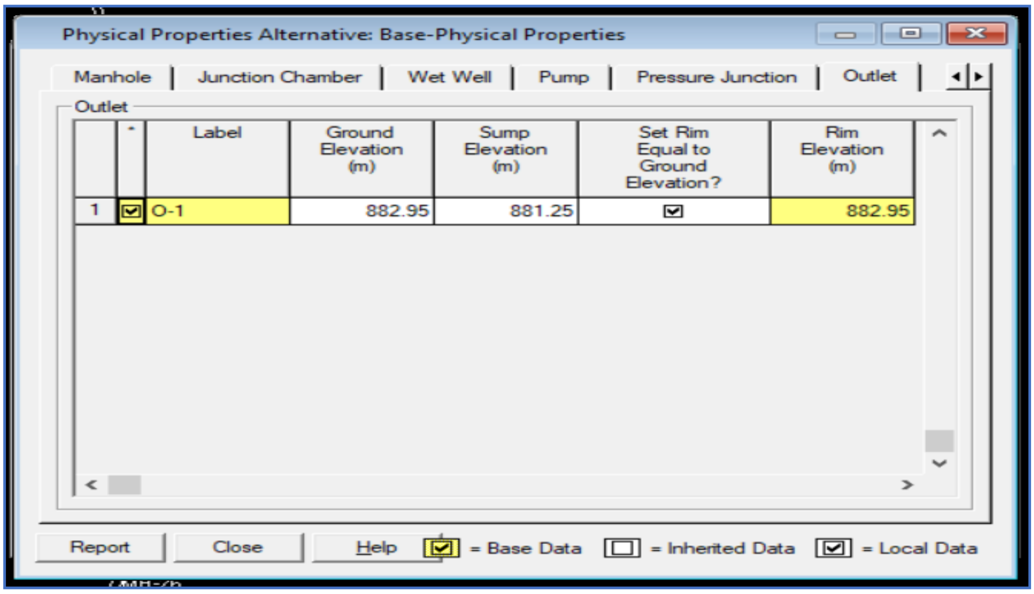
4. The ground elevation of the manhole locations are extracted from the DEM file of the project area and the values are entered into Analysis menu >> Alternatives >> Physical Proparities >> Manhole.



		Label	Ground Elevation (m)	Sump Elevation (m)	Set Rim Equal to Ground Elevation?	Rim Elevation (m)
1	☑	MH-1	962.24	960.54	☑	962.24
2	☑	MH-2	962.20	960.10	☑	962.20
3	☑	MH-3	962.60	959.79	☑	962.60
4	☑	MH-4	963.00	959.49	☑	963.00
5	☑	MH-5	963.00	959.25	☑	963.00
6	☑	MH-6	963.00	958.99	☑	963.00
7	☑	MH-7	962.80	958.87	☑	962.80
8	☑	MH-8	962.60	958.74	☑	962.60
9	☑	MH-9	962.20	958.42	☑	962.20
10	☑	MH-10	960.70	958.25	☑	960.70

Figure (4.7): Step (4) : adding ground elevation of the manhole locations

5. Outlet elevation is also entered from the Analysis menu >> Alternatives >> Physical Proparities >> Outlet.



		Label	Ground Elevation (m)	Sump Elevation (m)	Set Rim Equal to Ground Elevation?	Rim Elevation (m)
1	☑	O-1	882.95	881.25	☑	882.95

Figure (4.8): Step (5) : adding ground elevation of the outlet

6. From the Analysis menu >> Alternatives >> Sanitary (Dry Weather) >> Manhole , sanitary load type for the pipes is selected as “Pattern Load”.

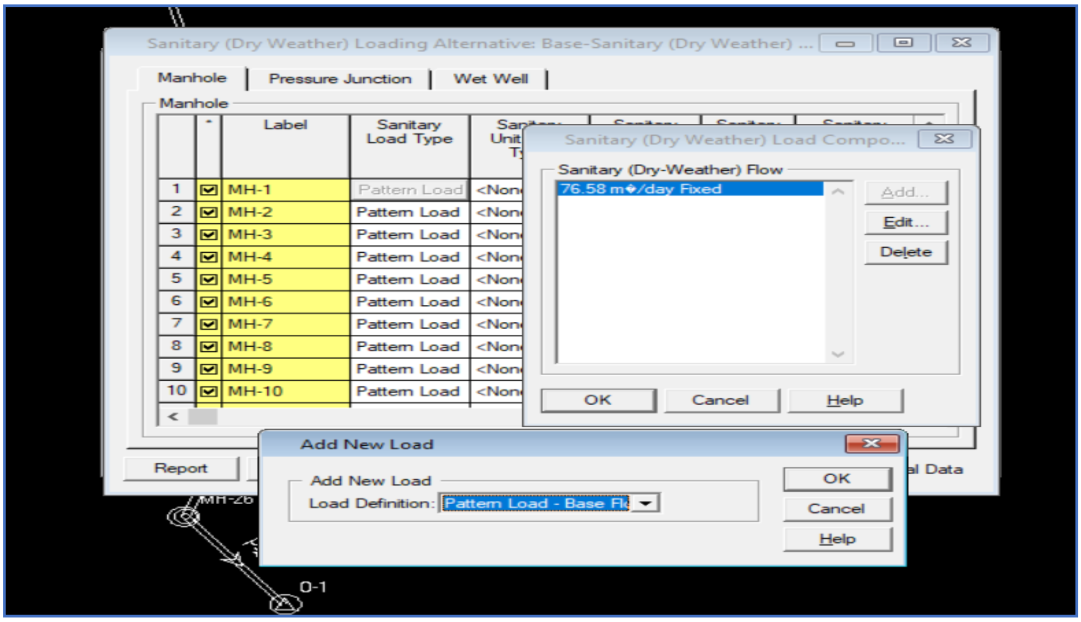


Figure (4.6): Step (6) : selecting sanitary load type

7. From the Analysis menu >> Alternatives >> Sanitary (Dry Weather) >> Manhole , design flow quantities (Q_{Max}) are entered for each pipe.

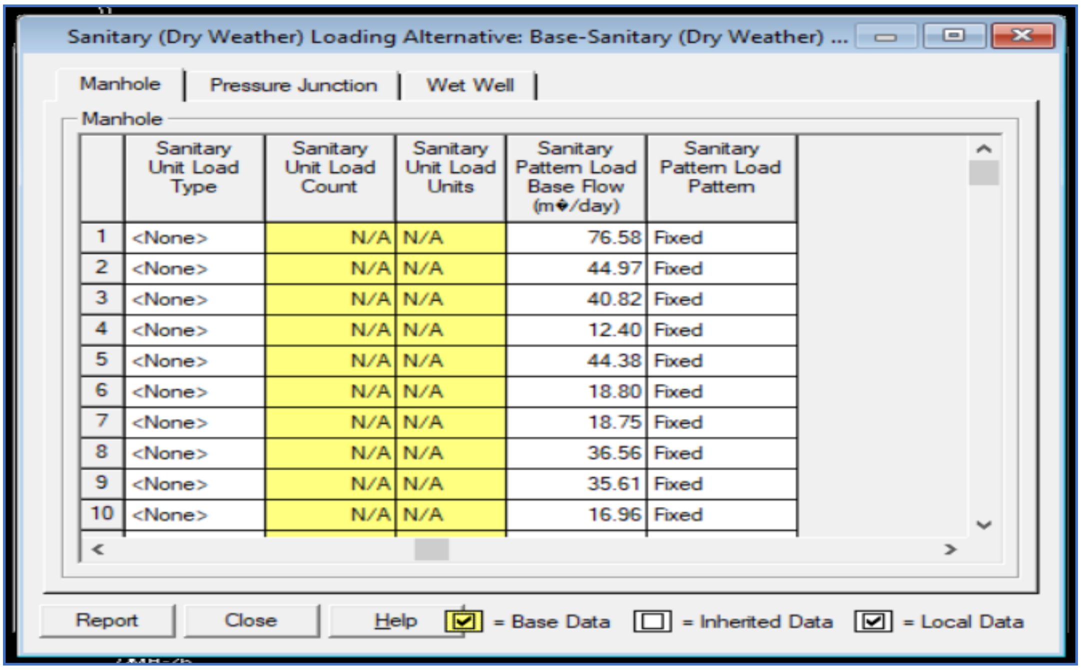


Figure (4.10) Step (7) : adding design flow quantities (QMax)

8. From the Analysis menu >> Alternatives >> Design Constrains >> Gravity Pipe ,the required design parameters are filled out.

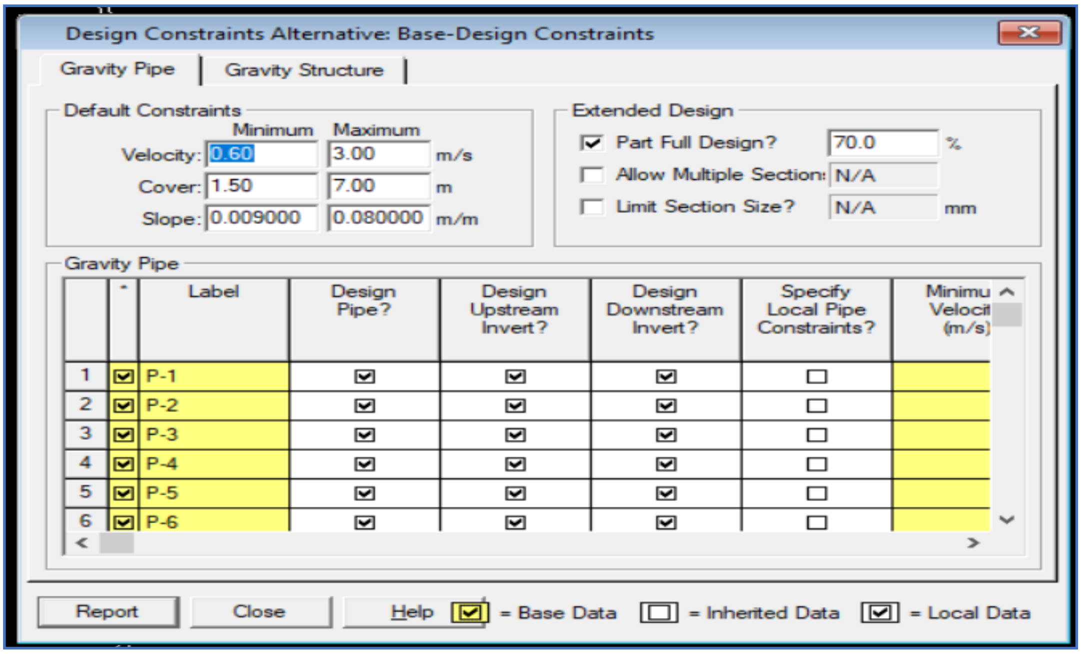


Figure (4.11): Step (8) : filling the required design parameters

9. After saving the file, the program is run to do the required calculations.

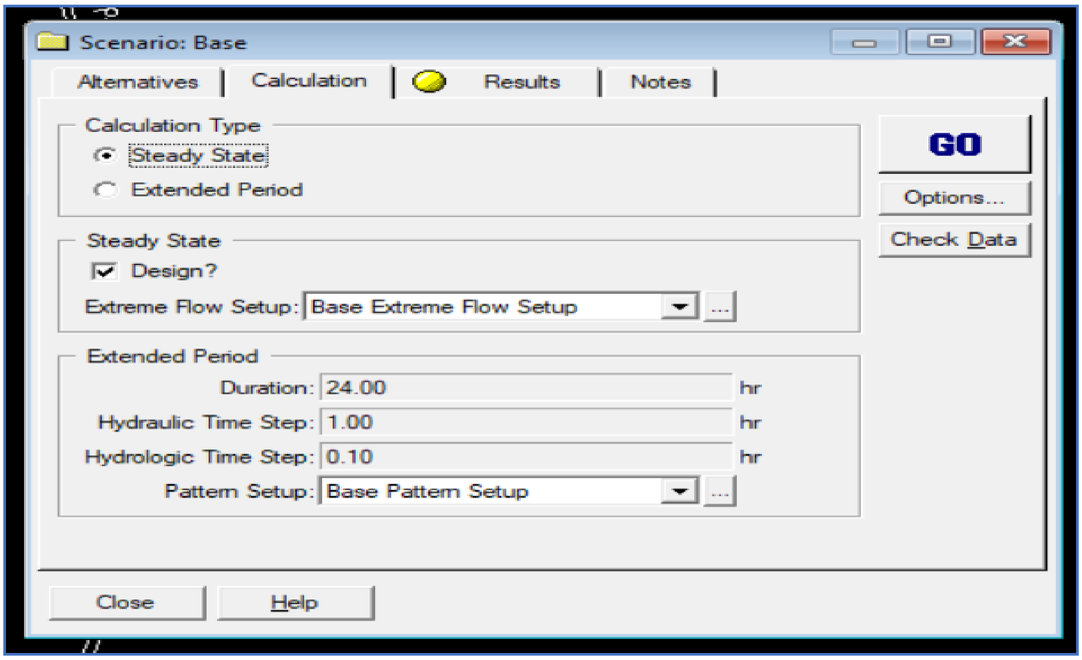


Figure (4.12): Step (9) : running the program

10. The program extracts errors and excesses in the design according to the inputs in the "Design Constrains".

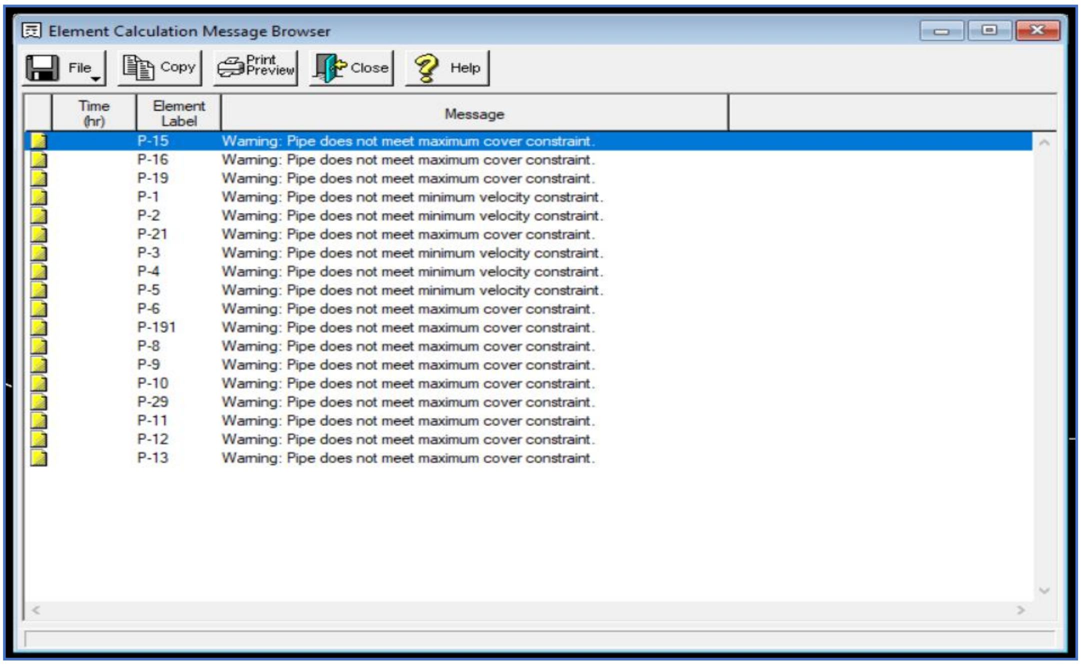


Figure (4.7): Step (10) : errors in the design according to the inputs in the "Design Constrains"

11. From the table manager field, the gravity pipe report is modified and the target data is selected.

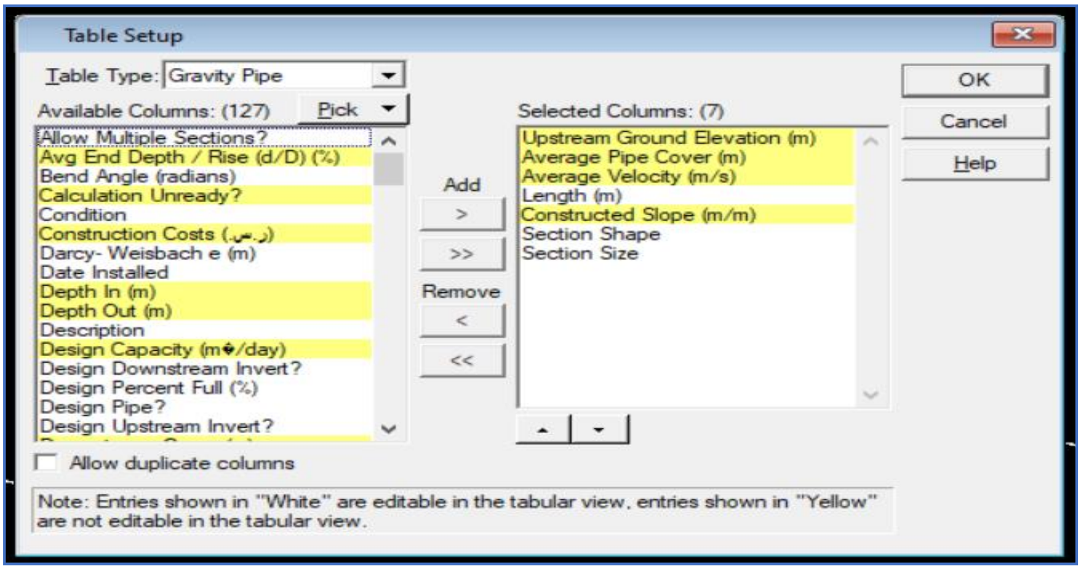
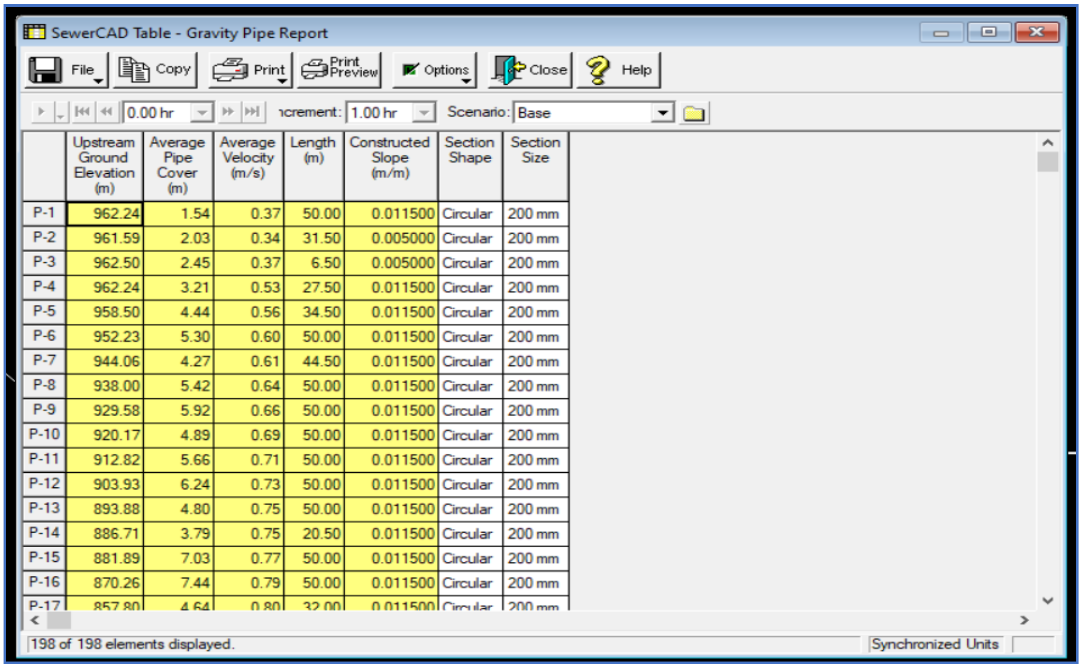


Figure (4.14): Step (11) : editing the report content

12. From the “Table Maneger”, the gravity pipe report is selected.Then the table exported to an excel file.



SewerCAD Table - Gravity Pipe Report

	Upstream Ground Elevation (m)	Average Pipe Cover (m)	Average Velocity (m/s)	Length (m)	Constructed Slope (m/m)	Section Shape	Section Size
P-1	962.24	1.54	0.37	50.00	0.011500	Circular	200 mm
P-2	961.59	2.03	0.34	31.50	0.005000	Circular	200 mm
P-3	962.50	2.45	0.37	6.50	0.005000	Circular	200 mm
P-4	962.24	3.21	0.53	27.50	0.011500	Circular	200 mm
P-5	958.50	4.44	0.56	34.50	0.011500	Circular	200 mm
P-6	952.23	5.30	0.60	50.00	0.011500	Circular	200 mm
P-7	944.06	4.27	0.61	44.50	0.011500	Circular	200 mm
P-8	938.00	5.42	0.64	50.00	0.011500	Circular	200 mm
P-9	929.58	5.92	0.66	50.00	0.011500	Circular	200 mm
P-10	920.17	4.89	0.69	50.00	0.011500	Circular	200 mm
P-11	912.82	5.66	0.71	50.00	0.011500	Circular	200 mm
P-12	903.93	6.24	0.73	50.00	0.011500	Circular	200 mm
P-13	893.88	4.80	0.75	50.00	0.011500	Circular	200 mm
P-14	886.71	3.79	0.75	20.50	0.011500	Circular	200 mm
P-15	881.89	7.03	0.77	50.00	0.011500	Circular	200 mm
P-16	870.26	7.44	0.79	50.00	0.011500	Circular	200 mm
P-17	857.80	4.64	0.80	32.00	0.011500	Circular	200 mm

198 of 198 elements displayed.

Figure (4.15): Step (12) : openning gravity pipe report and export it

13. From the Profile field, the profile is drawn and exported as a DXF file.

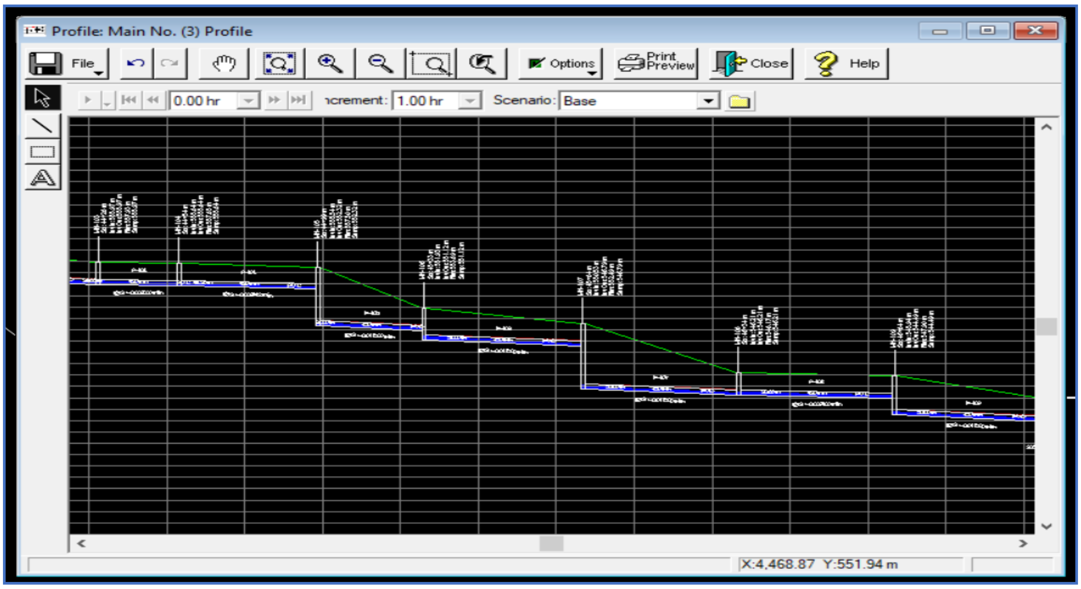


Figure (4.16): Step (13) : profile drwan from the results

Table (4.2) :The Design Report for the Wastewater Collection System of Bani Naim Town

SewerCad Report - Sub-Main Sewer No. (6.1) -								
Label Manholes 1	Ground Elevation (m) 2	Label Pipes 3	Average Pipe Cover (m) 4	Average Velocity (m/s) 5	Length (m) 6	Constructed Slope (m/m) 7	Section Shape 8	Section Size (mm) 9
MH - 1	935	P - 1	1.97	0.6	50	0.0592	Circular	200
MH - 2	932.98	P - 2	2.45	0.76	50	0.0700	Circular	200
MH - 3	927.58	P - 3	1.93	0.85	50	0.0700	Circular	200
MH - 4	923.21	P - 4	2.72	0.92	47	0.0700	Circular	200
MH - 5	917.47	P - 5	2.05	0.98	50	0.0700	Circular	200
MH - 6	912.87	P - 6	2.45	1.04	50	0.0700	Circular	200
MH - 7	907.47	P - 7	2	1.1	50	0.0700	Circular	200
MH - 8	902.96	P - 8	1.57	1.13	31	0.0700	Circular	200
MH - 9	900.64	P - 9	2.38	1.17	50	0.0700	Circular	200
MH - 10	895.37	P - 10	2.24	1.2	36.5	0.0700	Circular	200
MH - 11	891.34	P - 11	2.63	1.24	50	0.0700	Circular	200
MH - 12	885.58	P - 12	3.11	1.27	50	0.0700	Circular	200
MH - 13	878.85	P - 13	1.5	0.7	38.5	0.0119	Circular	200
O - 1	878.39	....	....	....	....	....	....	....

4.5 Profiles of Sewers

The profiles of sewer area assist in the design and are used as the basis of construction drawings. The profiles are usually prepared for each sewer line at a horizontal and vertical scale. The profile shows the ground or street surface, tentative manhole locations, elevation of important subsurface strata such as rock, locations of borings, all underground structures, basement elevations, and cross streets. A plan of the line and relevant other structures are usually shown on the same street .

After all the calculation is completed and all the maps of the proposed collection system are prepared, Detailed profiles for each sewer is drawn. Example of profile of sewer line are shown in Figures 4.17. This profile shown the ground elevation, the proposed sewer lines, manholes (manholes number and the spacing between the manholes), depth of excavations, the diameters and slopes of the pipes.

The profiles of sewer lines for the wastewater collection system of Bani Naim town are shown in Appendix C.

Figure (4.8): Example of profile of sewer line

4.6 Summary

In this chapter, the layout of the proposed wastewater collection system for Bani Naim town has been described. The detailed design computations have been given and discussed. The proposed wastewater collection system has been presented. Finally the profiles of sewers have been presented.

Chapter (5) : Bill of Quantity for the Proposed Wastewater Collection System

5.1 Tables of Bill of Quantity for the Proposed Wastewater Collection System

5.1 Tables of Bill of Quantity for the Proposed Wastewater Collection System

Table (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	81797				
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	6432				
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	10556				
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	6732				
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	7789				
A6	Excavation of pipes trench in all kind of soil for one pipe diameter 24-inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	3153				
Sub-Total							
B	**PIPE WORK**						
	Supplying, storing and installing of PVC	LM	116457				
Sub-Total							

No.	EXCAVATION	UNIT	QTY	UNIT PRICE		TOTAL PRICE	
C	**PIPE BEDDING AND BACKFILLING** **Dimension and material**			**$**	**C**	**$**	**C**
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	81797				
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	6432				
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	10556				
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	6732				
C5	Supplying and embedment of sand for one pipe diameter 18-inch, depth up to 1.5 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	7789				
C6	Supplying and embedment of sand for one pipe diameter 24-inch, depth up to 1.5 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	3153				
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 1000mm, depth up to 1.5 m.	NR	1684				
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 2.5 m.	NR	1080				
Sub-Total							
E	**Concrete Surround**						
E2	Suppying and installing of reinforced concrete (B 200) protection concrete encasement for sewer pipe.	LM	116457				
Sub-Total							

No.	EXCAVATION	UNIT	QTY	UNIT PRICE		TOTAL PRICE	
F	**Air And Water Leakage Test**			**$**	**C**	**$**	**C**
F1	Air leakage test for sewer pipe lines 8,10,12,14,15,18 and 24 inch according to specifications, including for all temporary works.	LM	116457				
F2	Water leakage tests for manholes, depth up to 1.5 meter according to specifications.	NR	1684				
F3	Water leakage test for manholes , depth up to 2.5 meter according to specification	NR	1080				
	Sub-Total						
G	**Road reinstatment**						
G1	Removing and dispose of the asphalt anf repaaviing and re-Asphalting after BACKFILL, road structure layers compacted basecoarse 125+125 mm, MCO layer 11/m2, asphalt layer 50mm(3/4”).	LM	22992				
Sub-Total							
H	**Survey work**						
H1	Topographical survey required for shop drawings and as built DWGS using absoluet Elev. And coordinate system	LM	116457				
Sub-Total							

Chapter (6) : Conclusions and Recommendations

6.1 Conclusions and Recommendations

6.1 Conclusions and Recommendations

In the proposed study for the wastewater collection system for Bani Naim Town, the trial is made to design the main trunks of the collection system for year 2048. Main conclutions for this study :-

1. the collection system covers most of the area of Bani Naim Town which the main,sub-main and lateral sewers are distributed over the region as follows:
   - (6) main sewer lines
   - (34) sub-main sewer lines
   - (8) Lateral sewer lines
2. The slope of the pipes follow the slope of ground, which leads to many number of drop manholes. Among the 2764 manholes, there are 1080 drop manholes.
3. In same pipes, the velocity of flow is less than 0.6 m/sec (minimum velocity) in the beginning of 19 sewer of them, which means flushing, are required from time to time
4. Four pumps are required in the west and east region to pump wastewater form low-lying sections. Which (4) of the sewer lines run by pumping and (44) by gravity
5. It was ensured that the flow velocity were kept within the permitted range as much as possible. The maximum speed in the pipes reached 2.81 m/s, while the minnimum speed was 0.17 m/s.
6. In total, 48 outlets were produced for the sewers .The outlets of the lateral sewers flow into the sub-main sewers, as well as the outlets of the sub-main sewers into the main sewers, reaching the pumping stations or the treatment plant.

References

[1] C. L. David Pearce and Giles Atkinson, " "THE CONCEPT OF SUSTAINABLE Development.An evaluation of its usefulness. Ten years after Brundtland"," *Centre for social and Economic Research on the Global Environment University college,* pp. 98-02, 2007.

[2] J. D, Global land outlook, United Nations, 2022.

[3] R. Arbour, Basic Wastewater Collection Systems, vol. Second Edition , Sacramento: California State University, 1995.

[4] Palestinian Hydrology Group, "Water and Wastewater Master Plan For Tulkarem Governorate," Palestinian National Authority, Ramallah, 2011.

[5] T. J. Mc Ghee, ""Locality Type Booklet: Population,Housing, and Establishment Census"," Statistical Reports Series, Ramallah, 1991.

[6] S. R. Qasim, "Wastewater treatment plants planning, Design, and operation"," The University of Texas at Arlington, U.S.A., 1985.