DESIGN OF WASTEWATER COLLECTION SYSTEM FOR BAIT KAHIAL

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DESIGN OF WASTEWATER COLLECTION SYSTEM FOR BAIT KAHIL TOWN

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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**

June - 2008

إهـــــــــداء

من شوك الصبار تعلمنا ان نصبر مهما تألمنا
نرضى بالجوع ولا نركع
ان نجعل من حجر مدفع ان نبني عزا يتربع
فوق الأرض فوق المصنع
هذا ما قالته لنا امي

للعيون اللاتي تبقى في الليالي ساهرات لكم من شفاهي اليوم قبلة ... امي وابي .

للشموع المضيئه والقلوب الجريئة و النبض الذي يجري في عـــــروقي(مادمتم معي) ... إخوتي الأعزاء .

دروب الحياة عديده ومنها اوقات سعيده قضيناها معاودموعا ذرفناها معا لمن شكلو علامه فارقه في حياتي ...اصدقائي صديقاتي.

للقناديل التي أضاءت لي الدرب ... أساتذتي الأجلاء .

لفلسطين الاباء ... حاضنة ارواح الشهداء .

لكل شيء طاهر جميل في هذا الوطن.

الى هؤلاء نهدي عملنا هذا.

رشا أبوعيهور نبال كفافي ندى وراسنه

A KNOWLEDGEMENT

We would like to thank and gratitude to Allah, who gives us, the most Merciful who granted us the ability and willing to start project. We authentic and appeal to Allah give us blessed and power to contunue our project to the benefits of our country.

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

Work Team

ABSTRACT

DESIGN OF WASTEWATER COLLECTION SYSTEM FOR BAIT KAHIL TOWN

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There is no wastewater collection system at present in Bait kahil 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 Beit kahil 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 Bait kahil 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 Bait kahil 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 Bait kahil areas to minimize the cost of construction and excavations.

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1.5 STAGES OF THE PROJECT.

1.6 ORGANIZATION OF THE PROJECT.

CHAPTER ONE

INTRODUCTION

1.1 Background

Sanitary, there are no public wastewater collections and treatment creates major potential health and environmental problem to both the people and their surrounding in areas in the West Bank. And due raw wastewater large areas in the West Bank and ground water aquifer are being contaminated, from the lack of sewage collection and treatment system, 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.

Bait Kahil village like other villages 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 Bait Kahil 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 Objective of Project

The overall objective of this project is to investigate wastewater collection and treatment processes along with conceptual designs that are suitable for Bait Kahil village. More specifically the main objectives of this project may be classified as follow:

1. Display the current situation of wastewater disposal in Bait Kahil village.
2. Evaluate the existing sewerage facility and their locations that will need to be constructed.
3. Propose wastewater collection system for the village and design the main trunks of the proposed sewerage collection network.
4. Estimate the cost for construction of the collection network.

5. Prepare and drawing the maps and profile of the proposed main trunks, and then prepare bill of quantities for the proposer work.

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

1.4 Bait Kahil village

Bait Kahil village is located in the west north of the Hebron city, on the local line north side 108.61 m. and eventual local line from the east 156.86 m, it elevates 955m above sea level and keeps away 4 Km from Hebron city. The total land area of the village is about 600 hectare. It is surrounding by Hebron city, Bait Aula, Halhoul, and Tarqumia Town. As shown in the figure (1.1).

1.4.1 Topography

The topography of Bait Kahil village divided into three parts.

- ❖ Northern slope.
- ❖ Mountain crests.
- ❖ Southern slope.

The city is about 955 m. above mean sea level (AMSL). The area of city center is located in elevation ranges on average between (955m -760 m) AMSL.

1.4.2 Climate

The climate in Bait Kahil has a typical Mediterranean climate with two main seasons: the dry season from May to October and the rainy season from November to April, spring and autumn are short and have special characteristics. Is located at the elevation of +955 m (AMSL). The monthly average temperature range from 6-13^{0}C in winter to 17-30^o in summer. The average annual rainfall in Beit Kahil for the last five years is approximately (400) mm, of which about 98 percent falls between October and April. The maximum monthly rainfall recorded in January and amounted 100 mm. the relative humidity ranges from 20% - 80%, it reaches the maximum value in February.

1.4. 3 Demographic Features

The population within village's boundary has been determined according to a census carried out by the Palestinian Central Bureau of Statistic (PCBS) December1977. The final result of the census show that the total population of Bait Kahil village is 7000 inhabitants.

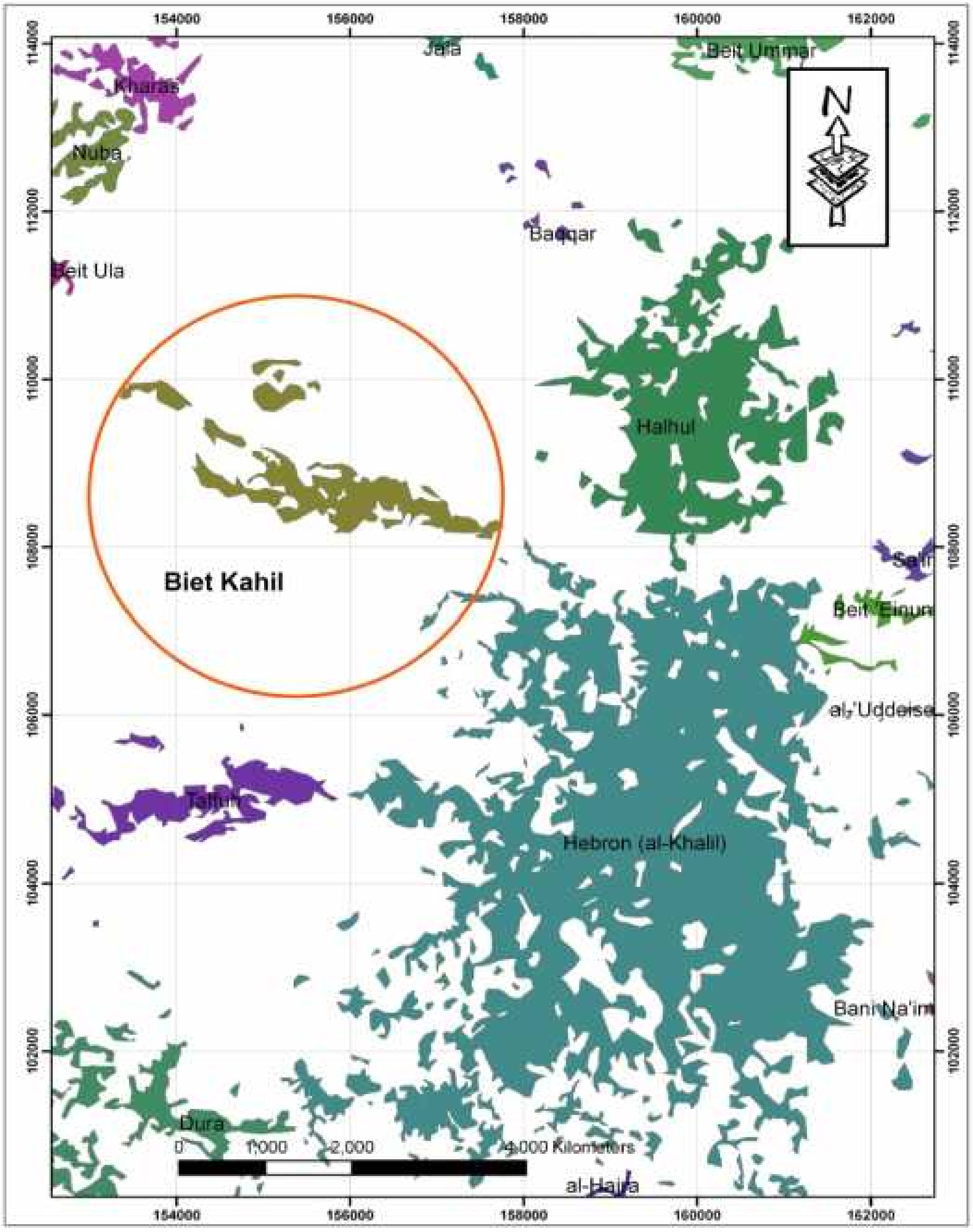

Fig.1.1-Location Map of Bait Kahil village

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	ration							
		10/07	11/07	12/07	1/08	2/08	3/08	4/08	5/08
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 areas 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 2032.

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 2032.
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.

1.5 Organization Of The Report

The study report has been prepared in accordance with the objectives and scope of work. The report consists of four chapters.

The first chapter entitled **“Introduction”** outlines the problem, objective of project, characteristics of the Project Area, and phases of the project.

Chapter two 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 three 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 four entitled **“Bill of Quantities”** deals with the quantities needed to complete the design system.

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

CHAPTER TWO

DESIGN AND PLANNING CRITERIA

2.1 INTRODUCTION.

2.2 POPULATION FORECAST.

2.3 FUTURE WATER CONSUMPTION

2.4 DESIGN PARAMETERS

2.5 DESIGN AND PLANNING ASSUMPTIONS.

CHAPTER TWO
DESIGN AND PLANNING CRITERIA

2.1 Introduction

In the previous chapter, the problem of the study area has been defined and the objectives of the project have been listed. The characteristics of the project area 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.

2.2 Population Forecast

2.2.1 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 Bait Kahil 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 2007 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 Bait Kahil is 7000 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 Bait Kahil over the next 25 years.

2.2.2 Population projection

Prediction of the future population of Bait Kahil 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 Bait Kahil.

The base for the forecast is the 2007 population for Bait Kahil obtained from PCBS of 7000 inhabitants. The annual growth rates for the next twenty years are also obtained from the PCPS and they are presented in Table 2.1.

To calculate the population at the end of the design period (year 2032), a geometric increase is assumed, represented by the following equation:

$$P = P_0 * (1+ r)^{n} \qquad (2.1)$$

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 2.1 presents the population projection up to the design horizon of 2032. The data show that the population of Bait Kahil is estimated to be 16947 in year 2032.

Table 2.1: Population Forecast for Bait kahil village .

Year	Annual Growth Rate(%)	Population
2007	3.6	7000
2012	3.6	8354
2017	3.6	9874
2022	3.6	11899
2027	3.6	14200
2032	3.6	16947

2.2.3 Population Density Calculation

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.

Developing area of the Beit khahil City = 600 hectare.

Agricultural area = 159 hectare, the total peopled area = 596-159=438 hectare.

The peopled area divided to three sectors A (dense area as 15% of capacity), B (partial dense area as 60%) and C (Weak density as 25%).

Area of sector A= 63 hectare, B= 241 hectare, C= 132 hectare as shown in Fig.2.1

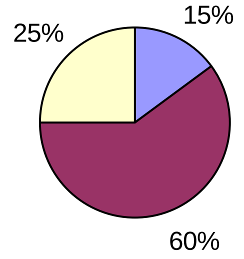

Figure 2.1:Divid of Sector .

Number of houses in sector A/10hectare = 185 = 18.5/ha as shown in Fig2.2

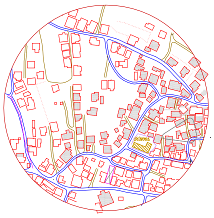

Figure 2.2: Sector (A) .

Number of houses in sector B/10hectare = 25 = 2.5/ha, as shown in Fig.2.3

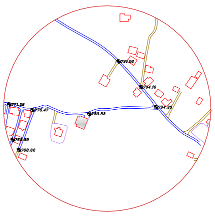

Figure 2.3: Sector (B) .

Currently there are no buildings in the sector C and there is no accommodation, but there is expected within 25 years to become the region population.

2.2.3.1 The Current population density in sectors calculated as follow

In sector A (mid village) approximately each building has two storey.

Assumed that in each storey live six persons and the full capacity of each building fur floors, the maximum density will be 24 persons / building in the future as shown in Fig. 2.2 above there's no enough space to a new constructions.

Dependent on this analysis the current population density calculated as:

The sector A in this day for each building has 2 storey =18.5x2x6=222p/ha.

The total population number in this sector = 222x63=13986p.

The sector B in this day for each building has 1 storey.

In sector B there's 2.5 houses/hectare, assuming 6 person live in each house the Current population density =2.5x6=15p/h.

The total population number in this sector = 15x241=3615 p.

The current population number in Bait khahil village app. 7000 person according to Village Council.

The calculated number above =13986+ 3615=17601p

Correction factor 7000/17601 = 0.3977

The realistic population number in each sector:

Sector A 13986 x 0.3977 = 5562p

Sector B 3615 x 5562 =1438p

Sum. 5562+1438=7000p

2.2.3.2 Population density at the end of design period

The population density at the end of design period (25 years) estimated as:-

$$P = P0 * (1+ r)^{n} \tag{2.1}$$

- In sector (A) ➔ Pf = 5562(1+0.036)25= 13460p in sector (A)

But the maximum =5562x2=11125p ➔density 11125/63=177p/ha.

So 13460-11125=2335p should be divided on sectors B&C 0.60 on B and 0.25 on C

Assume in each building has 3 storey

- In sector (B) ➔ Pf =1438x3 + (0.75x2335) =6065p ➔Density 5670/241=25p/ha.
- In sector(c) Pf =2335 x0.25 =584p ➔Density 584/132=5p/ha.

The total population in 2032 as estimated (177x63) + (24x241) + (5x132) =17595p

Pf = 7000(1+0.036)25 = 16947p< 17595 p ……. OK

The population density in sector A (175 p/hectare), in sector B (25 p/hectare) and in sector C (5 p/hectare).

Sewer design, however, is based on the net density of population, because the provision of sewers is limited to the built-up areas. The gross density is also used in the design of sewer system. The net density of population varies considerably from district to district.

2.3 Future Water Consumption

2.3.1 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 Bait Kahil 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 Bait Kahil for all purposes does not exceed 24 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).

2.3.2 Projected water consumption

The present average consumption of water for domestic use in Bait Kahil does not represent the present and actual demand of water. So, it is estimated the water consumption in village 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 village council of Bait Kahil 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 140 l/c.d including the physical losses in the year 2032. 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.

To calculate the population at the end of the design period (year 2032), a geometric increase is assumed, represented by the following equation:

$$Q_f = Q_i * (1 + n(a/100)) \qquad (2.2)$$

Where, Q_f the water demand at year (i), Q_i forecasted water demand after n years , n Design period , a the average annual population growth during the design period.

The estimated per capita water consumptions for the year 2007, 2013, 2018, 2023 and 2032, is presented in Table 2.2.

Table 2.2: Forecast Water Demand for Bait Kahil.

Year	Population	Water Demand (m ^{3}/year) Per Capita	Water Demand (l/c.d)
2007	7000	36.5	100
2012	8354	39.24	108
2017	9874	41.98	115
2022	11899	44.71	124
2027	14200	47.45	133
2032	16947	50.18	148

It may be noted from Table 2.2 that the projected water consumption for the design period (year 2032) is 150 liter per capita per day. And as mentioned earlier if the losses are 20% the per capita water consumption will be 120 liter per capita per day. This figure is used in the design of wastewater.

2.4 Design Parameters

2.4.1 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 Bait Kahil village in the year 2032 is 16947 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 2032.
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:

$$Pf = 1.5 + 2.5 / \sqrt{q} \qquad (2.3)$$

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 (Bait Kahil Village).

2.4.2 Hydraulic design

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

$$V = 1/n\ R^{2/3}\ S^{1/2} \qquad (2.4)$$

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

2.4.3 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.

2.4.4 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.

2.4.5 Manholes and covers

Manholes should be located at changes in size, slope direction or junction with secondary sewer. Manholes spacing generally does not exceed 40 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.

2.4.6 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.

2.4.7 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.

2.4.8 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.

2.5 Design and Planning Assumptions

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

1. Design period 25 year (from 2007-2032).
2. Present (2007) population of municipality of Bait Kahil village is7000 capita.
3. The growth rate will be 3.6 %.
4. The existing per capita water consumption has been assessed 100l/c.d.
5. Total administrative area of Bait Kahil village 600 hectare.
6. Future 2032 population of Bait Kahil village 16947 capita.
7. Per capita water consumption by 2032 will reaches 150 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)

$$V= (1/n)* R^{2/3} *S^{1/2} \qquad (2.4)$$

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 10 % of average domestic wastewater.
16. Peak factor determine by equation

$$P_f = 1.5 + (2.5 /\sqrt{q}) \qquad (2.3)$$

17. Depth of sewer pipe: Minimum covers not less than 1.5 from the crown.
18. Maximum slope S_{max} = 0.15.
19. Minimum slope S_{min} = 0.005.

CHAPTER THREE

ANALYSIS AND DSIGN

3.1 INTRODUCTION

3.2 LAYOUT OF THE SYSTEM.

3.3 DESIGN COMPUTATIONS.

3.4 THE PROPOSED WASTWATER COLLECTION .

3.5 PROFILES OF SEWER.

CHAPTER THREE
ANALYSIS AND DESIGN

3.1 Introduction

In this project, an attempt is made to evaluate and design wastewater collection system for Bait Kahil 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 system established is presented.

3.2 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 Bait Kahil 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 Bait Kahil, the lowest point is in the west part of the village.
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 Bait Kahil is illustrated in Figure A0.

3.3 Design Computations

3.3.1 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 upstream areas the next pipe in series, subject to the appropriate design constrains. The design computations and procedures for Bait Kahil sanitary sewers are illustrated in the design example given below. The design calculations necessary for Bait Kahil sanitary sewers are performed using SewerCAD Vs5 software. This computer program is develop by the Haestad Methods, Inc. More detailed about this program is given below.

3.3.2 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.

3.3.3 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.

3.3.4 Design example: Design a gravity flow sanitary sewer

Design a gravity flow trunk sanitary sewer for the (main line) shown in Figure (A-0). 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 3.6%
3. For water consumption uses100 l/c.d, for the current use and 150 l/c.d, for the future use. The wastewater calculates as 80% of the water consumption.
4. For infiltration allowance use 10% of the domestic sewerage flow.
5. Peaking factor depending on the formula :

$$Pf = 1.5 + (2.5/\sqrt{q}). \tag{2.3}$$

6. For the hydraulic design equation use the Manning equation with a value of 0.011.
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.

3.3.2 Solution

1. Lay out the trunk sewer. Draw a line to represent the proposed sewer (Figure A-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 40 to 60 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 (A-a) and (A-b). The data in the table are calculated as follow:
   a. The entries in columns 1 the section line numbers.
   b. The entries in columns 2 the sewer name.
   c. The entries in columns 3 through 5 are used to identify the sewer manholes, their numbers and the spacing between each two manholes.

d. 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.

e. The Future population (year 2032) including population density, incremental population, and cumulative total population are entered in (columns 8 and 9) respectively. The population density (person/ha) is obtained by determine the number of population on the all area. The incremental population (column 8) is obtained by multiplying population density by (column 6).(Column 9) show the cumulative total population by adding (column 8) to the last figure of(column 9).

f. To calculate cumulative peak design flow (columns 10, 11, and 12) are used. (Column 10) is obtained by multiplying future wastewater production (80% * 150 l/c.d.) with the future incremental population (column 8) then dividing by (24 hours *60 minutes*60 seconds). The peak factor (column 11) is calculated using equation 2.3 as: $P_f = 1.5 + 2.5/\sqrt{q}$, where q = Average Domestic sewage flow (Column 10). (Column 12)represents the Maximum Domestic (Q) in (l/s), the value of it is obtained from multiplying (column 10) by (column 11). (Column 15) gives the infiltration allowance, which equal 0.01 * (Column 10).

g. The entries in (columns 16) (total average flow rate) is calculated by sum the (Column 15) and (Column 10).

h. The entries in (columns 17) (total maximum flow rate) is calculated by sum the (Column 10) and (Column 12).

i. The entries in (columns 18) maximum flow rate in each manhole .

j. The necessary layout data for the sewer (columns 19 through 20) are obtained as follows: The number of manhole and The ground surface elevations at the manhole locations entered in columns 19 and 20. (The ground slope obtained by subtracting downstream elevation from upstream elevation and dividing the result by sewer length).

k. Sanitary Sewer design information is summarized in columns 21 through 34. The slope of sewer (column 28) is depending on the values of the slope of the ground (taking the value of ground slope 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. (2) calculate the ratio Q_p/Q_{full}, where Q_p is the total maximum flow rate l/s , 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 ≤ 0.5. The last values of pipe diameter and full capacity of selected pipe obtained are given in columns 30 and 31.

l. 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 Vp/Vfull 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 then use the tables to find Vp/Vfull ratio, where V_p here represent the minimum velocity and calculate the minimum velocity by multiplying Vp/Vfull with full velocity. The data of minimum velocities are given in (column 32).

The final design of this trunk sanitary sewer is shown in Figures of (A-1 to A-10). The lengths and diameters of the pipes along with the manholes are shown in this figure.

3.4 The Proposed Wastewater Collection System

In the proposed study for the wastewater collection system for Bait Kahil, the trial is made to design the main trunks of the collection system for year 2032. This section deals with the results of the suggested wastewater collection network for year 2032.

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 of Appendix-A 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.

It is observed form the tables and figures that the collection network covers most of the area , 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**.**

3.5 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 of Appendix-B . 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 FOUR

BILL OF QUANTITY

CHAPTER FOUR

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	**9802**		
1.1.2	Ditto, but for excavations between 2.00-2.50m	L.m	**974**		
1.1.3	Ditto, but for excavations between 2.50-3.00m	L.m	**1471**		
1.1.4	Ditto, but for excavations more than 4 m .	L.m	**640**		
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	**2304**		
1.2.2	Ditto, but for excavations between 2.00-2.50m	L.m	**733**		
1.2.3	Ditto, but for excavations between 2.50-3.00m	L.m	**711**		
1.2.4	Ditto, but for excavations more than 4 m	L.m	**311**		
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	**1214**		
1.3.2	Ditto, but for excavations between 2.00-2.50m	L.m	**225**		
1.3.3	Ditto, but for excavations between 2.50-3.00m	L.m	**166**		
1.3.4	Ditto, but for excavations more than 4 m	L.m	**40**		

2– Pipes

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
2	**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	**12887**		
2.2	Ditto, but for pipes diameter **300mm(u PVC)**	L.m			
2.3	Ditto, but for pipes diameter **250mm(u PVC)**	L.m	**4060**		
2.4	Ditto, but for pipes diameter **200mm(u PVC)**	L.m	**1644**		

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.	NO.	**334**		
3.2	Ditto, but depth between 2.00-2.50m	NO.	**49**		
3.3	Ditto, but depth between 2.50-4m	NO.	**55**		
3.4	Ditto, but depth more than 4 m .	NO.	**48**		

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	**12887**		
4.2	Ditto, but for pipe diameter **300mm**	L.m	**4060**		
4.3	Ditto, but for pipe diameter **250mm**	L.m	**1644**		

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	40		

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	**12887**		
6.1.2	Nominal bore 300mm	L.m	**4070**		
6.1.3	Nominal bore 250mm	L.m	**1644**		
6.1.4	Nominal bore 200mm	L.m	**486**		

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	**11130**		

Summary Table (for the project)

1	**Excavations and backfilling**	**18591**
2	**Pipes**	**18591**
3	**Concrete manholes**	**486**
4	**Pipe bedding**	**18591**
5	**Concrete works**	**40**
6	**Air leakage test**	**18591+486**
7	**Road reinstatement**	**11130**
	Construction of Dura sewage network Total	

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

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

CHAPTER FOUR

CONCLUSION

CHAPTER FIVE
CONCLUSIONS

The trial is made to evaluate and design wastewater collection system for Bait Kahil 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 at now from the present study are summarized below:

1. Bait Kahil village like other village in the west bank 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 ratio of population growth is taken as 3.6%.the population of Bait Kahil in 2032 is16947 persons.
3. Restrictions on the West Bank led to limited quantity of water supplied to the village and due to this condition the average consumption of water in the town in general is low (100 l/c.d) and does not represent the present actual demand of water. The future water consumption is estimated to be 150l/c.
4. As a result of the long period of occupation, the village lacks well studies and prepared master plan for land use ,Village planning, and the design of utilities.
5. 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.
6. The must flow in the proposed wastewater collection system is going by gravity (gravity flow sanitary sewer system).

7. In the design of the wastewater collection system, the slope of sewers followed the slope of the ground to decrease the cost of construction the sewers, and due to this condition many drop manholes are seen in the sewer profiles.
8. The depths of all sewer pipes in the collection system are kept 1.5 m below in the base of ground floor just to minimize the cost of excavation.
9. 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.

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APPENDIX-A :CALCULATIONS TABLES

APPENDIX-B :LAYOUT AND PROFILES