DESIGN OF WASTEWATER COLLECTION SYSTEM FOR AL BURJ VILLAGE

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HEBRON- WEST BANK
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A PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF REQUREMENTS FOR

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CERTIFICATION

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The Senior Project Entitled:

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Prepeared By:

BADEE' KARAKI **ISLAM DOU'DRA**

In accordance with the recommendation of the project supervisors, 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 Department for the degree of Bachelor of Science in Engineering.

Project Supervisors **Department Chairman**

الإهداء

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

إلى جرحانا الذين ترجلوا في وجه العدو الغاصب وجراحهم تنزف وصدورهم عارية في وجه البنادق.

إلى أسرانا البواسل القابضين على الجمر، خلف القضبان، الصامدين تحت سيطرة الجلادين.

إلى ساعدي أبي الذي انتزع الصخرة ليجعل منها شهادة لميلادي.

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إسلام دعدره

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

Work Team

ABSTRACT

Design of Wastewater Collection System for Al Burj Village

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There is no wastewater collection system at present in Al-Burj village. The sewage from residential and public buildings in the area is drained to cesspits. These have become clogged with time and require frequent emptying. The continued use of cesspits with the increase in population will cause environmental and health problem, and may create contamination of the underground water aquifer. Furthermore, emptying cesspools constitutes an offensive odor nuisance to the population. On the other hand, emptying the vacuum trunks in the nearly wadi causes negative impacts on the visual landscape.

In reference to above description of the existing situation, there is a clear need of project in order to improve the sanitary level in Al-Burj village town. The first step is serving the town with wastewater collection system, which is one of the main objectives of this project.

The present study considered the annual population growth, their water demand and wastewater quantity for the coming 25 years that will be the design period, along with the commercial and industrial development in the area. The hydraulic calculation needed for the design of wastewater links pipelines will be carried out using Sewer-CAD software.

By the end of this project, a complete design for water distribution network and waste water collection system for Al-Burj village will be ready along with bill of quantities, cost estimate, and the suggested phases of construction.

TABLE OF CONTENTS

APPENDIX-B: DESIGN TABLES

LIST OF TABLES

LIST OF FIGURES

CHAPTER

1 *INTRODUCTION*

1.1 Background

1.2 Problem Definition

1.3 Purpose of the Project

1.4 Project Area

1.5 Stages of the Project

1.6 Organization of the Report

CHAPTER ONE

INTRODUCTION

1.1 Background

Currently, there are no public wastewater collection and treatment facilities serving most of rural areas in the West Bank. And due to the lack of sewage collection and treatment system, large areas in the West Bank and ground water aquifer are being contaminated by raw sewage. This contamination will have long-term impact on agricultural land and creates health hazards when utilized for human consumption. For the above mentioned reasons, serious and major steps should be taken to collect, dispose and treat the wastewater before discharging it in open environment.

1.2 Problem Definition

More than 60% of the water used for domestic purposes and industry turn into sewage requiring purification (treatment) for reuse in irrigation or alternative disposal. Contrarily, if wastewater not treated and not disposed of, sewage may contaminate sources of drinking water. In Palestine, water-borne diseases are very commonplace.

In the West Bank, no piped wastewater disposal system is available in most of the rural areas. Wastewater from individual residence is discharge directly into subsurface pits, allowing the wastewater to seep into the surrounding soil and percolate into the underlying aquifer causing ground water pollution.

Al Burj village like other towns and villages in the West Bank has no sewage facility and the people are using latrines, cesspits and septic tanks for the disposal of wastewater. 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 overflow from the cesspits and excessive recharges of ground water in Dura area.

In view of this bad condition, and since there is no sewerage exist, along with the fast increase in the environmental and health problems, an evaluation and design of wastewater collection system study become a pressing necessity so as to solve all the problems that were mentioned above. This project which includes evaluation and design will consider the annual growth of the people and their water consumption for the coming 25 years, which will be the design period, along with the commercial and industrial development in the area.

1.3 Purpose of Project

The overall purpose of this project is to evaluate and develop preliminary conceptual design for sewer networks for Al Burj village in Dura area of the Hebron district. The preliminary design will incorporate a variety of design criteria including: investigation of site, site suitability, design alternatives, environmental consideration and cost estimate. More specifically the main purposes of this project may be classified as follow:

1. Propose wastewater collection system for the village and design the main trunks of the proposed sewerage collection network.
2. Estimate the cost for construction of the collection network.

The project will help in reducing the threat to the environment, water and land resources and to the health of the people living in Al Burj village.

1.4 Project Area

Al Burj is a village in the Dura area which is located 35 kilometers southwest of the City of Hebron, in the southern part of the West Bank as shown on the project location map Figure 1.1. It is bordered by Al Bireh village to the east, Beit Mirsim to the north, Ar Ramadin to the south, and by the 1949 Armistice Line (the Green Line) to the west. The general view and the aerial maps of the village are presented in Figures (1.2) and (1.3).

The total area of Al Burj village is approximately 9,910 dunums, of which 160 dunums are Palestinian built-up areas, 6,850 dunums are agricultural lands, 1,906 dunums can be categorized as forest, uncultivated, or public land, and 2,000 dunums which have been confiscated by the Israeli forces to build settlements and construct the segregation wall.

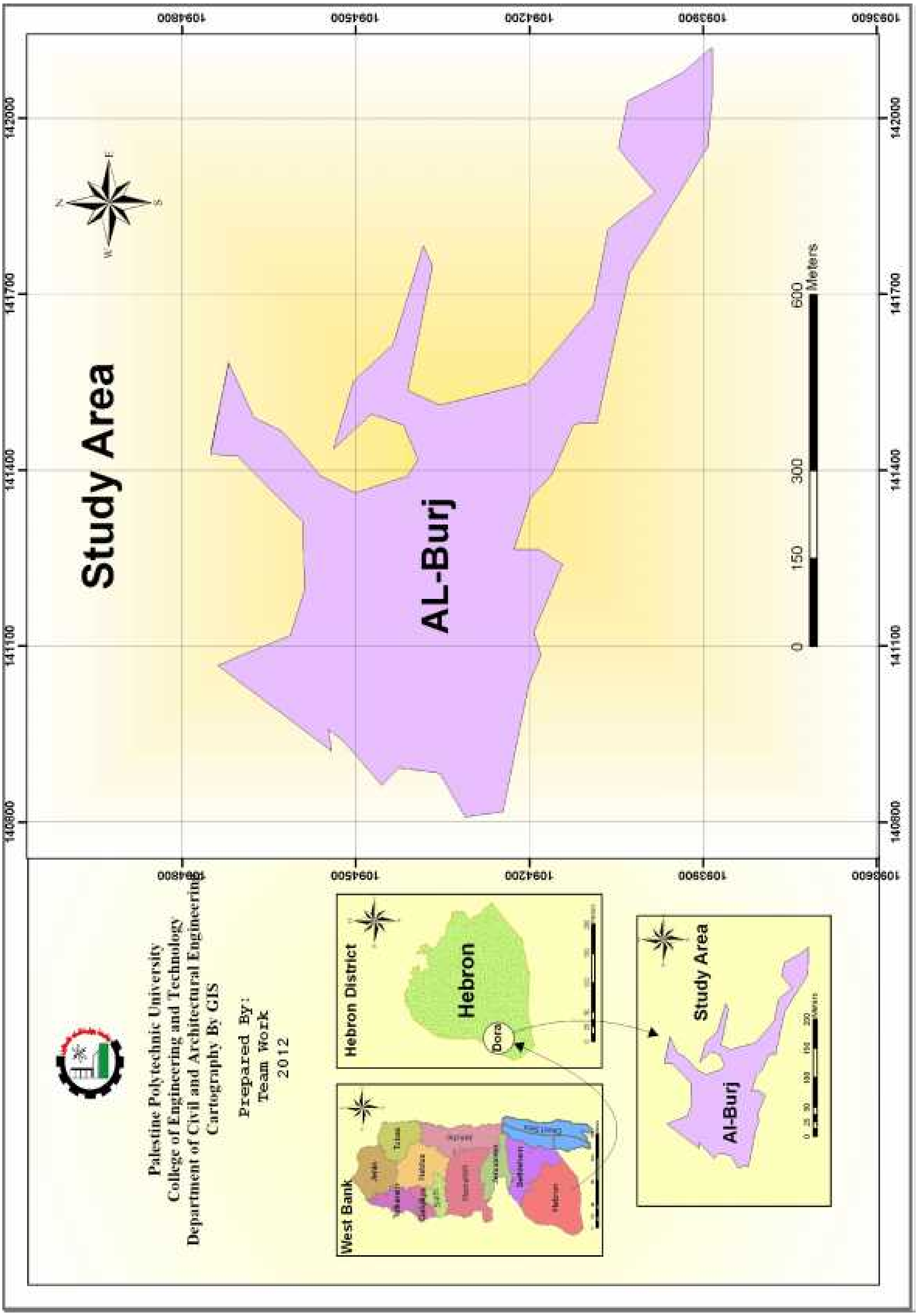

Figure (1.1): Location Map of the project Area (Al Burj village)

Figure (1.2): General View of Al Burj Village

Figure (1.3): Aerial Map of the project Area (Al Burj Village)

Al Burj lies on a hill, with an evaluation of 464 m above sea level. The mean annual rainfall in Al Burj is 400 mm; the average annual temperature is 15.7 ^{o}C, and the average annual humidity is 60.6% (ARIJ GIS).

The total population of Al Burj, in 2007, is estimated to be 2,289. this is an estimate number based on the Palestinian Central Bureau of Statistics (PCBS) Census of 1997,of which 1,141 were males and 1,148 were females. The present population is around 3000 person

Since 1987, Al Burj has been connected to a water network supplied by the Israeli company (MECOROT). The village authorities estimate that 60% of the housing units are connected to this network. In terms of alternative sources, the residents depend on cisterns, buying portable tanks, and a natural water spring that exists on Al Burj side of the Segregation Wall. The per capita water supply is 100 liters per day, and the per capita water use is 61 liters per day. As mentioned earlier, the village does not have a sewage disposal network, and wastewater is disposed of by means of cesspits.

1.5 Stages of the Project

The project consists of six phases, which are proposed to be completed in accordance with time schedule shown in (Table 1.1). The description of each of the six phases of the project and tasks involved is listed below:

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

Phase No.	**Title**	**Duration**								
		09/11	**10/11**	**11/11**	**12/11**	**01/12**	**0 2/12**	**03/12**	**04/07**	**05/12**
1	Collection and Analysis of Data	■	■	■						
2	Surveying Works.			■	■					
3	Design of the Sewage Network.				■	■	■			
4	Draw layouts and Profiles.				■	■	■			
5	Preparing Bill of Quantities						■	■		
6	Writing the Report.						■	■	■	■

Phase 1: Collection and Analysis of Data

During this phase, available data and information were collected from different sources. Moreover, many site visits to the project area were undertaken. First phase included the following tasks:

1. Collection of aerial and topographical maps of the area.
2. Collection, analysis and augmentation as necessary data on population, land use, zoning, water consumption and environmental conditions.

Phase 2: Perform the Surveying Works

The tasks which were performed in the second phase are:

1. Evaluate of the contour maps and matching it with actual ground levels.
2. Performing and selecting topographic survey for the sewage network.

Phase 3: Design of the Sewage Network

During the third phase, the areas to be served by sewage were defined, the layout was established, and the necessary hydraulic calculations needed for the design of one of the main trunks were carried out. The tasks, which were performed in this phase, are:

1. Define the area to be served by sewerage and establish the boundaries.
2. Establish a system layout which includes the areas that are going to be served, existing streets and roads, topography ….. etc.
3. Establish the main catchments areas and routes of the sewer.
4. Prepare a design criterion that meets the sewage contribution and flow for the entire area through the year 2035.
5. Do the necessary hydraulic calculation and find out the sewers diameter.

Phase 4: Preparing Plan Drawings and Profiles

Plan drawings and profiles with appropriate scales for the wastewater collection system were prepared.

Phase 5: Preparing Bill of Quantities and Cost Estimates

After finishing the design calculation of the main trunks, the research team prepared bill of quantities and estimate the cost of the project.

Phase 6: Writing the Report

Upon the completion of the work, one final report was written and submitted to the Department of Civil and Architectural Engineering at Palestine Polytechnic University.

1.6 Organization of the Report

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, purpose of project, scope of the work and phases of the project.

Chapter two entitled **" WASTEWATER COLLECTION SYSTEMS** " 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.

Chapter three entitled **"Design and Planning Criteria"** presents information about population and their densities, the actual water consumption, land use, and design criteria applicable to the sewerage networks.

Chapter four entitled **"Analysis and Design"** Design the Wastewater system by using SewerCAD software and preparing the profiles of sewer lines .

Chapter Five entitled **"Bill of Quantity"** After finishing the design the team prepared bill of quantity.

Chapter six, which is the last chapter, entitled **"Conclusions"** summarized the project into briefly notes.

CHAPTER

2 *WASTEWATER COLLECTION SYSTEMS*

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CHAPTER TWO

WASTEWATER COLLECTIOM SYSTEMS

2.1 BACKGROUND

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.

2.2 MUNICIPAL SEWERAGE SYSTEM

2.2.1 Types of Sewers

The types and sizes of sewers used in municipal collection system will vary with size of the collection system and the location of the wastewater treatment facilities. The municipal or the community sewerage system consists of (1) building sewers (also called house connections), (2) laterals or branch sewers, (3) main and submain sewers, (4) trunk sewers, and (5) intercepting sewers.

House sewers connect the building plumbing to the laterals or to any other sewer lines mentioned above. Laterals or branch sewers convey the wastewater to the main sewers. Several main sewers connect to the trunk sewers that convey the wastewater to large intercepting sewers or the treatment plant. The types of sewers usually used in wastewater collection system are shown in Figure 2.1, and a typical layout of a municipal sewerage system is shown in Figure 2.2 (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).

2.2.2 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.

2.3 TYPES OF WASTEWATER COLLECTION SYSTEMS

2.3.1 Gravity Sewer System

Collecting both wastewater and storm water in one conduit (combined system) or in separate conduits (separate system). In this system, the sewers are partially filled. A typical characteristic is that the gradients of the sewers must be sufficient to create self-cleansing velocities for the transportation of sediment. These velocities are 0.6 to 0.7 m/s when sewers are flowing full or half-full. Manholes are provided at regular intervals for the cleaning of sewers.

2.3.2 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.

2.3.3 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.

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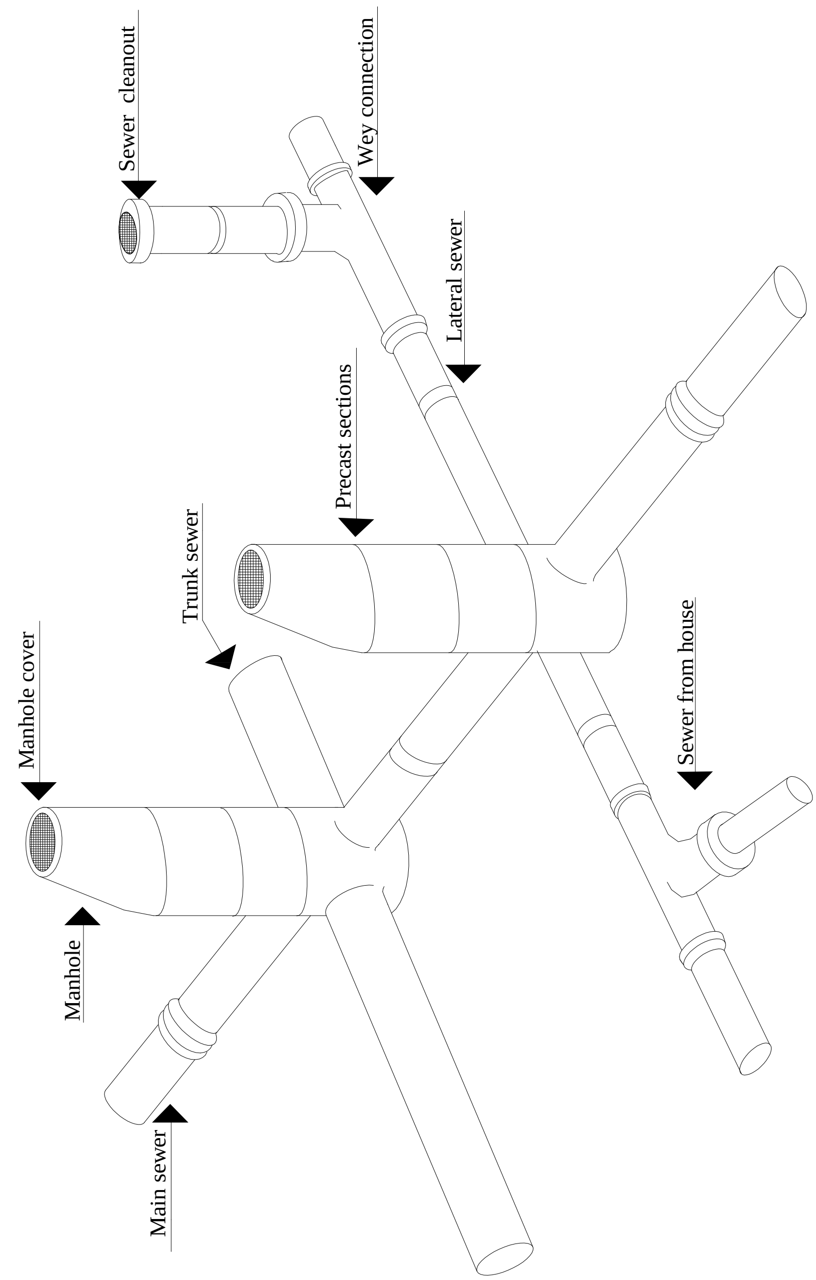

Figure 2.1: Types of Sewers Used in Wastewater Collection System

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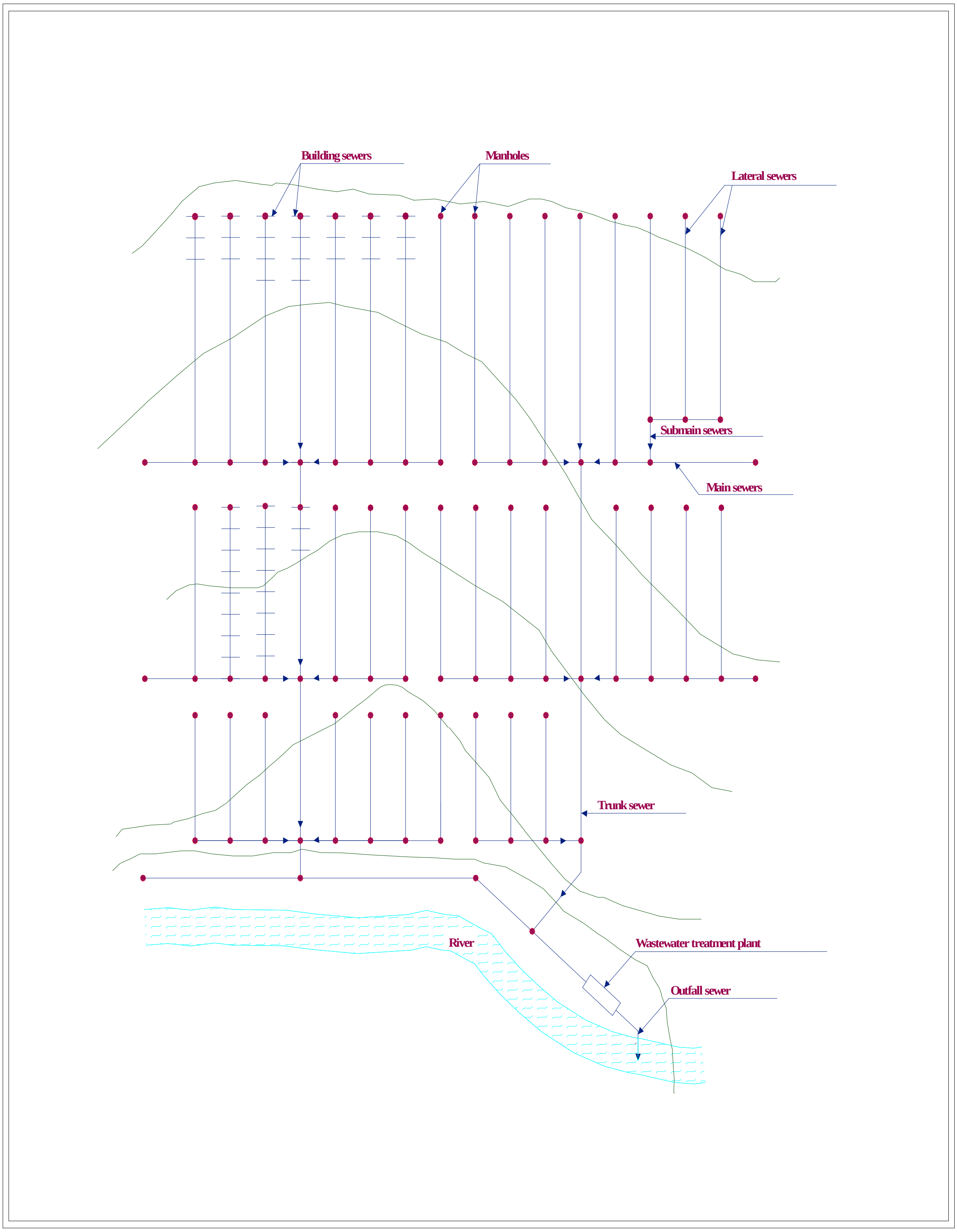

Figure 2.2: Typical Layout of Municipal Sewarage System

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.

2.4 SEWER APPURTENANCES

2.4.1 Manholes

Manholes should be of durable structure, provide easy access to the sewers for maintenance, and cause minimum interference to the sewage flow. Manholes should be located at the start and at the end of the line, at the intersections of sewers, at changes in grade, size and alignment except in curved sewers, and at intervals of 90-180 m in straight lines.

The general shapes of the manholes are square, rectangular or circular in plan, the latter is common. Manholes for small sewers are generally 1.0-1.2 m in diameter. For larger sewers larger manhole bases are provided. The maximum spacing of manholes is 90-180 m depending on the size of sewer and available size of sewer cleaning equipment (Qasim,1985).

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

Drop Manholes

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 out going 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 2.3 (Hammer, 1977).

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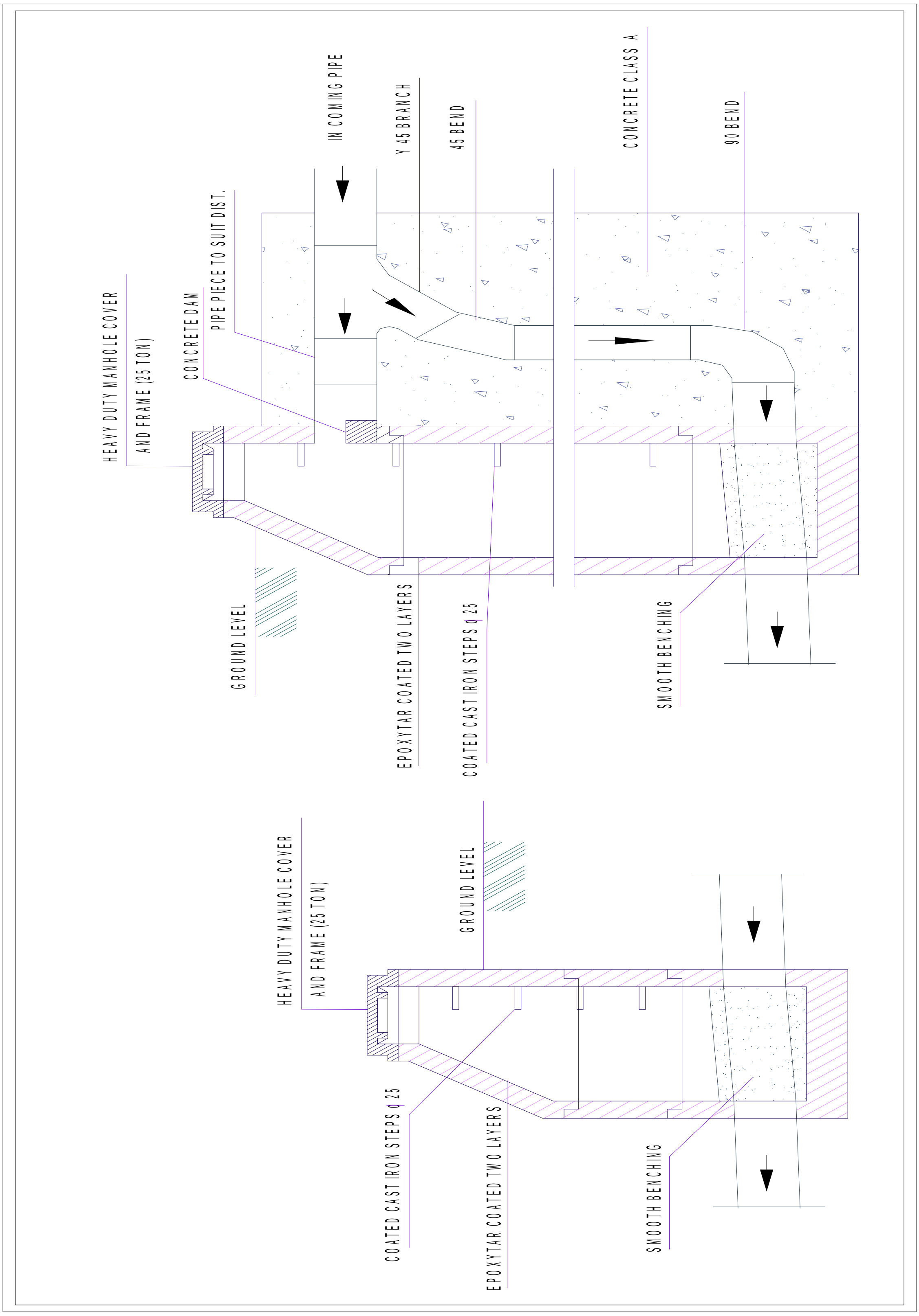

Figure 2.3: Typical Layout of Municipal Sewarage System

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2.4.2 House Connections

The house sewers are generally 10-15 cm in diameter and constructed on a slop of 0.02 m/m. house connections are also called, service laterals, or service connections. Service connections are generally provided in the municipal sewers during construction. While the sewer line is under construction, the connections are conveniently located in the form of (Y)s or (T)s, and plugged tightly until service connections are made. In deep sewers, a vertical pipe encased in concrete is provided for house connections (Qasim, 1985).

2.4.3 Inlets

Inlets are structures through which storm water enters the sewers. Their design and location require consideration of how far water will be permitted to extend into the street under various conditions. The permissible depth of water in the gutter is limited to 150 mm on residential streets and to that depth, which will leave two lanes, clear of standing water on arterials and one lane on major streets (Mc Ghee, 1991).

2.4.4 Inverted Siphons

An inverted siphon is a section of sewer, which is dropped below the hydraulic grade line in order to avoid an obstacle such as a railway or highway cut, a subway, or a stream. Such sewers will flow full and will be under some pressure; hence they must be designed to resist low internal pressures as well as external loads. It is also important that the velocity be kept relatively high (at least 0.9 m/s) to prevent deposition of solids in locations, which would be very difficult or impossible to clean (Mc Ghee, 1991).

Since sewage flow is subject to large variation, a single pipe will not serve adequately in this application. If it is small enough to maintain a velocity of 0.9 m/s at minimum flow, the velocity at peak flow will produce very high head losses and may actually damage the pipe. Inverted siphons normally include multiple pipes and an entrance structure designed to divide the flow among them so that the velocity in those pipes in use will be adequate to prevent deposition of solids (Mc Ghee, 1991).

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2.4.5 Sewer Outlets and Outfalls

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

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

2.4.6 Pumping of Sewer

There are many communities in which it is possible to convey all the sewage to a central treatment location or point of discharge in only a gravity system. In other areas with flat terrain, more than one drainage area, low-lying sections, or similar complications, pumping may be required. Pumping may also be required at or within sewage treatment plants, in the basements of buildings which are below the grade of the sewer, and to discharge treated wastewater to streams which are above the elevation of the treatment plant (Mc Ghee, 1991).

Pumping of untreated sanitary sewage requires special designs, since sewage often contains large solids. Nonclog pumps have impellers, which are usually closed and have, at most, two or three vanes. The clearance between the vanes is sufficiently large that anything, which will clear the pump suction, will pass through the pump. A bladeless impeller, sometimes used as a fish pump, has also been applied to this service. For a specified capacity, bladeless impellers are larger and less efficient than vaned designs (Mc Ghee, 1991).

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

2.5 HYDRAULICS OF SEWER DESIGN

2.5.1 Introduction

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

2.5.2 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

$$V = C\sqrt{RS} \quad (2.1)$$

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

$$H = \lambda\ L*V^2/(D*2g) \quad (2.2)$$

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

$$V = 1/n\ R^{2/3}\ S^{1/2} \quad (2.3)$$

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 2.1.

-

Table 2.1: Common Values of Roughness Coefficient Used in 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

2.5.3 Hydraulics of Partially Filled Sections

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

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

2.6 DESIGN SYSTEM AND CONSTRUCTION COMMUNITY SEWERAGE SYSTEM

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

1. Define the service area.
2. Conduct preliminary investigations.

-

3. Develop preliminary layout plan and profile.
4. Selection of design parameters.
5. Review construction considerations.
6. Conduct field investigation and complete design and final profiles.
7. Prepare contract drawing and specifications.

2.6.1 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.

2.6.2 Preliminary Investigations

The design engineer must conduct the preliminary investigations to develop a layout plan of the sewerage system. Site visits and contacts with the city and local planning agencies and state officials should be made to determine the land use plans, zoning regulations, and probable future changes that may affect both the developed and undeveloped land. Data must be developed on topography, geology, hydrology, climate, ecological elements, and social and economic conditions. Topographic maps with existing and proposed streets and other utility lines provide the most important information for preliminary flow routing (Qasim, 1985).

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

2.6.3 Layout Plan

Proper sewer layout plan and profiles must be completed before design flows can be established. The following is a list of basic rules that must be followed in developing a sewer plan and profile (Qasim, 1985):

1. Select the site for the wastewater treatment plant. For gravity system, the best site is generally the lowest elevation of the entire drainage area.

2. The preliminary layout of sewers is made from the topographic maps. In general, sewers are located on streets, or on available right-of-way; and sloped in the same direction as the slope of the natural ground surface.
3. The trunk sewers are commonly located in valleys. Each line is started from the intercepting sewer and extended uphill until the edge of the drainage area is reached, and further extension is not possible without working downhill.
4. Main sewers are started from the trunk line and extended uphill intercepting the laterals.
5. All laterals or branch lines are located in the same manner as the main sewers. Building sewers are directly connected to the laterals.
6. Preliminary layout and routing of sewage flow is done by considering several feasible alternatives. In each alternative, factors such as total length of sewers; and cost of construction of laying deeper lines versus cost of construction, operation, and maintenance of lift station, should be evaluated to arrive at a cost- effective sewerage system.
7. Sewers should not be located near water mains. State and local regulations must be consulted for appropriate separation distance between the sewers and water lines.
8. After the preliminary sewer layout plan is prepared, the street profiles are drawn. These profiles should show the street elevations, existing sewer lines, and manholes. These profiles are used to design the proposed lines.

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 2.4 and Figure 2.5 (Viessman, 1985).

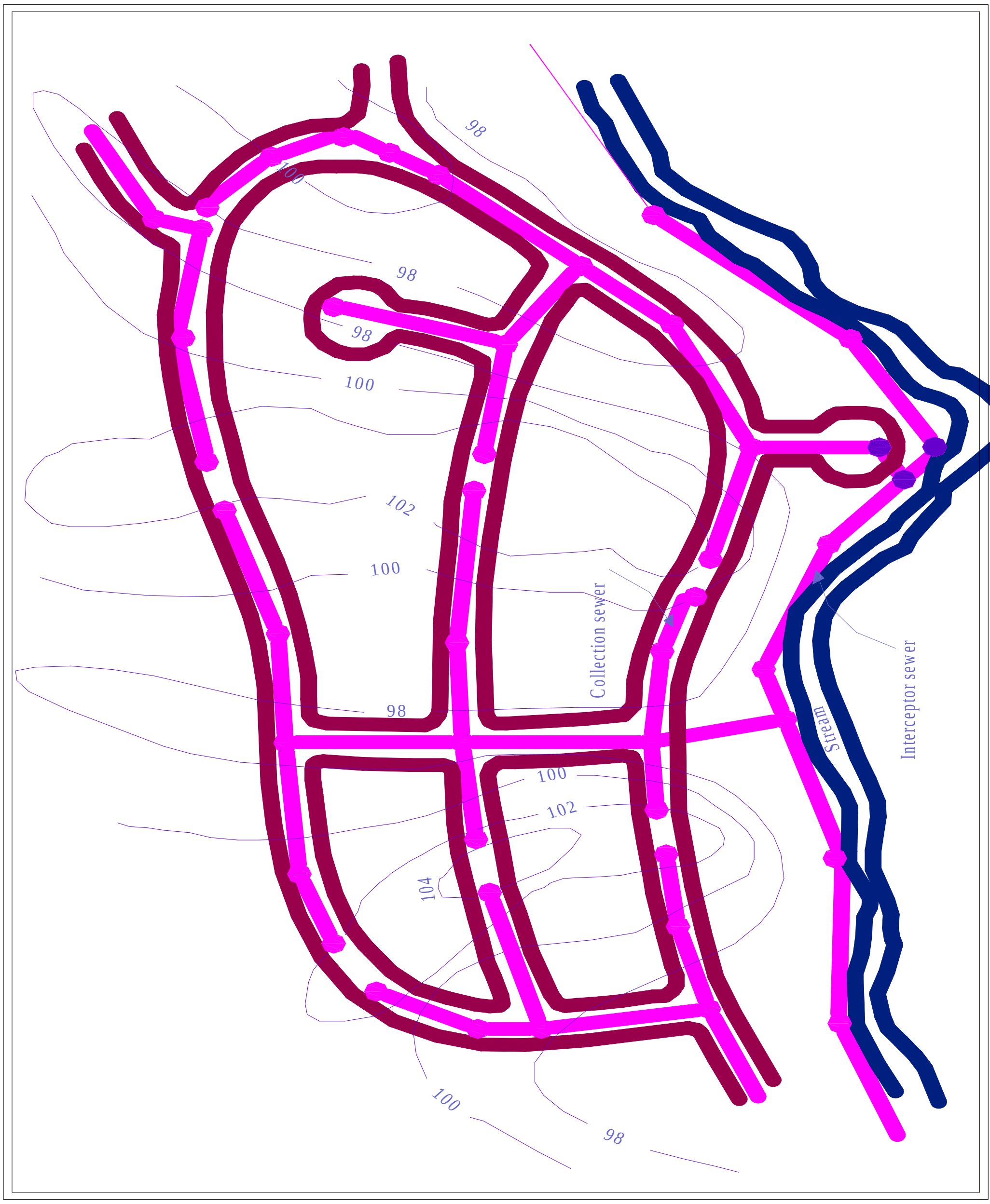

Figure 2.4: Typical Layout of Municipal Sewarage System

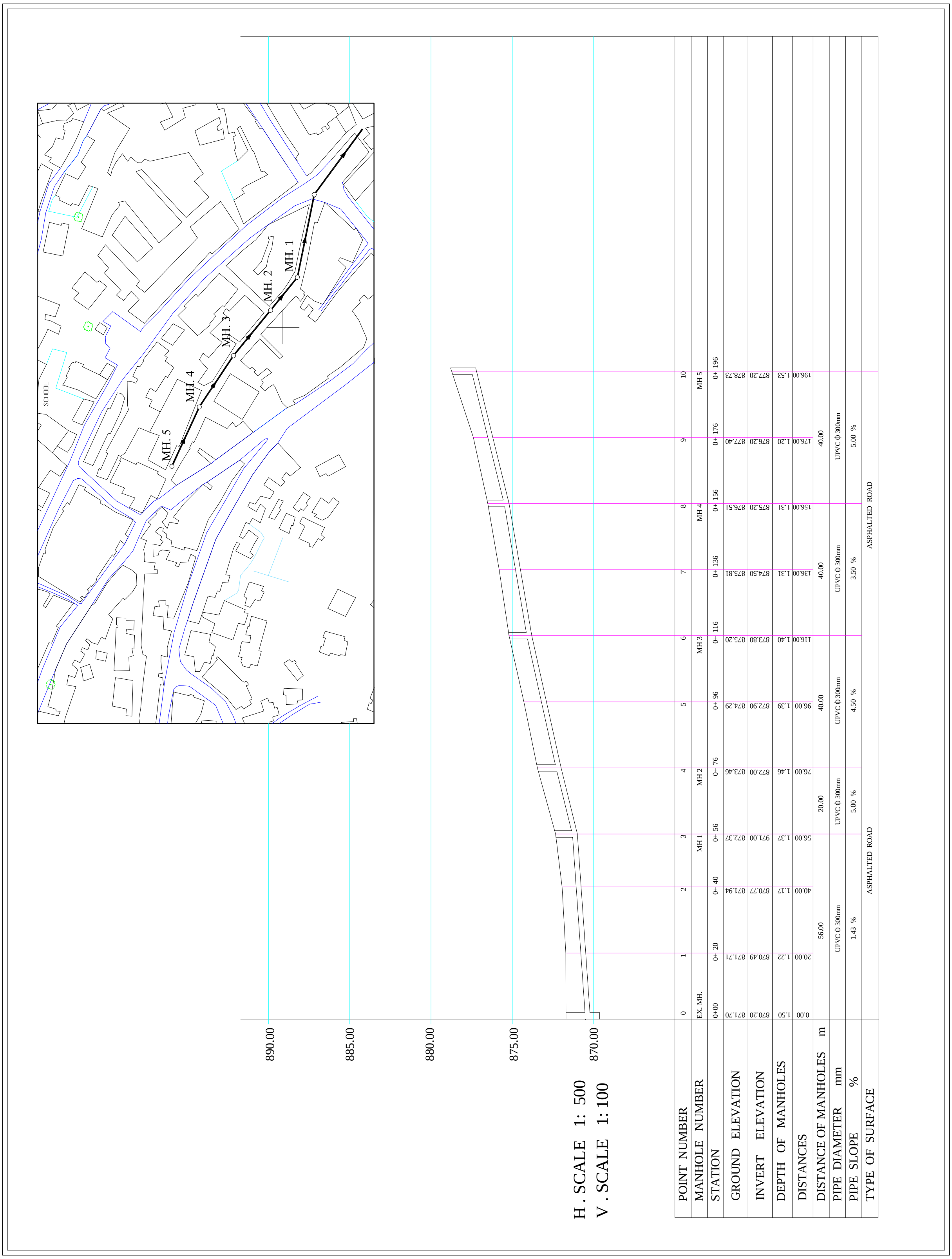

Figure 2.5: Typical Plan and Profile Drawing for Sanitary Sewer

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2.6.4 Selection of Design Parameters

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

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

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

3. **Design Flow Rate:** Sanitary sewers should be designed to carry peak residential, commercial, and industrial flows, and the normal infiltration and inflow where unfavorable conditions exist.
4. **Minimum Size:** As mentioned earlier, minimum sewer size recommended is 20 cm (8 in). Many countries allow 15 cm (6 in) lateral sewers.

5. **Minimum and Maximum Velocities:** In sanitary sewers, solids tend to settle under low-velocity conditions. Self-cleaning velocities must be developed regularly to flush out the solids. Most countries specify minimum velocity in the sewers under low flow conditions. A good practice is to maintain velocity above 0.3 m/s under low flow conditions. Under peak dry weather condition, the lines must attain velocity greater than 0.6 m/s. This way the lines will be flushed out at least once or twice a day. In depressed sewers self-cleaning velocities of 1.0 m/s must be developed to prevent accumulation of solids. Velocities higher than 3 m/s should be avoided as erosion and damage may occur to the sewers or manholes.

6. **Slope:** Flat sewer slopes encourage solids deposition and production of hydrogen sulfide and methane. Hydrogen sulfide gas is odorous and causes serious pipe corrosion. Methane gas has caused explosions. The minimum slopes are such that a

velocity of 0.6 m/s is reached when flowing full and n =0.015. Minimum sewer slopes for different diameter lines are summarized in Table 2.2.

Table 2.2: Minimum Recommended Slopes of Sanitary Sewer.

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

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

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

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

$$V = 1/n\ R^{2/3}\ S^{1/2} \qquad (2.3)$$

$$Q = (0.312\ /n)\ D^{8/3}\ S^{1/2} \quad \text{(circular pipe flowing full)} \qquad (2.4)$$

Where Q is the flow rate.

Various types of nomographs have been developed for solution of problems involving sewers flowing full. Nomographs based on Manning's equation for circular pipe flowing full and variable n values are provided in Figure 2.6. Hydraulic elements of circular pipes under part-full flow conditions are provided in Figure 2.7. It may be noted that the value of n decreases with the depth of flows Figure 2.7. However, in most designs n is assumed constant for all flow depths. Also, it is a common practice to use d, v, and q notations for depth of flow, velocity, and discharge under partial flow condition while D, V, Q notations for diameter, velocity, and discharge for sewer flowing full. Use of equations 2.3 and 2.4 and Figures 2.6 and 2.7 are shown in the design calculation in chapter five (Qasim, 1985).

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 2.3 is typical of the way in which data can be organized to facilitate computations (Viesman, 1985).

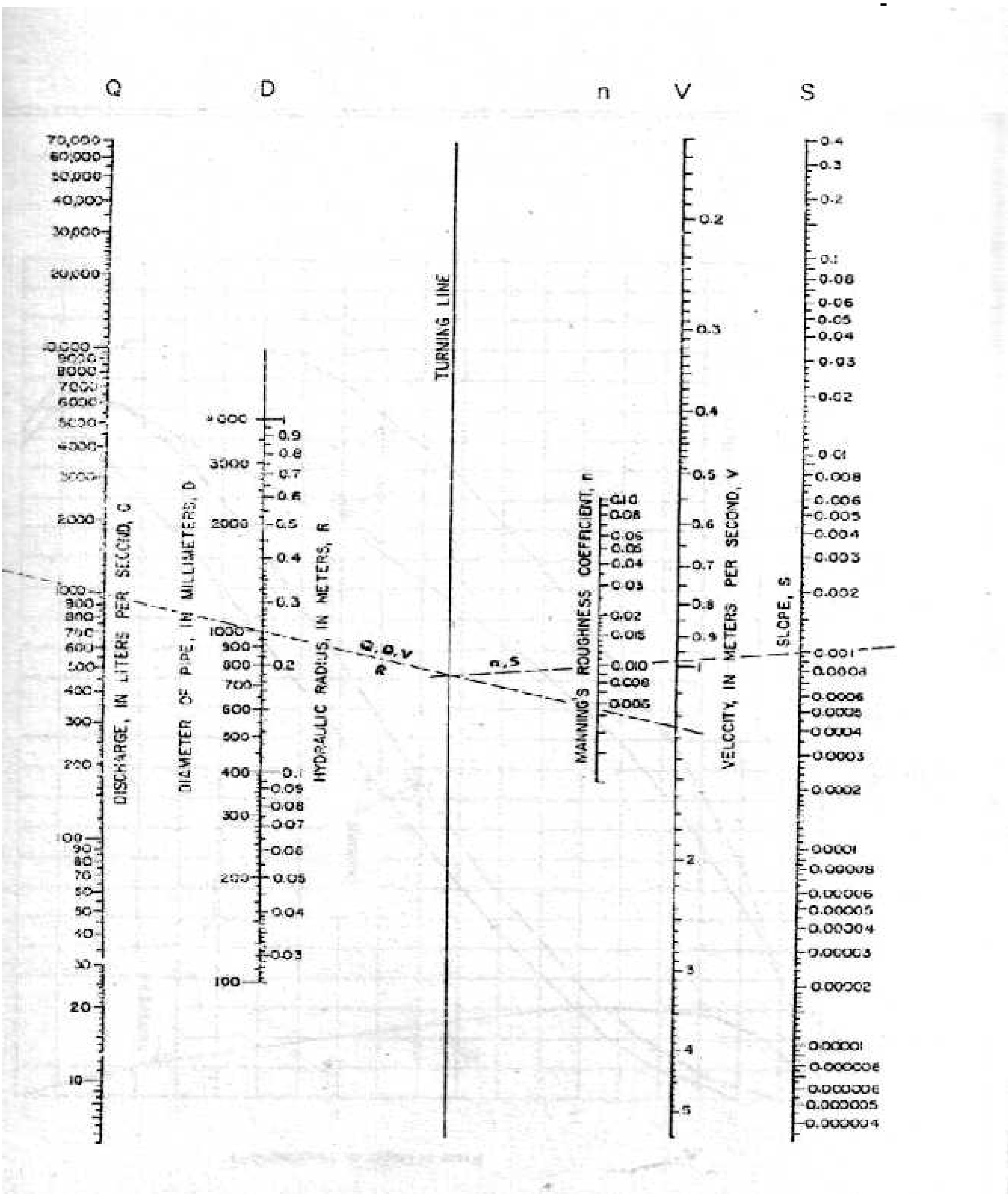

Figure 2.6 Manning's equation for circular pipe flowing full and variable n values

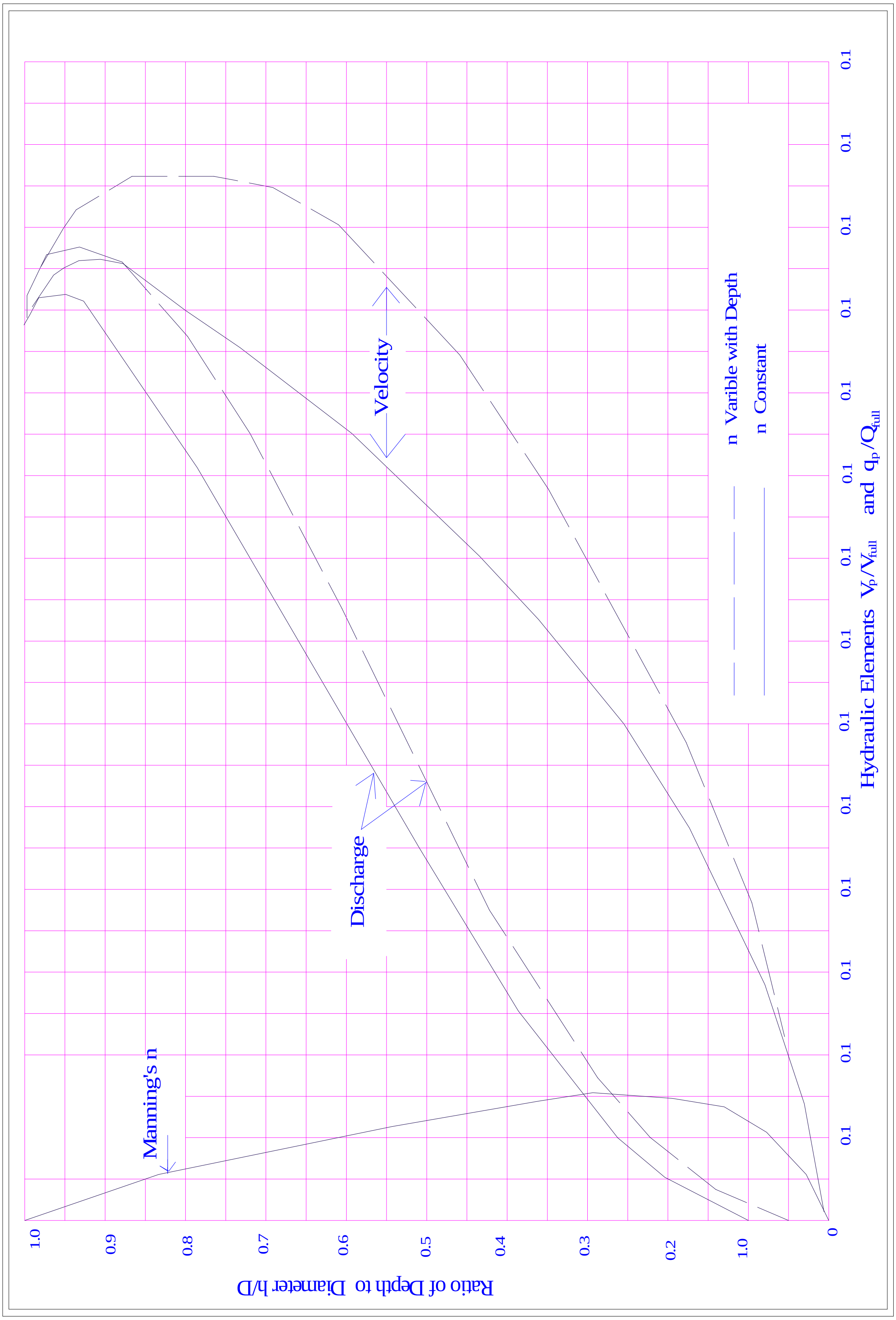

Figure 2.7: Hydraulic Properties of Circular Sewer

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2.6.5 Construction Consideration

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

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

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

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

- **Excavation**: After the sewer alignment is marked on the ground, the trench excavation being. Machinery such as backhoe, clamshell, dragline, front-end loader or other specialized equipment is used. Hand excavation may be possible only for short

-

distances. Hard rocks may be broken by drilling; explosives may also be used where situations permit.

-

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

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

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

2.6.6 Field Investigations and Completion of Design

Fieldwork should be conducted to establish benchmarks on all streets that will have sewer lines. Soil borings should be conducted to develop subsurface data needed for trenching and excavation. The depth of boring should be at least equal to the estimated depth of the sewer lines. Detailed plans should be drawn showing the following: (1) contours at 0.5 m intervals in map with scale 1 cm equal to 6 m, (2) existing and proposed streets, (3) streets elevations, (4) railroads, building, culverts, drainage ditches, etc, (5) existing conduits and other utility lines, and (6) existing and proposed sewer lines and manholes. The sewer profiles should also be developed showing ground surface and sewer elevations, slop, pipe size and type, and location of special structures and the appurtenances. Profile drawing should be prepared immediately under the sewer plan for ready reference Figure 2.5.

2.6.7 Preparation of Contract Drawings and Specifications

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

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

2.7 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.

2.8 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

3 *DESIGN AND PLANNING CRITERIA*

3.1 Background

3.2 Population

3.3 Future Water Demand

3.4 Design Parameters

3.5 Design and Planning Assumptions

CHAPTER THREE
DESIGN AND PLANNING CRITERIA

3.1 Background

In the previous chapter, the problem of the study has been defined and the objectives of the study have been listed. The wastewater collection system has been described. In this chapter, design and planning criteria will be discussed including population and population forecasting, future water demand, design parameters, and and planning assumption.

3.2 Population

3.2.1 Introduction

The ideal approach for population forecasting is by the study and use of previous census records, which cover along period. The longer the period, 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 Al Burj village, 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 and later in different years when the Palestinian Central Bureau of Statistic (PCBS) conducted comprehensive census covering the West Bank and Gaza Strip.The final results of this census show that the total population of Al Burj village is 2300 for year 2011 inhabitants.

Due to the unstable condition of the area during the last 50 years, it would be very difficult to develop a statistical interpretation to extrapolate future population. Some reasonable assumptions have, therefore, been made to project the future population of Al Burj village over the next 25 years.

3.2.2 Population Forecast

Prediction of the future population of Al Burj village is very difficult due to the lack of reliable historic data, and the political uncertainties, which will greatly influence future social and economic development At the same time, the available data on past population growth do not constitute a reliable basis for projecting the future population growth in Al Burj village.

The base for the forecast is the 2011 population for Al Burj village obtained from PCBS of 2300 inhabitants. The rate of population growth for the purpose of our study was based on estimation used for other towns of similar population composition and characteristics. The rate of population growth in other towns in the West Bank is between 3.0-4.0%. Therefore, the rate of 3.6% per year was used for the future growth of the population of Al Burj village.

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

$$P = Po * (l + r)^{n} \tag{3.1}$$

Where, P is the future population, Po is the present population, r is the annual population growth rate, and n is the period of projection.

Using the above assumption and equation, Table 3.1 presents the population projection up to the design horizon of 2035. The data show that the population of Al Burj village is estimated to be 5568 in year 2036.

Table 3.1: Population Forecasts for Al-Burj Town

Year	2011	2021	2026	2031	2036
Population	2300	3276	3910	4666	5568

3.2.3 Population Density

When determining the density of population, it is either related to the total municipal area (gross density) or to the built—up area only (net density). The gross density related to the municipal area includes large industrial areas, agricultural areas, un-built areas, public parks, large water surfaces, forests ... etc. The net density is related to the built up area, but it includes small-scale industries, schools, public and commercial buildings, and roads.

Water supply system, however, is based on the net densities of population, because the provision of net works is limited to the built-up areas. The net density of population varies considerably from district to district. There are no studies done concerning the population densities in Al Burj village. Population densities are based on the city structure plan, which serves for issuing building permit. The population density for Al Burj village is calculated using structure plan map as follow:

The population area divided into three sectors A (dense area as 8.7% of capacity), B (partial dense area as 52.7%) and C (Weak density as 38.6%).

Developing area of the AL- Burj village =367 hectare .

Area of sector A= 32 h , B= 193.5 h , C= 141.5 h.

Number of houses in sector A/10 hectare = 33 .

Number of houses in sector B/10 hectare = 17.

Number of houses in sector C/10 hectare = 2.

Present Population density:

The current population density in sectors above are calculated as follow:

In sector A (mid town): each building has two storey. Assumed that six persons are live in each storey. This means, the current population density for sector A is: 33x2x6=39.6 p/ha, and the total population number in sector A = 3.96x32=1267 person.

In sector B, each each building has 1 storey, with six person in each story. So,the current population density in sector B is =17x1x6=10.2 p/h. The total population in this sector is 10.2x193.5=1974 p.

In sector C, each building has 1 storey, where six people are live in each storey. Current population density = 2x1x6=1.2 p/h. The total population in sector C is 1.2x141.5=170 p.

As mentione earlier, the present population number in AL- Burj village is 2300 person.
The calculated number above =1267+ 1974+170=3411 person..
Correction factor 2300/34111 = 0.674

The realistic population number in each sectors:
Sector A 1267x 0. 674 = 855 p.
Sector B 1974 x 0.674 =1331 p.
Sector C 170 x 0.674 =115 p.
Sum . 855+1330+115=2300 p.

Population density at the end of design period

The population density at the end of design period (2036) is estimated as :-
$P_f = P_c(1+I)^n$
P_f : Population in future.
P_c : Current population.
I : Natural increasing ratio/year (3.6%)
n : Design period (years).

In sector (A),
P_f = 855 (1+0.0.036)^{25}= 2070 p.
but the maximum =855x2=1710 p ➔p.density 1710/32=53.43=54 p/ha.
So: 2070-1710=360 p should be divided on sectors B and C 0.75 on B and 0.25 on C
In sector(B),
P_f =1331x4 +(0.75x360)=5594 p.
➔density 5594/193.5= 28.9=29 p/ha.

In sector(C) P_f =115x4 +(0.25x360)=550 p.
➔density 550/141.5=3.89 = 4 p/ha.
The total population in 2039 as estimated (53.43x32)+(28.9x193.5)+(3.89x141.5)=7852p.
P_f = 2300(1+0.036)^{25}= 5568p< 7852 p ……. OK.

3.3 Future Water Demand

3.3.1 Introduction

Water consumption is not constant, yearly, monthly, weekly, daily, and hourly variations in water consumption are observed. Certain dry years cause more consumption. In hot months water is consumed in drinking, bathing, and watering lawns and gardens. On holidays and weekends the water consumption may be high Even during a day water use varies with high use during morning hours and close to noon and low use at night.

Maximum daily demand or maximum daily consumption usually occurs during summer months. The ideal approach to assess the existing and future per capita water consumption is by analyzing and extrapolating the available record on water consumption and demand in conjunction with the expected social and economical development. This approach can be adopted in areas having continuous supply systems where reliable information about population, population distribution and demand are known. There are problems in adopting this approach for Hebron area including Al Burj village due to insufficient data and also the intermittent water supply.

Restrictions on the Palestinian use of the annual ground water resources of the West Bank led to the availability limited quantities of water and due to this condition, the average consumption of water in Al Burj village for all purposes does not exceed 21.9 cubic meter per capita per year. Given these circumstances, the approach to determine per capita water consumption depends on the analysis of the existing information. The existing per capita consumption has already been assessed at (60 litter/capita, day).

3.3.2 Future Water Demand

The present average consumption of water for domestic use in Al Burj village is low (60 liter/capita.day) and does not represent the present and actual demand of water. The future water demand should be calculted with the assumption of better living standard and economic condition, but the Muncipilty doses not expect any appreciable increase in the quantity of water in the near future expect that which meet with the increase in the population. So, the present and near future water demand for domestic purposes of Al Burj village will be the same as 60 liter/capita.day. The value could reach 70 l/c.d after 10 years aand 100 l/c.d at the end of the design period in 2036.

Based on the above assumptions, the population of Al Burj village at years 2020, 2030 and 2035, and the annual residential water demand per capita for the same years were calculated along with water demand per capita per day. The data obtained were given in Table 3.2

.

Table 3.2: Future Water Demand for Al Burj village

Year	Population	Water Demand(m^3/year)		Water Demand(l/c.d)
		Per Capita	Total	
2011	2300	21.90	50370	60
2021	3276	25.55	83702	70
2026	3910	29.20	114172	80
2031	4666	32.85	153278	90
2036	5568	36.50	203232	100

It may be noted from Table 3.2 that the projected water demand for the design period (year 2036) is 203232 cubic meter per year which is equivalent to 557 cubic meter per day.

3.4 Design Parameters

3.4.1 Flow rate projections

The total wastewater flow in sanitary sewers is made up of two main components: (1) Residential. (2) Infiltration. Sanitary sewers are designed for peak flows from residential and peak infiltration allowance for the entire service area. The flow rate projections are necessary to determine the required capacities of sanitary sewers. These projections will be based on:

1. Population: Future population at the end of design period should be estimated. The estimated population of Al Burj village in the year 2036 is 5568 inhabitants.
2. The present domestic water consumption and future consumption.
3. The percentage of water going to the sewer: In general, the average wastewater flow may vary from 60 to 90 percent of the water used in the community. A value of 80 percent has generally been agreed upon by all the authors of earlier projects in the West Bank and other locations under similar conditions.
4. The service connection percentage: The percentage of houses that will be served by sewers will depend on the nature of the habitat in the catchments area considered and of

the design period. It has been assumed that the service connections will increase, to full coverage for the urban population in year 2036.

5. The uncontrolled inflow and infiltration: Infiltration is the entrance to the collection system of water from outside sources such as groundwater. Inflow is the entrance to the collection system of runoff during a rainfall event. Infiltration depends mainly on the state of the network; the depth at which it is buried and the groundwater elevations. Most of the sewers to be laid will be new and the ground water elevations in the area are low. Ground water infiltration seems then to be not significant. The network will be designed to avoid rainwater inflow. However, there will always be cases of manhole leaks, loose joints and private individuals who link up their rainwater pipes to the sewerage network. Given the difficulty of accurately estimating these parameters and according to previous studies and data of another area under similar conditions, a mean discharge increase of liter per second per hectare will be applied when dimensioning the sewerage system.
6. The peak coefficient : In general, this coefficient increases when the rate of connected population decrease, for example when the flow rate is weak. In the other hand, when the connected population is important, the variation around a mean discharge is weaker. As there are few field investigations conducted in the study area to estimate this factor; it will be determined from the practice and experience of the designer. The following relation has been used commonly by the designer and gives satisfactory results:

$$Pf = 1.5 + 2.5 / \sqrt{q} \qquad (3.2)$$

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

Using these assumptions, the flow rate projections were evaluated for the study area (Al Burj village).

3.4.2 Hydraulic design

As mentioned earlier and according to usual practice, the sewers will be designed for gravity flow using Manning's formula:

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

Depending on pipe materials, the typical values of n are:

- Reinforced Concrete (RC) n = 0.013
- Polyvinyl Chloride (PVC) n = 0.011

- Ductile Iron: n = 0.013
- Asbestos Cement: n = 0.012

3.4.3 Minimum and maximum velocities

For a circular sewer pipe, the velocity at half-depth is equal to the velocity at full-depth. To prevent the settlement of solid matter in the sewer, the literature suggested that the minimum velocity at half or full depth – during the peak flow period – should not be less than 0.6 m/s, but point out that the minimum self cleansing velocity of 1.0 m/s is to be preferred wherever this is practicable. Usually, a maximum sewer velocity are limited to about 3 m/s in order to limit abrasion and avoids damages which may occur to the sewers and manholes due to high velocities.

3.4.4 Pipes and sewers

i) Necessary because some large objects such as scrub brush, sometimes gets into sewers. Experience indicates a minimum diameter of 200 mm (8 in) for sewer pipes. For house connections, smaller sizes may be used.

ii) Pipe Materials: different pipe materials may be recommended for the sewers.

1. Polyvinyl chloride PVC, vitrified clay VCP or polyethylene PE material for small size pipes (approximately up to the size 400 mm in diameter).
2. Centrifugal cast reinforced concrete pipes may be used for larger diameter.

3.4.5 Manholes and covers

Manholes should be located at changes in size, slope direction or junction with secondary sewer. Manholes spacing generally does not exceed 60 m and should never be greater than 100 m except in sewers which can be walker through gravity. The minimum cover over sewer line will be of 1.5 m, for the buried section.

3.4.6 Sewer slope

For a circular sewer pipe, the slope must be between the minimum and maximum slope, the minimum and maximum slope is determined from minimum and maximum velocity. Generally the natural ground slope is used because it is the technical and economic solution, the solution is therefore recommended.

3.4.7 Depth of sewer pipe

As mentioned earlier, the depth of sewers is generally 1-2 m below the ground surface. Depth should be enough to receive the sewage by gravity, avoid excessive traffic loads, and avoid the freezing of the sewer. It is recommended that the top of sewer should not be less than 1 m below basement floor.

3.4.8 Design period

Sewers are designed on estimated future flows at the end of a design period. So the design period is thus the length of time throughout which the capacity of a sewer will be able to cope with the expected flows and may be assumed at:

1. Drains (concrete): 20 – 30 years.
2. Sanitary sewers: 25 – 30 years.
3. Pumping station: Equipment: 15years.
4. Buildings: 25 – 30 years.

The design period adopted for this project is 25 years.

3.5 Design and Planning Assumptions

The design and planning assumptions used in this project are as follow:

1. Design period 25 year (from 2011-2036).
2. Present (2011) population of municipality of Al Burj village town is 2300 capita.
3. The growth rate will be 3.6% .
4. The existing per capita water consumption has been assessed 60 l/c.d.
5. Total administrative area of municipality of Al Burj village town 32000 dounm.
6. Future 2036 population of Al Burj village 24210 capita.
7. Per capita water consumption by 2036 will reaches 100 l/c.d.
8. The wastewater production is about 80% of their water consumption.
9. Formula to be used in design of sewers :(Manning formula)

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

10. Minimum velocity 0.6 m/sec.
11. Maximum velocity 3.0 m/sec.
12. h/D = 0.5 for main trunks.
13. Maximum manhole spacing 50 m for main trunk.

14. Minimum pipe diameter = 8 inch (200 mm).
15. Infiltration rate 20 % of average domestic wastewater.
16. Peak factor determine by equation

$$P_f = 1.5 + (2.5 /\sqrt{q}) \qquad (3.2)$$

17. Depth of sewer pipe: Minimum covers not less than 1.5 from the crown.
18. Maximum slope S_{max} = 15 %
19. Minimum slope S_{min} = 0.5%

CHAPTER

4 *ANALYSIS AND DESIGN*

4.1 Background

4.2 Method of Calaculation

4.3 Layout of the Sewer System

4.4 The proposed Wastewater Collection System

4.5 Profiles of Serwer

CHAPTER FOUR
ANALYSIS AND DESIGN

4.1 Background

In this project, an attempt is made to evaluate and design wastewater collection system for Al Burj village, 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 wastewater system established is presented, and the computation procedures and tables are given along the drawings of layout and profiles for all the lines designed.

4.2 Method of Calculation

4.2.1 Introduction

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 areas, were the design of water network involves the selection of appropriate pipe sizes with required velocities and pressure..

The design calculations necessary for Al Burj village sanitary sewers are performed using SewerCAD Vs5 software. This computer program is developed by the Haestad Methods, Inc. More detailed about this program is given below.

4.2.2 What is SewerCAD?

SewerCAD is an extremely powerful program for the design and analysis of gravity flow and pressure flow through pipe networks and pumping stations. The program can be run in AutoCAD mode, giving you all the power of AutoCAD's capabilities, or in Stand-lone mode utilizing our own graphical interface. SewerCAD allows you to construct a graphical representation of a pipe network containing information such as pipe data, pump data, loading, and infiltration. You have a choice of conveyance elements including circular pipes, arches, boxes and more.

The gravity network is calculated using the built-in numerical model, which utilizes both the direct step and standard step gradually varied flow methods. Flow calculations are valid for both surcharged and varied flow situations, including hydraulic jumps, backwater, and drawdown curves. You also have the flexibility to mix gravity and pressure components freely, building your systems in parallel or in series as they exist in
the field. Pressure elements can be controlled based on system hydraulics, turning pumps on and off due to changes in flows and pressures.

SewerCAD's flexible reporting feature allows you to customize and print the model results in both a report format and as a graphical plot.

4.2.3. When to Use SewerCAD?

SewerCAD is so flexible you can use it for all phases of your project, from the feasibility report to the final design drawings and analysis of existing networks. During the feasibility phase, you can use SewerCAD to create several different system layouts with an AutoCAD or Micro Station drawing as the background, or within AutoCAD itself. For the final design, you can complete detailed drawings with notes that can be used to develop the construction plans. In summary, you can use SewerCAD to:

- Design multiple sanitary sewer systems.
- Analyze various design scenarios for sanitary sewer systems.
- Import and export AutoCAD and Micro Station .DXF files.
- Generate professional-looking reports for clients.
- Generate plan and profile plots of a network.

4.3 Layout of the Sewer 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 or 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 Al Burj village 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.
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 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 the wastewater collection system for Al Burj village is shown in the attached drawings.

4.4 The Proposed Wastewater Collection System

In the proposed study for the wastewater collection system for Al Burj village, the trial is made to design the main trunks of the collection system for year 2036. There are eight main trunks. This section deals with the results of the suggested wastewater collection network for year 2036. In the beginning, the values of maximum wastewater flow rate were calculated and given in Appendix-A.

The appropriate pipe diameters, lengths, land slopes, and location of the manholes are found by doing the calculations given in the previous section. During and once the sewer design computations have been completed, alternative alignments have be examined, and the most cost–and energy–effective alignment has been selected. The final results for the appropriate diameters for the proposed wastewater collection system, slopes and lengths of the pipes are given in attached tables along with all relevant data. The calculated velocities, flow rates, and depth of flow in pipes are given in the same tables.

It is observed form the tables and figures that the collection network covers most of the area of Al Burj village, the slope of the pipes follow in most cases the slope of the ground.

4.5 Profiles of Sewer

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 (McGhee, 1991).

After all the calculation is completed and all the maps of the proposed collection system are prepared, detailed profiles for each sewer is drawn. The profiles of sewer lines are shown in attached figures. These profiles had 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, and the type of soil.

CHAPTER

5 BILL OF QUANTITY

BILL OF QUANTITY

CHAPTER

6 *CONCLUSIONS*

CHAPTER SIX

CONCLUSIONS

The trial is made to evaluate and design the wastewater collection system for Al Burj village considering the annual growth of the 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. Al Burj village 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 Al Burj village is around 2300 person. Prediction of the future population of Al Burj village is very difficult due the political uncertainties. The rate of population growth is taken as 3.6%.

3. Restrictions on the Palestinian use of the annual ground water resources of the West Bank led to limited quantities of water supplied to Al Burj village and due to this condition the average consumption of water in the camp in general is low (60 l/c.d.) and does not represent the present actual demand of water. As a result of the long period of occupation, the village lacks well studies and prepared master plan for land uses, city planning, and the design of utilities. The future water consumption is estimated to be 100 l/c.d.

4. The maximum depth of flow in the sewer taken as 50% of the sewer diameter to be capable to receive any unexpected infiltration from the storm water or miss use of the sewer by the people by throughing solid waste.

5. The proposed wastewater collection system for Al Burj village covers most of the areas of the city.

6. In some sewers the velocity is less than 0.6 m/s especially in the beginning of the trunk. So, flushing of the trunk is needed in the first years of usage.

APPENDIX

A COMPUTATION TABLES

APPENDIX

B *DESIGN TABLES*

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REFERENCES

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CHAPTER FIVE

BILL OF QUANTITY
FOR THE PROPOSED WASTEWATER COLLECTION SYSTEM

1 – Excavations and backfilling

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
1.1	Excavations and backfilling nominal pipe diameter 200 mm				
1.1.1	Excavation of pipe trench in all kinds of soil, rock, etc, the price shall include cost of backfilling with selected suitable material approved by the engineer, and shall include leveling and compaction to a depth not exceeding 2 m and disposing surplus material outside the site according to drawings. And specifications.	L.m	**9003.5**		
1.1.2	Ditto, but for excavations between 2.00-2.50m	L.m	**872.5**		
1.1.3	Ditto, but for excavations between 2.50-6m	L.m	**1464**		

2– Pipes

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
	Pipes				
2.1	Supply, store and installation of pipes diameter **200(uPVC)**with the Techen stamp or equivelant, along with the fittings, according to drawings, and specifications.	L.m	**11340**		

3 – Concrete manholes

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
3	**Concrete manholes** **Precast manholes**				
3.1	Supplying and installation of manhole, coated with coal tar epoxy, including excavations in all kinds of soil, rock, etc, shall include cost of backfilling with selected suitable material approved by the engineer, and steps and benching, heavy duty cover 25 tons for streets, and 8 tons for cross country fields and backfilling not exceeding 2m .**Diameter1200mm** according to drawings and specifications.	Nr.	**256**		
3.2	Ditto, but depth between 2.00-2.50m	Nr.	**24**		
3.3	Ditto, but depth between 2.50-6.00m	Nr.	**43**		

4 – Pipe bedding

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
4	**Pipe bedding**				
4.1	Supplying, installation and compaction of (**Absolet**) fine granular material, under, above and around pipe Diameter (according to depth at items 1.1) **200mm** according to the drawings and specifications.	L.m	**11340**		

5– concrete works

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
5	**Concrete works**				
5.1	Supply and cast encasement plain concrete (B-200) surround for sewer, according to drawings and specifications.	m^3	**100**		

6 – Air leakage test

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
6	**Air leakage test**				
6.1	Air leakage test for **sewer** pipelines according to specifications, including for all temporary works				
6.1.1	Nominal bore 200mm	L.m	**9003.5**		
6.2	Water leakage test for all **manholes**, according to specifications, including for all temporary works.				
3.2	Ditto, but depth between 2.00-2.50m	Nr.	**872.5**		
3.3	Ditto, but depth between 2.50-3.00m	Nr.	**1464**		

7 – Road reinstatement

Item	Item Description	Unit	Quantity	Unit Price €	Amount €
7.1	Provide and place 250 mm, base coarse For Sewer Pipes Ø 200along with 50 mm asphalt over it, after compaction, all the work includes compaction, bitumen layer (1.0 lt./m 2) between the base coarse layer.	Lm	**10730**		

Summary Table (for the project)

1	**Excavations and backfilling**	**11340**
2	**Pipes**	**11340**
3	**Concrete manholes**	**323**
4	**Pipe bedding**	**11340**
5	**Concrete works**	**100**
6	**Air leakage test**	**11340**
7	**Road reinstatement**	**10730**
	Construction of Yatta sewage network Total	

Discount as percentage of the total amount= ------------------------

TOTAL CONTRACT AMOUNT AFTER DISCOUNT = ------------------------