DESIGN OF WASTEWATER COLLECTION SYSTEM FOR DURA TOWN

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HEBRON- WEST BANK

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CERTIFICATION

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The Senior Project Entitled:

DESIGN OF WASTEWATER COLLECTION SYSTEM FOR DURA TOWN

Prepared By:

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In accordance with the recommendations of the project supervisor, and the acceptance of all examining committee members, this project has been submitted to the Department of Civil and Architectural Engineering in the College of Engineering and Technology in partial fulfillment of the requirements of the department for the degree of Bachelor of Science in Engineering.

Project Supervisor **Department Chairman**

December- 2006

إهـــــــــداء

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

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

إلى من أهدتني بهم السماء ... أصدقائي الأحباء .

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

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

إلى أرواح كل الشهداء ... إلى فلسطين الإباء .

إلى كل شيء طاهر جميل في هذا الوطن المعطاء .

إلى كل هؤلاء ... أهدي ما جنيت بعناء .

باهر سلطان

صفاء غيث

مهند الحموري

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Work Team

ABSTRACT

DESIGN OF WASTEWATER COLLECTION SYSTEM FOR DURA TOWN

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There is no wastewater collection system at present in Dura town. 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 icrease in population will cause environmental and health problem, and may create contamination of the underground water aquifer. Furthermore, emptying csspools 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 Dura town. The first step is serving the city with wastewater collection system. So, the main objective of this project is to design wastewater collection network for Dura town of the Hebron district.

The present study considered the annual population growth and their water consumption for the coming 25 years that will be the design period, along with the commercial and industrial development in the area. The necessary hydraulic calculation needed for the design of the main trunks was carried out by simple calculation.

The results of the study show that wastewater disposal in Dura area causes problems to the peoples; subsequently there is a big need for immediate steps for construction of the proposed wastewater collection system. Gravity flow sanitary sewer was proposed for most of Dura areas to minimize the cost of construction and excavations with two pumping stations.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

1.2 PROBLEM DEFINITION

1.3 PURPOSE OF PROJECT

1.4 SCOPE OF THE WORK

1.5 STAGES OF THE PROJECT

1.6 ORGNIZATION 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. At the same time, the existing treatment plants are heavily overloaded and poorly operated and maintained.

Dura town like other towns in 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 investigate and evaluate wastewater collection and treatment processes along with conceptual designs that are suitable for Dura town. More specifically the main purposes of this project may be classified as follow:

1. Display the current situation of wastewater disposal in Dura town.
2. Define the types of sewage facilities and their locations that will need to be constructed.
3. Propose wastewater collection system for the town and design the main trunks of the proposed sewerage collection network.
4. 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 Dura town.

1.4 Scope of the Work

The scope of work of this project is to evaluate and develop preliminary conceptual design for sewer networks for Dura town 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.

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								
		2/06	**3/06**	**4/06**	**5/06**	**6/06**	**9/06**	**10/06**	**11/06**	**12/06**
One	Collection and Analysis of Data.	■	■	■						
Two	Performing the Surveying Works.			■	■					
Three	Design of the Sewage Network.				■	■	■			
Four	Preparing Plan Drawings and Profiles.				■	■	■			
Five	Preparing Bill of Quantities and Cost Estimates.						■	■		
Six	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.
3. Projection on land use development, population growth and density, and economic growth (industrial, commercial, etc).
4. Determination of the wastewater quantities and projection of wastewater production in year 2030.

Phase 2: Perform the Surveying Works

The tasks which were performed in the second phase are:

1. Determination of the coordinates of some points in the area which help in preparing the necessary maps for the project.
2. Evaluation of the contour maps and matching it with actual ground levels.
3. 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 2028.
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 five chapters.

The **first chapter** entitled **“Introduction”** outlines the problem, purpose of project, scope of the work and phases of the project.

Chapter two entitled **“Characteristics of the Project Area”** talks about Dura town, physical features, demographic features and water supply.

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”** deals with the layout of the system, design calculation of the main trunks, and the profiles of the lines designed.

Chapter five, entitled **“Bill of Quantities”** deals with the quantities needed to complete the design system.

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

CHAPTER TWO

CHARACTEEISTICS OF THE PEOJECT AREA

2.1 DURA TOWN

2.2 PHYSICAL FEATURES

2.3 DEMOGRAPHIC FEATURES

2.4 WATER SUPPLY

CHAPTER TWO

CHARACTEEISTICS OF THE PEOJECT AREA

2.1 Dura Town

Dura town is located 8 kilometers to the southwest of the city of Hebron. The total land area of the town is about 14,000 dounms.

Dura is considered as a center of several surrounding villages such as Al-Tabaqa, Khorsa, Deir Samet, Al-Kom, etc. It is center for region of population not less than 40,000. The location and the aerial maps of the town are shown in Figures 2.1 and 2.2.

2.2 Physical Features

A summary of physical features of the study area based on available data is presented below.

2.2.1 Topography

The study area consists of mountains with steep slopes and few plain areas located east of the city. The city is about 900 meters above mean sea level (AMSL). The area of city center is located between 820 m and 870 m AMSL. The built-up area of town spreads between the elevations of 760 m to 890 m AMSL.

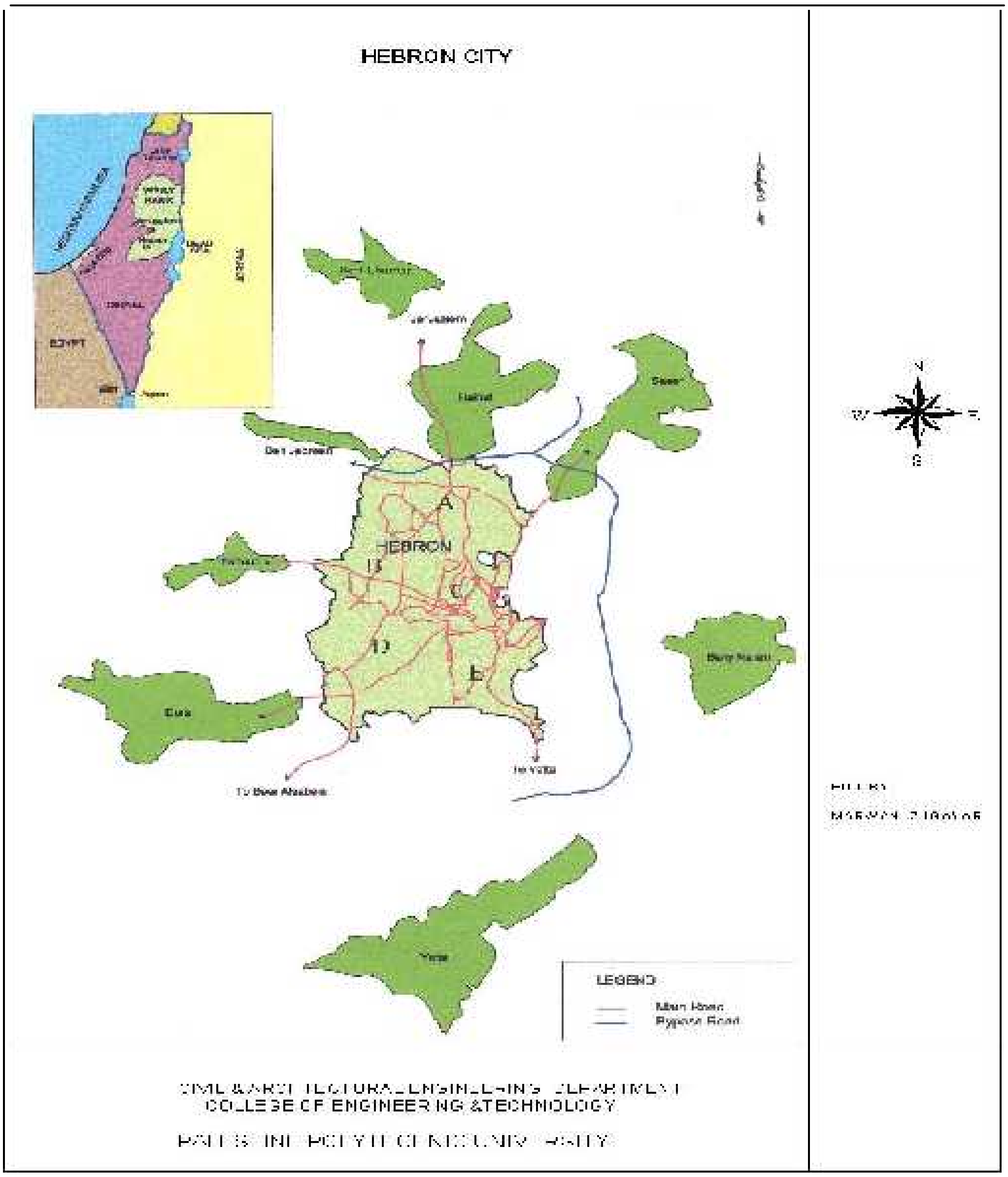

Fig.2.1-Location Map of Dura Town

2.2.2 Climate

Dura city has a typical Mediterranean climate with two main seasons: the dray season from May to October and the rainy season from November to April, spring and autumn are short and have special characteristics. The climatelogical data presented in the following paragraphs were obtained from the survey carried out by Meteorological Station which is located at the elevation of (+900) m AMSL.

2.2.2.1 Rainfall

The average annual rainfall in Dura city for the last five years is approximately (500) mm, of which about 98 percent falls between October and April. The maximum monthly rainfall recorded in January and amounted (145.93) mm. Table (2.1) shows the monthly rainfall during the period 2000-2005 at the Dura Meteorological Station.

2.2.2.2 Temperature

The temperature range is characterized by considerable variations between summer and winter. The mean temperature values at the Dura Metrological Station for the period 2000 – 2005 are given in Table 2.1. The following characteristics values are shown:

- Mean maximum temperature: 20 ˚C
- Mean minimum temperature: 11 ˚C
- Maximum temperature recorded 3.96 ˚C
- Minimum temperature recorded 27.23 ˚C

Table2.1: Meteorological Conditions at Dura Town Weather Station for (2000-2005)

Month	Rainfall (mm)	Maximum Temperature (˚C)	Minimum Temperature (˚C)	Relative Humidity (%)	Evaporation (mm/month)
September	0.0	10.25	3.96	74.19	65.10
October	11.75	11.58	4.70	72.22	81.20
November	51.83	14.57	6.46	65.96	93.00
December	142.57	19.59	9.93	54.62	138.60
January	145.93	23.63	13.23	48.25	165.80
February	88.5	25.90	15.77	51.03	199.50
March	37.35	27.16	17.04	56.77	220.70
April	17.5	27.23	16.96	59.88	225.00
May	4.5	25.97	15.94	61.66	156.50
June	0.0	23.18	14.02	58.89	111.60
July	0.0	17.50	9.90	64.07	87.00
August	0.0	12.09	5.62	72.69	62.00
Total	**499.43**				**1606.10**

2.2.2.3 Relative humidity

Dura situated at a considerable distance from the sea in a mountains region on the outskirts of the desert. Dura has low values of relative humidity as compared to those in the plain. As shown in Table 2.1 the relative humidity in Dura city ranges from 48% - 72%, it reaches the maximum value in August.

2.2.2.4 Winds

The directions and velocities of wind vary depending on the season of the year. In winter, the wind blows in the morning from the southwest, around noon from southwest and west, and at night from west and northwest. In summer, a north easterly wind blows all day long. According to the data obtained from the Dura Metrological Station, the average wind velocity in winter is about 12 m/s and in summer 8 m/s.

2.3 Demographic Features

2.3.1 Population

The population within the municipal boundary has been determined according to a census carried out by the Palestinian Central Bureau of Statistic (PCBS) on the night of 9/10 December 1977. According to this census, the population of Dura Town and the surrounding suburbs (Taruseh, Al-Hijreh, Kreesa, Al Rafadeh and Urqan Awad) is about 19,100.

2.3.2 Population density and zoning

According to data obtained from Municipality, the town of Dura is subdivided into planning zones according to the land use. The zones are residential, agricultural, commercial and industrial. In addition to the old city, the residential zones are subdivided into sub-zones A, B and C. There is an ongoing modification to the existing planning zone of 1922. The total municipal area is approximately 7,000 dounms and there is a plan to expand the municipal boundaries to become 14,000 dounms. It should be noted that the population of the old city, which represents the highest population density, will remain almost constant as it is already saturated while the other residential zones represent the attractive areas for the citizens.

2.4 Water Supply

The main water source for Dura town is from Al-Fawwar well, which is owned and operated by Hebron Municipality. The average water quantity which is supplied to Dura is around 400 cubic meters per day. Table 2.2 represents the quantities of water supplied and billed for the last three years.

Table 2.2: Quantities of Water Supplied and Billed for Dura Town

Year	Water Supplied (m^3)	Water Billed (m^3)	Unaccounted for Water (%)
1996	146036	77353	47
1997	155370	95074	39
1998	138726	89476	36

As presented in Table 2.2, the unaccounted for water in the distribution network is about 35-51% of the quantity of water pumped into the network.

Due to insufficient water quantities pumped into the network, the people of Dura rely on rainwater harvesting as an additional water supply source. Almost all new houses have underground cisterns built at the time of construction. It is estimated that around 70% of houses have individual cisterns with an average capacity of 40 m^3 per each.

The people of Dura are forced to purchase water through the water tanker during the summer season to meet their basic needs. There is no data available about the commercial and industrial water consumption for the Dura town. Main water consumers are the two stone cutting factories and the five brick plants.

CHAPTER THREE

DESIGN AND PLANNING CRITERIA

3.1 INTRODUCTION

3.2 POPULATION

3.3 PROJECTED WATER CONSUMPTION

3.4 DURA MASTER PLAN

3.5 DESIGN PARAMETERS

CHAPTER THREE

DESIGN AND PLANNING CRITERIA

3.1 Introduction

In the previous chapters, the problem of the study area has been defined and the objectives of the project have been listed. The characteristics of the project area (Dura town) have been described. Wastewater collection systems and design of sewer system were explained. In this chapter, basis for planning and design will be discussed including present population, population forecasting, projected water consumption, town structure plan, and the design and planning criteria of the project.

3.2 Population Forecast

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, and the more comprehensive the census data, the more accurate will be the results, which will be obtained. In the analysis of these data, demographical, economical and political factors should be considered in order to develop a method of forecasting which will predict the expected growth rate, future population and its distribution in the different zones of the area under consideration.

In Dura town, there is great uncertainty in the political and economical future. Additionally, there were no accurate population data since the occupation of the West Bank in 1967, until 1997 when the Palestinian Central Bureau of Statistic (PCBS) conducted comprehensive census covering the West Bank and Gaza Strip. The final results of this census show that the total population of Dura town is 19100 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 Dura town over the next 25 years.

3.2.2 Population projection

Prediction of the future population of Dura town 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 Dura town.

The base for the forecast is the 1997 population for Dura town obtained from PCBS of 19100 inhabitants. The annual growth rates for the next twenty years are also obtained from the PCPS and they are presented in Table 3.1.

To calculate the population at the end of the design period (year 2030), a geometric increase is assumed, represented by the following equation:

$$P = P_0 * (1+ r)^n \quad (3.1)$$

Where, P is the future population, P_0 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 2030. The data show that the population of Dura town is estimated to be 49670 in year 2030.

Table 3.1: Population Forecast for Dura Town.

Year	Annual Growth Rate(%)	Population
2000	4.56	21800
2005	4.24	26800
2010	3.73	32200
2015	2.51	36450
2020	2.26	40750
2030	2.00	49670

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 urban area, but it includes small-scale industries, schools, public and commercial buildings, and roads.

Sewer design, however, is based on the net densities of population, because the provision of sewers is limited to the built-up areas. The gross density are also used in the design of sewer system. The net density of population varies considerably from district to district. For Dura town the net densities it varies between 18.4 and 185 capita per hectare. The gross density for the same areas varies between 1.5 and 5.8 per hectare.

The Dura municipality studies the population densities for different areas of Dura based on the town study master plan, which serves for incisive building permits. The values of gross and net population densities are given in Table 3.2 along with the names of district and areas.

Table 3.2: The Present and Future Population and Densities for Different Area of Dura Town

Area Name	Current Pop.	Area (ha)	Built Up Area(ha)	Net Pop. Density (C/ha)	Future Pop.	Future Built Up Area(ha)	Net Future Pop. Density (C/ha)	Gross Future Pop. Density (C/ha)
Kriseh	2100	208	3.9	538	4397	7.1	617	21
Wadi El Hamam	1500	17	2.7	556	3141	21	147	185
Sharafa	2930	36	5.5	533	6135	21	299	170.4
Wadi Sood	780	35	1.5	520	1633	9.6	170	46.67
Namoos	1500	70	2.8	536	3141	9.3	340	45
Old City	3800	54	7	543	7956	18	437	147
Abaheer	1730	45	3.2	541	3622	12	293	80.5
Ihnianah	1280	60	2.4	533	2680	9.3	290	44.67
Abu Hilal	1730	99	3.3	524	3622	8.6	422	36.6
Kannar	3200	107	6	533	6700	11	617	63
Abu El Qamra	1220	139	2.3	530	2554	6.9	370	18.4
Sinjer	3100	91	5.8	534	6491	12	558	71.3
Almadares	1500	28	2.8	536	3141	15	206	112.2
Naqit Nooh	1450	52	2.7	537	3036	10	291	58.4

In present project, the gross population densities are used in design of wastewater collection system for Dura town, which give the same results if we use the net densities.

3.3 Future Water Consumption

3.3.1 Introduction

Water consumption is not constant, yearly, monthly, weekly, daily and hourly variations in water consummations 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 day water use various 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 adopting this approach for Hebron area including Dura Town 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 limited quantities availability of water and due to this condition; the average consumption of water in Dura Town for all purposes does not exceed 36.5 cubic meters 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 (100 liter/capita. day).

3.3.2 Projected water consumption

The present average consumption of water for domestic use in Dura Town does not represent the present and actual demand of water. So, it is estimated the water consumption in Dura will dramatically increase during the next few years, due to several ongoing water projects, which are:

1. Drilling new production wells;
2. Upgrading the existing water supply system;
3. Rehabilitation of the existing network; and
4. Detecting network leakage as well as dealing with institutional development of water sector and tariff structures.

The Dura municipality has estimated the existing per capita water consumption at about 100 l/c.d, and the rate of increase in the annual water consumption per capita to 1.5 %. It is estimated that the per capita water supply will be 143 l/c.d including the physical losses in the year 2030. Assuming the physical losses at about 15%, the per capita water consumption will be around 120 l/c.d. It should be noted that the figure includes commercial and industrial consumption. The estimated per capita water consumptions for the year 2005, 2010, 2015, 2020 and 2030, is presented in Table 3.3.

Table 3.3: Forecast Water Demand for Dura Town.

Year	Population	Water Demand (m^3/year)		Water Demand(l/c.d)
		Per Capita	Total	
2005	26800	36.5	978200	100
2010	32200	39.42	1269324	108
2015	36450	42.34	1543293	116
2020	40750	45.63	1859422.5	125
2030	49670	52.20	4158774	143

It may be noted from Table 3.3 that the projected water consumption for the design period (year 2030) is 143 liter per capita per day. And as mentioned earlier if the losses are 15% the per capita water consumption will be 120 liter per capita per day. This figure is used in the design of wastewater.

3.4 Design Parameters

3.4.1 Flow rate projections

The total wastewater flow in sanitary sewers is made up of two 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 Dura town in the year 2030 is 4967070 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 2031.
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 (Dura town).

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.

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 2006-20230).
2. Present (2006) population of municipality of Dura town is 26800 capita.
3. The growth rate will be 2%-4.5%.
4. The existing per capita water consumption has been assessed 100 l/c.d.
5. Total administrative area of municipality of Dura town 14,000 dounm.
6. Future 2030 population of Dura town 49670 capita.
7. Per capita water consumption by 2030 will reaches 120 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)

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

10. Minimum velocity 0.6 m/sec.
11. Maximum velocity 2.5-3.0 m/sec.
12. h/D = 0.5 for main trunks.
13. Maximum manhole spacing 60 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

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

17. Depth of sewer pipe: Minimum covers not less than 1.5 from the crown.

18. Maximum slope Smax = 0.05.

19. Minimum slope Smin = 0.005.

CHAPTER FOUR

ANALYSIS AND DESIGN

4.1 GENERAL

4.2 LAYOUT OF THE SYSTEM

4.3 DESIGN COMPUTATIONS

4.4 PROFILES OF SEWERS

CHAPTER FOUR

ANALYSIS AND DESIGN

4.1 Introduction

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

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 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 Dura 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 Dura area, the lowest point is in the southern part of the town.
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 wastewater collection system for Dura town is illustrated in Figure 4.1.

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 surroundings and upstream areas the next pipe in series, subject to the appropriate design constrains. The design computations and procedures for Dura sanitary sewers are illustrated in the design example given below.

4.3.1 Design example: Design a gravity flow sanitary sewer

Design a gravity flow trunk sanitary sewer for the area from the old city center to outfall (line A) shown in Figure 4.1. 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%.
3. For water consumption uses 100 l/c.d, for the current use and 120 l/c.d, for the future use. The wastewater calculates as 80% of the water consumption.
4. For infiltration allowance use 20% of the domestic sewerage flow.
5. Peaking factor depending on the formula :

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

6. For the hydraulic design equation use the Manning equation with a value of 0.015.
7. Minimum pipe size: the building code specifies 200 mm (8 in) as the smallest pipe permissible foe 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. The minimum cover depth over the top of the sewer is 1.5 m.

4.3.2 Solution

1. Lay out the trunk sewer. Draw a line to represent the proposed sewer (Figure 4.1).
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 50 to 70 m or less. Identify each manhole with a number.
3. Prepare a sewer design computation table. Based on the experience of numerous engineers, it has been found that the best approach for carrying out sewer computations is to use a computation table. The necessary computations for the sanitary sewer are presented in Table 4.1. The data in the table are calculated as follow:
   a. The entries in columns 1 and 2 are used to identify the line numbers and location.
   b. The entries in columns 3 through 5 are used to identify the sewer manholes, their numbers and the spacing between each two manholes.
   c. The entries in columns 6 and 7 are used to identify the sewered area, column 6 shows the incremental sewered area in hectare, and column 7 shows the cumulative area.
   d. The Future population (year 2030) including population density, incremental population, and cumulative total population are entered in columns 8, 9, and 10 respectively. The population density (person/ha) in column 8 is obtained by determine the number of population on the all area. The incremental population (column 9) is obtained by multiplying column 8 by column 6. Column 10 shows the cumulative total population by adding column 9 to the last figure of column 10.

e. To calculate cumulative peak design flow columns 11, 12, 13, and 13 are used. Column 11 is obtained by multiplying future wastewater production (80% * 120 l/c.d.) with the future incremental population (column 9) then dividing by (24 hours *60 minutes*60 seconds). The peak factor (column 12) is calculated using equation 3.2 as: $P_f = 1.5 + 2.5/\sqrt{q}$, where q = Average Domestic sewage flow (Column 12). Column 13 represents the Maximum Domestic (Q) in (l/s), the value of it is obtained from multiplying column 11 by column 12. Column 14 gives the infiltration allowance, which equal 0.02 * Column 11.

f. The entries in columns 15 (total average flow rate) is calculated by sum the Column 11 and Column 13.

g. The entries in columns 16 (total maximum flow rate) is calculated by sum the Column 13 and Column 14.

h. The necessary layout data for the sewer (columns 17 through 20) are obtained as follows: The ground surface elevations at the manhole locations entered in columns 17 and 18. The ground slope given in column 19 is obtained by subtracting downstream elevation from upstream elevation (column 17-column 18) and dividing the result by sewer length (column 5).

i. Sewer design information is summarized in columns 20 through 29. The slope of sewer (column 20) is taken as the slope of the ground or less depending on the values of the slope given in tables of Appendix-B (taking the value of ground slope and look to the tables and take the same value or the nearest less value). The reason for taking the slope of sewer equal to the slope of ground is to decrease the cost of construction the sewers. The required pipe size (diameter) is chosen by trial and error as follow: (1) beginning with the minimum size (20 cm), the full capacity of selected pipe (Q_{full}) at a given slope and diameter is obtained from the tables (Appendix), (2) calculate the ratio Q_p/Q_{full}, where Q_p is the total maximum flow rate l/s (column 16), (3) from the table of hydraulic properties for partially filled circular sewers given in Appendix, the ratio of h/D is obtained, where d is the depth of flow and D is the chosen diameter, (4) If the value of $h/D > 0.5$ choose a larger diameter and repeat the same procedures until the value of $h/D \leq 0.5$. The last values of pipe diameter and full capacity of selected pipe obtained are given in columns 2 1 and 22.

j. The entries in columns 23 (depth of flow) is calculated by multiply the value of h/D by Diameter.

k. For the same pipe diameter and same ratio of Q_p/Q_{full} or h/D, the value of full velocity (V_{full}) and ratio of V_p/V_{full} is obtained from the tables, where V_{actual} is the minimum partial velocity. The values of minimum velocities are calculated by multiplying V_{full} with V_p/V_{full} and presented in column 24. And then use the tables to find V_p/V_{full} ratio, where V_p here represent the minimum velocity and calculate the minimum velocity by multiplying V_p/V_{full} with full velocity. The data of minimum velocities are given in column 25.

The final design of this trunk sanitary sewer is shown in Figures 4.2a-4.7a. The lengths and diameters of the pipes along with the manholes are shown in this figure.

4.4 The Proposed Wastewater Collection System

In the proposed study for the wastewater collection system for Dura town, the trial is made to design the main trunks of the collection system for year 2030. There are five main trunks. This section deals with the results of the suggested wastewater collection network for year 2030.

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 Tables 4.2 through 4.5 along with all relevant data. The calculated velocities, flow rates, and depth of flow in pipes are given in the same tables. The proposed design of the collection system for each of the main trunk are plotted separately and shown in Figures 4.8a to 4.15a.

It is observed form the tables and figures that the collection network covers most of the area of Dura, the slope of the pipes follow in most cases the slope of the ground, In same pipes, the velocity of flow is less than 0.6 m/sec (minimum velocity) in the beginning of the line, which means flushing, are required from time to time. Finally, two pumps are required in the east and north region to pump wastewater form low-lying sections.

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 Figures 4.2b-4.15c. 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 FIVE

BILL OF QUANTITY

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 **350mm**				
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 1.5m and disposing surplus material outside the site according to drawings. And specifications.	L.m			
1.1.2	Ditto, but for excavations between 2.00-2.50m	L.m	**857**		
1.1.3	Ditto, but for excavations between 2.50-3.00m	L.m			
1.2	Excavations and backfilling nominal pipe diameter **300mm**				
1.2.1	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 1.5m and disposing surplus material outside the site according to drawings. And specifications.	L.m			
1.2.2	Ditto, but for excavations between 2.00-2.50m	L.m	**1263**		
1.2.3	Ditto, but for excavations between 2.50-3.00m	L.m			
1.3	Excavations and backfilling nominal pipe diameter **250mm**				
1.3.1	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 1.5m and disposing surplus material outside the site according to drawings. And specifications.	L.m			
1.3.2	Ditto, but for excavations between 2.00-2.50m	L.m	**348**		
1.3.3	Ditto, but for excavations between 2.50-3.00m	L.m			
1.4	Excavations and backfilling nominal pipe diameter **200mm**				
1.4.1	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 1.5m and disposing surplus material outside the site according to drawings. And specifications.	L.m			
1.4.2	Ditto, but for excavations between 2.00-2.50m	L.m	**5891**		
1.4.3	Ditto, but for excavations between 2.50-3.00m	L.m	**276**		

2– Pipes

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
	Pipes				
2.1	Supply, store and installation of pipes diameter **350mm(uPVC)**with the Techen stamp or equivelant, along with the fittings, according to drawings, and specifications.	L.m	**857**		
2.2	Ditto, but for pipes diameter **300mm(u PVC)**	L.m	**1263**		
2.3	Ditto, but for pipes diameter **250mm(u PVC)**	L.m	**348**		
2.4	Ditto, but for pipes diameter **200mm(u PVC)**	L.m	**6167**		

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 1.5m.**Diameter1000mm** according to drawings and specifications.	Nr.			
3.2	Ditto, but depth between 2.00-2.50m	Nr.	**169**		
3.3	Ditto, but depth between 2.50-3.00m	Nr.	**8**		

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) **350mm** according to the drawings and specifications.	L.m	**857**		
4.2	Ditto, but for pipe diameter **300mm**	L.m	**1263**		
4.3	Ditto, but for pipe diameter **250mm**	L.m	**348**		
4.4	Ditto, but for pipe diameter **200mm**	L.m	**6167**		

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 350mm	L.m	**857**		
6.1.2	Nominal bore 300mm	L.m	**1263**		

6.1.3	Nominal bore 250mm	L.m	**348**		
6.1.4	Nominal bore 200mm	L.m	**6167**		
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.	**169**		
3.3	Ditto, but depth between 2.50-3.00m	Nr.	**8**		

7 – Road reinstatement

Item	Item Description	Unit	Quantity	Unit Price €	Amount €
7.1	Provide and place 250 mm, base coarse For Sewer Pipes Ǿ 350,300,250 & 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	**8635**		

Summary Table (for the project)

1	**Excavations and backfilling**	**8635**
2	**Pipes**	**8635**
3	**Concrete manholes**	**177**
4	**Pipe bedding**	**8635**
5	**Concrete works**	
6	**Air leakage test**	**8635+177=8812**
7	**Road reinstatement**	**8635**
	Construction of Dura sewage network Total	

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

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

CHAPTER FIVE

CONCLUSION

CHAPTER SIX

CONCLUSIONS

In this project, the trial is made to design wastewater collection system for Dura town. During the first three months the project team completed the preliminary investigation and collected all necessary data and maps. The surveying working is also performed and the layout of the system was established.

The necessary hydraulic calculations needed for the design of the main trunk is started and will be completed in coming three months.

The preliminary investigation and data show the problems of the existing wastewater disposal, and the needs of design and construction of sewerage system. The proposed layout covers most of the areas of Dura town with sewer pipes that goes under gravity except of some areas where pumping stations is required.

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APPENDIX-A

CALCULATIONS TABLES