Palestine Polytechnic University

College of Engineering & Technology
Civil & Architecture Engineering Department

Graduation Project

Analyses And Design Of Water Distribution
Network For Beit Kahel Village

Project Team

Rafeq AL-masre   Farhan AL-asafrah

Project Supervisors

Dr. Majed Abu Sharkh

Eng. Imad AL-zeer

Hebron – Palestine

June, 2004

Palestine Polytechnic University

College of Engineering and Technology

Civil and Architectural Engineering Department

Graduation Project

Analyses And Design Of Water Distribution Network For Beit Kahel Village

Project Team

Rafeq AL-masre Farhan AL-asafrah

This project is submitted to the Civil and Architectural Engineering Department in the college of engineering and technology, for partial fulfillment of requirements for the degree of Bachelor in **Building Engineering**

Project Supervisors

Dr. Majed Abu Sharkh Eng. Imad AL-zeer

Hebron – Palestine

June, 2004

CERTIFICATION

Palestine Polytechnic University

(PPU)

Hebron-Palestine

The Senior Project Entitled:

"ANALYSIS AND DESGIN OF WATER DISTRIBUTION NETWORK FOR BEIT KAHELVILLAGE"

Prepared by:

RAFEQ AL-MASRE FARHAN AL-ASAFRAH

In accordance with the recommendation 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 Engineering.

Project Supervisors **Department Chairman**

June, 2004

إهداء

إلى روح أبي الغالي رحمه الله

إلى نبع الحنان أمي الغالية رفيقة دربي في ليالي السهر الطوال

إلى إخوتي أمل المستقبل ومثال كل الرجال

إلى أخواتي مشاعل النور ومربيات الأجيال

إلى أصدقائي شركائي في درب الآمال

إلى معلمي منارة طريقي ومن كان لي خير مثال

إلى شهداء الوطن الاجلال وأسرى الحرية الأبطال

إليهم جميعاً نهدي هذا العمل

الباحثان

رفيق المصري

برحان العصافرة

ACKNOWLEDGEMENT

We wish to express our deep and sincere thanks and gratitude to Eng. Imad AL-Zeer and Dr. Majed Abu Sharkh for him valuable helps, encouragement, guidance and supervision in solving the problems that we faced during this study. Our sincere thanks are also to Eng.Kamal Ghatash, Eng. Ghade Zakarna and Beit Kahel Municipality for there help in obtaining the necessary data and information to design the water distribution network for Beit Kahel villige .

We are also wish to record our appreciation of the assistance rendered by the Department of Civil and Architectural Engineering, College of Engineering and Technology, Palestine Polytechnic University.

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

Work Team

ABSTRACT

ANALYSIS AND DESIGN OF WATER DISTRIBUTION NETWORK FOR BEIT KAHEL VILLAGE

By

RAFEQ AL-MASRE FARHAN AL-ASAFRAH

Palestine Polytechnic University

Supervisor : Dr. Majed Abu Sharkh
Eng. Imad alzeer

Beit Kahel village is located in Hebron district in the West Bank- Water shortage, water demand in the village are increasing from year to year due to increase in the population. At the same time, the existing water distibution network is insufficient to meet the water demand because beside the limited quantities of water supplid , many of the pipelines are old , for the same reason, the supply of water is rationed by ration in view of this situation , it is necessary to study and evaluate the existing water supply system , and propose a new network for the next (25) years , that meet the water demand and provid the people in the Beit Kahel village (24) hours water supply , and this is the interest of this project .

This project is conducted to study the water distribution network for the Beit Kahel village cooresponding to the water demand in the near future and a ccordance with a hight population growth , and considerable increas in per capita water requirements.

The calculations necessary for the network design are performed by the EPANET computer software that make use of Hardy Cross methods.

This existing water distribution network can not provides the village of Beit Kahel with adequate good water supply system , The proposed network is meet with the required velocities in the pipes and pressures in the nodes until to the year 2028.

TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

1.2 THE PROBLEM

1.3 OBJECTIVES

1.4 METHEDOLOGY

1.5 ORGANIZATION OF THE REPORT

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Water is one of the most valuable natural resources in Palestine , Therefore, it is very crucial for the Palestinians to achieve proper planning and management to their water resources to ensure proper usage of their water in the different sectors (domestic , agricultural , industrial,etc…), Moreever , many of palestinian localities still lack the existence of water networks while many others sufferfrom the poor conditions and high losses in their networks.

Palestine suffers from water scarcity due to its arid and semi – arid climatic conditions rainfall variability , and the abnormal political situation resulting israels complete control over all natural resources in palestine .

The dispute over shared water resources , between palestinian authority and Isreali icupation has adversely affected the development of water resources, the present problems that are related to water in the west bank are many and varied , and the disparity between water supply and demand is growing with time due to rapid population grouth , which leads to asevere deficit of the water balance.

Beit Kahel avillage is located in the west north of the Hebron City. It is a hilly area with an average height of 850 m with respect to sea level . The temperature is relatively high in summer (20-30 ^{0}C) and winter temperature is low.

The average rainfall is around 400 mm and the present population is around 6000 with annual population growth of around 4 – 5%.(Palestinion Bureau of Statisttics,1999).

Beit Kahel is one of the village in hebron city in the West Bank- water shortage, water demand in the village is increasing from year to year due to increase in the population. At the same time, in this village a small water tank supplies very little amount of water ،and the people in this village are depending on the drain water that they are collected in wells .

The amount of water supplies to the village is very little and the existing water supply network is very old and does not satisfy the need of water. The lost of water in the distribution system is high comparing to the water supplied. Also, the municipality faces some difficulties in offering good water services that delay any improvement in the existing water supply network.

In view of this condition, the need for water supply system that will supply adequate amounts of water has become pressing and subsequently, this study was conducted to assess the water supply system for Beit Kahel village and the problems in this area.

1.2 THE PROBLEM

Water is indispensable to human life and is also a vital necessity of plant and animal life. The wide expansion and rapid increase of population of Beit Kahel village had led to an increase in amount of water consumption for domestic, public, irrigation and industrial water uses.

Beit Kahel faces great difficulties and different problems in water supply and water services due to population growth. Hence, the amount of water supplied to the village is very little and the existing water supply network is very old and does not satisfy the needs of water. A mentioned earlier, the Beit Kahel municipality faces some difficulties in offering good water services that delay any improvement in the existing water supply network.
At present, the existing water supply system for Beit Kahel village is almost entirely provided by Palestinian Water Authority. The water in the village is distributed directly by a network of steel pipelines, most of them are very old and exposed to the traffic. The pipelines diameters range from 1" to 3" and many are in bad state of repair, and there is ahigh quantity of water is lost .

In view of this bad condition, it is very necessary to develop future plans for water supply corresponding to water demand in the near future in accordance with high population growth and considerable increase in per capita water requirements. This study will be based on the present population of 6000 census with an annual population growth around 4 - 5%. These plans should be capable of supplying water required to the entire areas of the village. (Palestinion Bureau of Statisttics,1999).

1.3 OBJECTIVES

The overall objective of this project is to produce feasible planning scheme for the water supply of Beit Kahel village. Achievement of this objective requires the water resources potential of the village, estimation the village population, water requirements for different purposes, location of the water source and topography of the village. It also requires evaluation of the existing water distribution network. More specifically the main objectives of this project may be classified as follows:

1. Developing and make contour planing by used avertical photograph of the village, and estimate of the coordinates and elevationes of the village by using GIS software.
2. Study and evaluation of the existing water network in Beit Kahel village , and display the difficulties , which the municipality faces in order to develop and improve the existing water mains .
3. Estimating the daily amount of water required per capita for all purposes up to the planning horizon of 2028 taking into consideration the present and future population .
4. Investigation and discussion of the appropriate changes in the existing mains and presentation of the proposed water supply network , which meet the present and future water demand for all purposes and provide 24 hour water supply .
5. Development of several plans for the construction of the proposed water supply scheme and prepare bill of quantities.
6. Providing suggestions and recommendations regarding with Beit Kahel village water supply .

1.4 METHEDOLOGY

The main tasks, which had been under taken in order to develop this project, were as follows:

1. Make some visits to the Beit Kahel municipality to discuss the problems that the existing water network faces, knowing the complaints which the consumers reports, and data collection
2. Obtaining map on the existing water network from the municipality along with the detail Aerial photogrammetric map consists of contour lines, roads, and houses, and its elevations.
3. Collection of previous statistically studies concerning the population distribution and describes it in zones in order to determine the population forecasts for Beit Kahel village.
4. Estimate the water demand for the village up to the design period of 2028 taking into consideration the present and future population , and the future water sources.
5. Setup the existing water network with all branches on the Aerial photogrammetric map to review and assessment of the existing situation.
6. Filling up all the necessary data (demand, elevation, nodes, and coordinate) to the Epanet computer programe for the analysis and design of the network.
7. Design a new pipelines network for 25 years toward with all requirements.
8. Prepare bill of quantities for proposed new water distribution network.
9. Evaluating the conditions , size and the position of present reservoirs.
10. Preparation of the report. (Peary,1985)

1.5 ORGANIZATION OF THE REPORT

The subject matter of the project is presented in nine chapters. The first chapter entitled “Introduction” outlines the background , problem, objectives, methedology and organization of the report. The second chapter entitled “Basic Data of Beit Kahel village” describes the project area, physical features (topography and climate) demographic features, the economical and agricultural activities, infrastructure , the and the fundemental proplems in the village.

The third chapter entitled “Water Distribution Systems” deals with methods of water distribution , layouts of distribution networks, pipe lines and its kinde , pipe fittings, service reservoirs pumps and pumping, and excavation and backingfill. chapter four , entitled the network model , describes what is epanet , how to modeling pipes , pumps, and valves , and show what is minor losses , time patern , flow in pipe systems ,and the network design steps

Chapter five entitled “Design and Planing Criteria” describes population and population forecast, forecast water demand , pipe hydraulics ,reservoirs, and valves.

The sixth chapter on “Analysis and Discussion of Results” is devoted to the analysis and discussion of results, and development of future plans and appropriate technology for reconstruction and upgrading of the existing water network in Beit Kahel village. The Bill of Quantities are given in chapter seven and the overall Conclusions recomendation are given in chapter eight.

CHAPTER TWO

BASIC DATA OF BEIT KAHELVILLAGE

2.1 GENERAL INTRODUCTION

2.2 PHYSICAL FEATURES

2.3 DEMOGRAPHIC FEATURES

2.4 THE ECONOMICAL AND AGRICULTURAL ACTIVITIES

2.5 INFRASTRUCTURE

2.6 THE FUNDEMENTAL PROBLEMS IN THE VILLAGE

CHAPTER TWO

BASIC DATA OF BEIT KAHEL VILLAGE

2.1 GENERAL INTRODUCTION

Beit Kahel is one of the most ancient village in the Hebron district. In this chapter, the physical features of the village including location, topography and climate are described. The economical and agricultural activities will be reviewed, Infrastructure the importante places in the village , and the fundamental problems in the village

2.2 PHYSICAL FEATURES

A summary of physical features of the project area based on available data is presnted below.

2.2.1 Location

Beit Kahel is located in the west north of Hebron City, on the local line north side 108.61(m) and eventual local line from the east 156.86(m), It elevates 850(m) above sea level and keeps away 4 km from Hebron city and its whole area 5795 dounm , the building area is 863 dounm , it is surrounded by Bait Aula , Halhoul, Hebron ,and tarqumia lands .as shown in the figure (2.1) (Palestinion Bureau of Statisttics,1999)

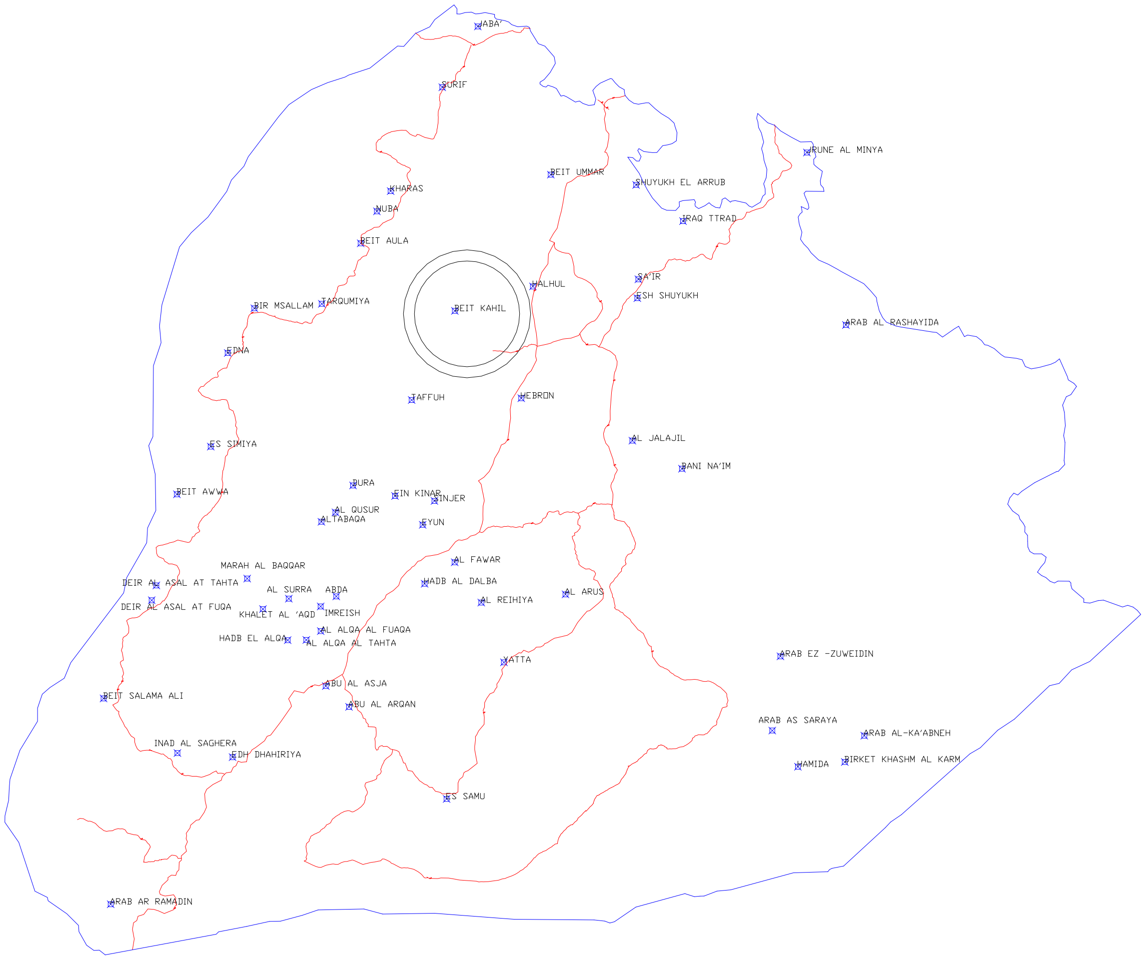


FIG. 2.1 - Location Map of Beit Kahel

2.2.2 Topography

The topography of Beit Kahel village can be divided into three parts :

- Northen slopes.
- Mountain crests.
- Southern slopes.

Acontourmap based on the created digital elevation model was constructed with contour intervalsof (1m).

Elevation ranges on average between (767 and 982) meters above sea level , the highest point in Beit Kahel village is(982m) above sea level and the lowest elevation is (767m) above sea level.

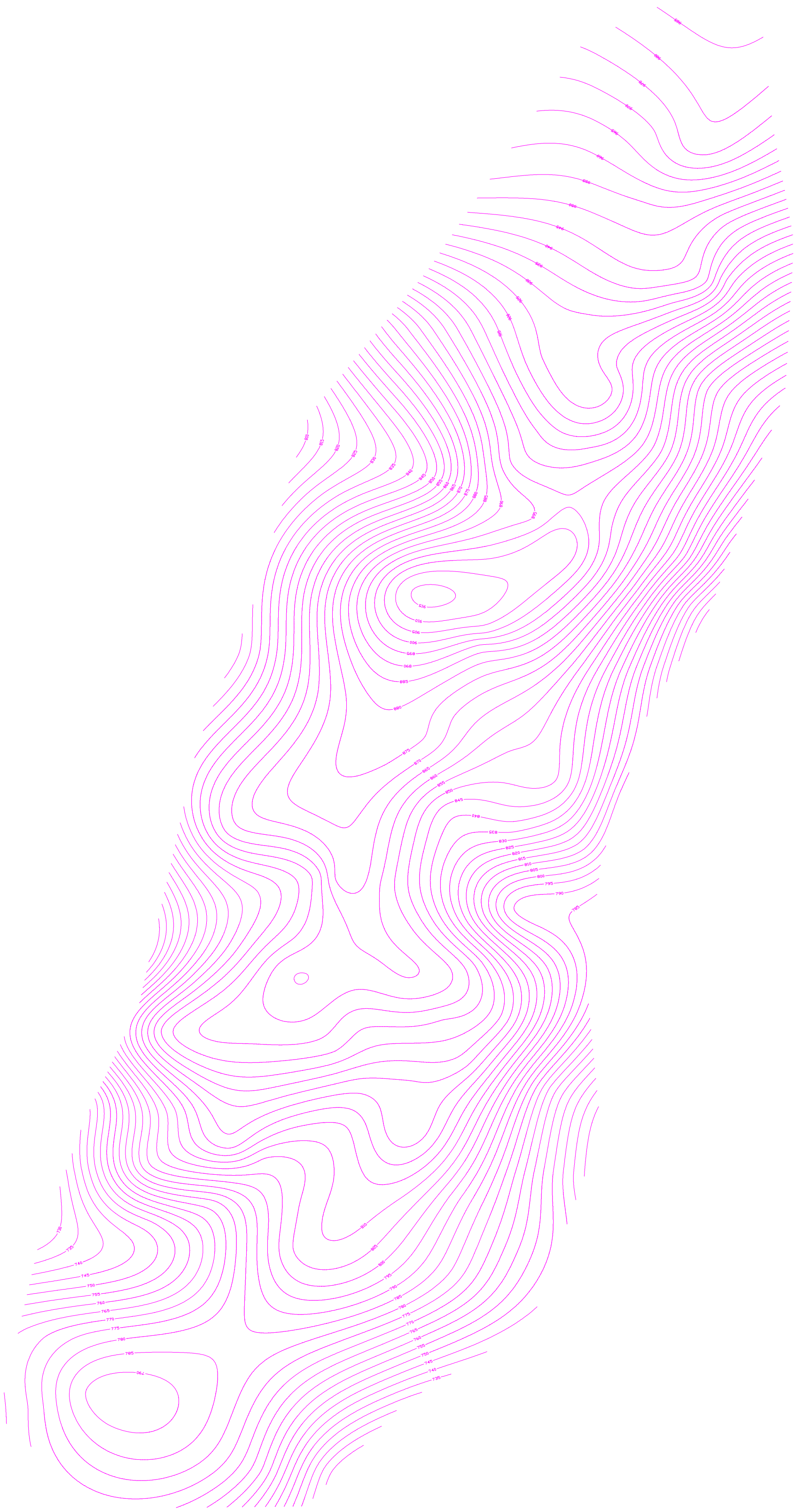


FIG. 2.2 – Topographic Map of Beit Kahel

2.2.3 Climate

The climate in Beit Kahel area ranges from arid to semi-arid. The monthly average temperature range from 6-13 ^{o}C in winter to 17-30 ^{o}C in summer. The mean annual rainfall for the last five years was approximately 400 mm, of which about 98 percent falls between October and April. The average monthly evaporation is 250 mm/month in summer, and 100 mm/month in winter. The relative humidity in Beit Kahel village ranged from 20-80%, it reached the maximum value in February (Palestinion Bureau of Statisttics,1999),

2.3 DEMOGRAPHIC FEATURES

This village considers a countryside according to the classification of the villages kind and which is mentioned at the central system of the Palestinian statistic. The number of this village interms of residents builings, and houses 4214 members according to the statistics 2176 from them are males , and 2083 are females , and the families were about 553 as the buildings are 586 buildings , the residential areas are 681dounm. it is amanged by acouncel , this is established and formed by nomination by the local govermevt union , (council) . it is consisted of 9 members , the area of this councel raises to 70m^2 .it is applied by 7 employers for the part of the developmental needs to the local authority is to serve computers . And we will veiw table the present and future population, and the figure explain the relation between years and growth rate. (Palestinion Bureau of Statisttics,1999),

2.4 THE ECONOMICAL AND AGRICULTURAL ACTIVITIES

The economical buildings who are working in this sector abauot 22 buildings (1997) they are distributed according to the economical activity as follows , the changeable industries , which are 15 workers who are working in this buildings , the whole sale and mending gear cars and bikes , as well as restaurants , which are 20 places they are managed by 38 workers as well as there is in it 35 farms for birds and animals ,and this village has two underground water springs .

Agriculture sector is on of the important sources of income in the area. Beit Kahel main product tomatoes , wheat , green beans , graps , and olives . There is a good opportunity for Beit Kahel villagers to exploit a huge green area in agriculture , but the insufficient support from the intersted parties as well as the insufficient income from agricalture made many of villagers to abandon farming and cultivation and to work as labour force inside the Green Line where they can get more income . (Palestinion Bureau of Statisttics,1999),

2.5 INFRASTRUCTURE

Beit Kahel has adistribution water network, the participants of its net works 600 participants in the residential sector , the village also has a general electricity net , the Israeli diagonal company forms , the main resourse for the accumulation except ther is no sewage networks , and waste water is extracted by absorbed holes , and it is left from it by sending it to vallies which is far 10 km .

And the tractor is used in accumulating the trash so it is the gathered two times weekly , it is exctracted by gathering it and burning it , the village also has telephone net works through mechanic disk , the telephone lines are abaut 200 lines according to 1999 statistics .

2.6 THE FUNDEMENTAL PROBLEMS IN THE VILLAGE

Beit Kahel endures some problems obstacles the agricultural production ,it ends from utilizing the lands which are suitable for planting , which is a shortage in money and water resources , and grass yards , in addition to the scarcely of agricultural guidance besides , there are many problems in marketing of the productions , also the village endures from the side electricity and drinking water , in which the weakness of electric current , in addition to the ancient for both electricity and water distribution network , also there are some regions are unserved with both electric and water nets . so the use of extracting from drained water and trashes near the village produce bad healthy effects lead to this location to pollute the deep water and plants , it forms a source for bad smells and diseases and a place to grow insects .

CHAPTER THREE

WATER DISTRIBUTION SYSTEMS

3.1 INTRODUCTION

3.2 METHODS OF DISTRIBUTION

3.3 LAYOUTS OF DISTRIBUTION NETWORKS

3.4 PIPE LINES

3.5 PIPE FITTING

3.6 SERVICE RESERVOIRS

3.7 PUMPS

3.8 EXCAVATION AND BACKINGFILING

CHAPTER THREE

WATER DISTRIBUTION SYSTEMS

3.1 INTRODUCTION

To deliver water to individual consumers with appropriate quality, quantity. and pressure in a community setting requires an extensive system of pipes, storage reservoirs, pumps, and related appurtenances. The term distribution system is used to describe collectively the facilities used to supply water from its source to the point of usage.

3.2 METHODS OF DISTRIBUTION

Depending on the topographic relationship between the source of supply and the consumer, water can be transported by canals ,flumes, tunnels, and pipelines. Gravity, pumping, or a combination of both may be used to supply water to the consumers.

3.2.1 Gravity Distribution

This is possible when the source of supply is a lake or impounding reservoir at some elevation above the city so that sufficient pressure can be maintained in the mains for domestic and fire service ,this is the most reliable method if the conduit leading from source to city is aduqate in size and well safe guarded against accidental breaks , high pressure for fire fighting, however may be obtinable only by using the motor pumpers of the fire department.

3.2.2 Destribution by Means of Pumps With More or Less Storage

in this method the excess water pumped during period of low consumption is stored in elevated tanks or reservoirs during periods of high consumption the stored water is drawn upon to augment that pumped , this method allows fairly uniform rates of pumping and hence is economical , for the pumps may be operated at their rated capacity ,since the water stored furishes areserve to care for fire sand pump breakdown, this method of operation is fairly reliable ,motor pumpers must ordinarily be used for higher fire pressure although it is possible to close the valves leading to the elevated storage tank and operate afire pump at the pumping plant .

3.2.3 Use of Pumps Without Storage:

In this method the pumps force water directly into the mains With no other outlet than the water actually consumed. It is the least desirable system, for a power failure Would mean complete interruption in water supply. As consumption varies, the pressure in the mains is likely to fluctuate. To conform to the varying consumption several pumps are available to add water output when needed, a procedure requiring constant attendance. (Steel,1991).

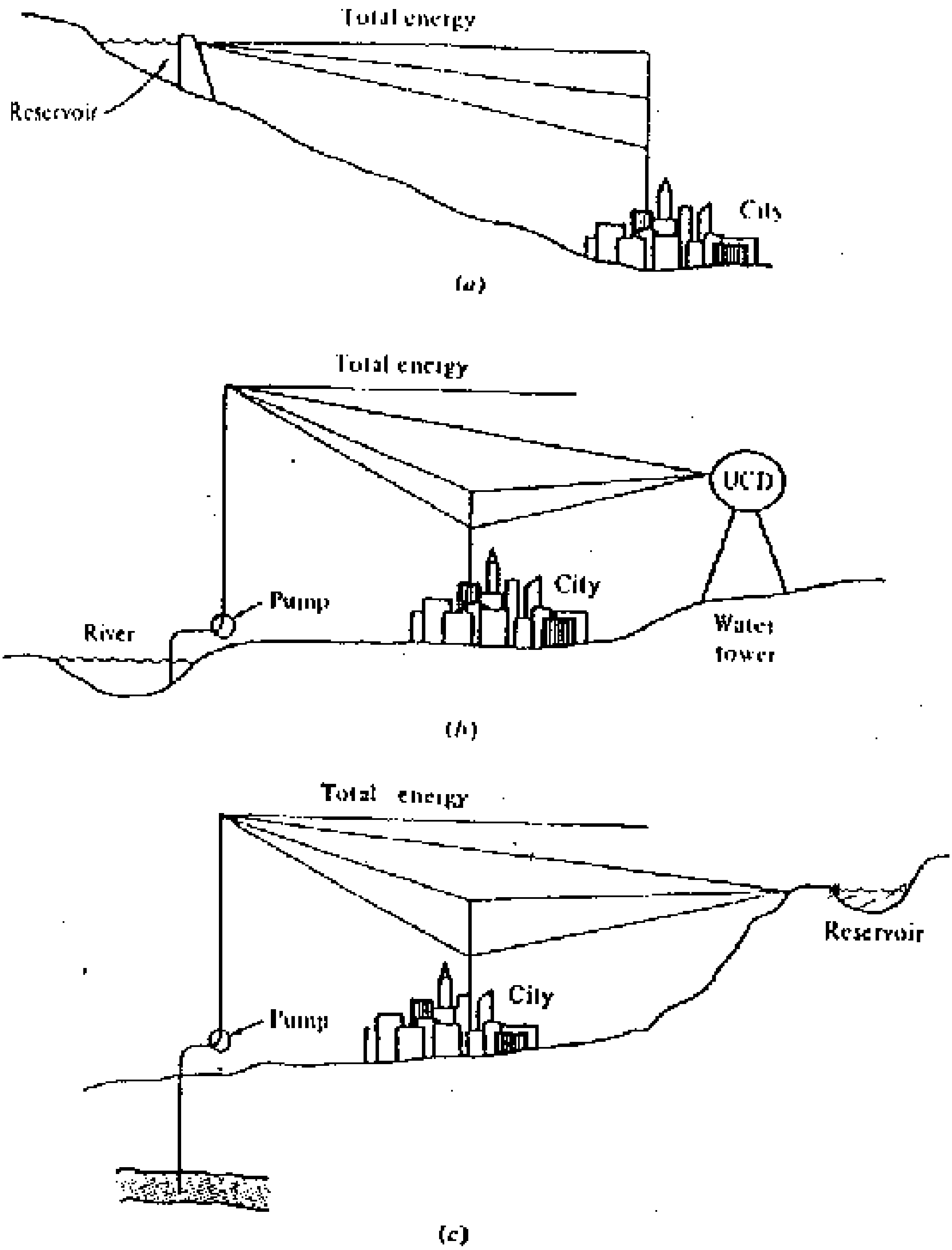


Figure (3.1) Method of Water Supply and Distribution

3.3 LAYOUTS OF DISTRIBUTION NETWORKS

3.3.1 General Introduction

As pointed out earlier, a network of pipes is used to distribute water to a community. There are, in general, four different types of pipe networks, any one of which either singly or in combinations, can be used for particular place, depending upon the location conditions and orientation of roads. These system are: dead end system, grid iron system, ring system, and radial system, The different types of distribution networks are described below.

3.3.2 Dead-end System

In the dead end system, which is also sometimes called tree system, there is one main supply pipe, from which originates a number of sub-main pipes. Each sub-main, then divided into several branch pipes, called laterals. From the laterals, service connections are given to the consumers. A typical of such a network is shown in Fig. (3.2a).

Branching pattern with dead-ends is very simple method of water distribution, the design of such a pipe network is simple, and the required dimensions of the pipes are economical. But this system has the disadvantage of sediments accumulate due to stagnation of the dead end, the area receiving water from a pipe under repair is without water until the work is completed, and insufficient water pressure may occur when additional areas are connected to the water supply system (Garg, 1998).

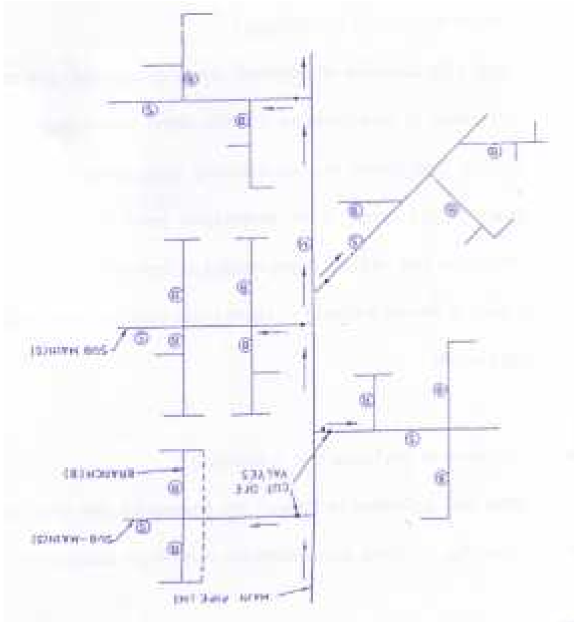


Fig (3.2 a) Dead-End Systems

3.3.3 Grid-iron System

In this system, the mains, sub-mains and branches are all inter-connected with each other, as shown in Fig (3.2.b), Water can reach any point from more than one direction. The advantages of this system are, water in the supply system is free to flow in more than one direction and stagnation does not occur, in case of repair or a break in a pipe the area connected to that pipe will continue to receive water, and there will be little adverse effect on the supply of water due to large variations in water consumption. The main disadvantages of this system are the calculation of pipe sizes is more complicated, and more pipe and fittings are required (Garg, 1998).

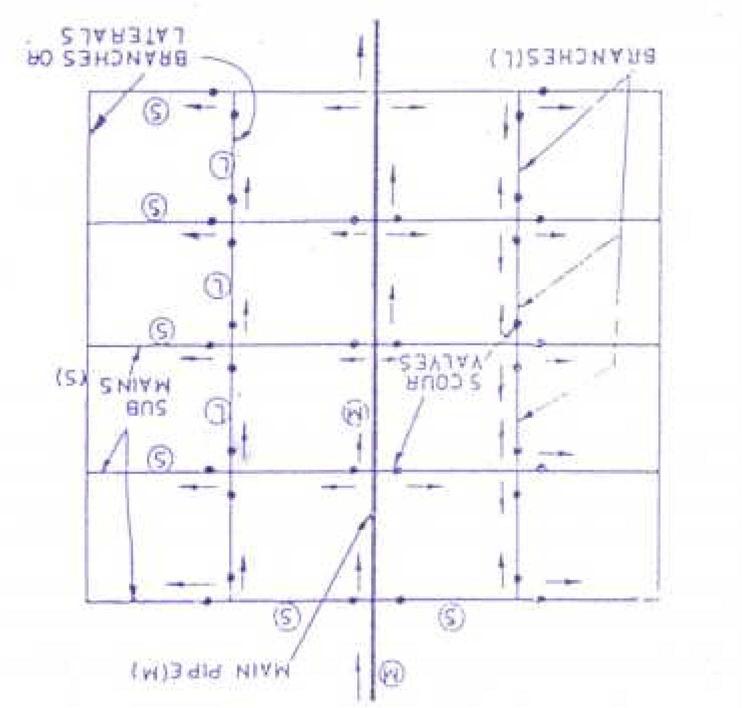


Fig (3.2b) Grid-Iron Systems

3.3.4 Ring System

This system is also sometimes called circular system. In this system, a closed ring, either circular or rectangular, of the main pipes is formed around the area to be served as shown in Fig (3.2c), The distribution area is divided into rectangular or circular blocks, and the main water pipes are laid on the periphery of these blocks.

The sub- mains may be placed as shown. The advantages and disadvantages of this system are the same as that of the grid iron system.

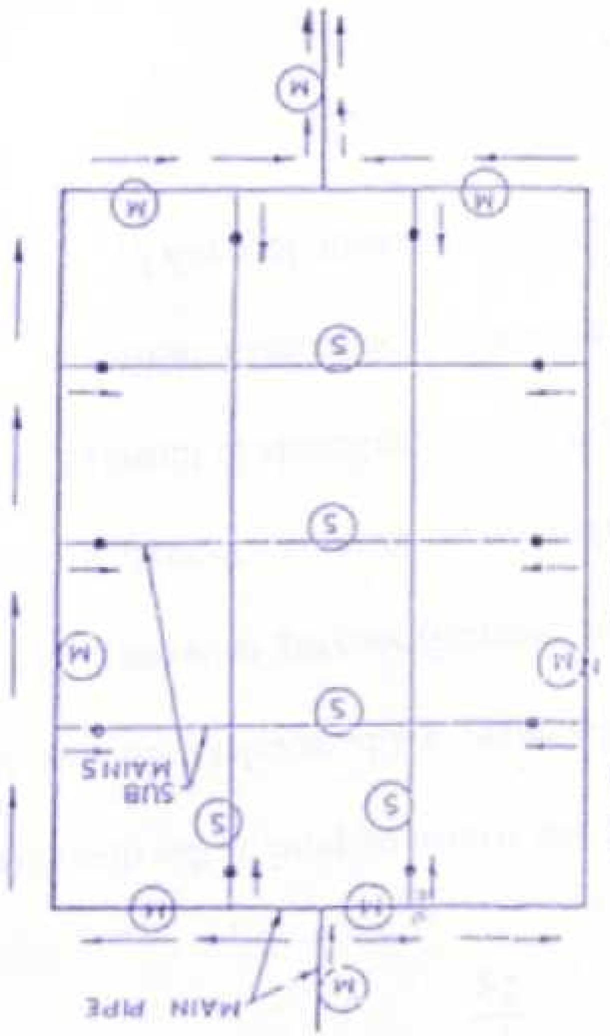


Fig (3.2c) Ring Systems

3.3.5 Radial System

If a city or town is having a system of radial roads emerging from different centers, the pipelines can be best laid in a radial method by placing the distribution reservoirs at these centers. In this system, water, is therefore, taken from the water mains, and pumped into the distribution reservoirs placed at different centers, as

shown in Fig (4.1d). The water is then supplied through radial laid distribution pipes. This method ensures high pressures and efficient water distribution. The calculations for design of sizes are also simple (Garg,1998).

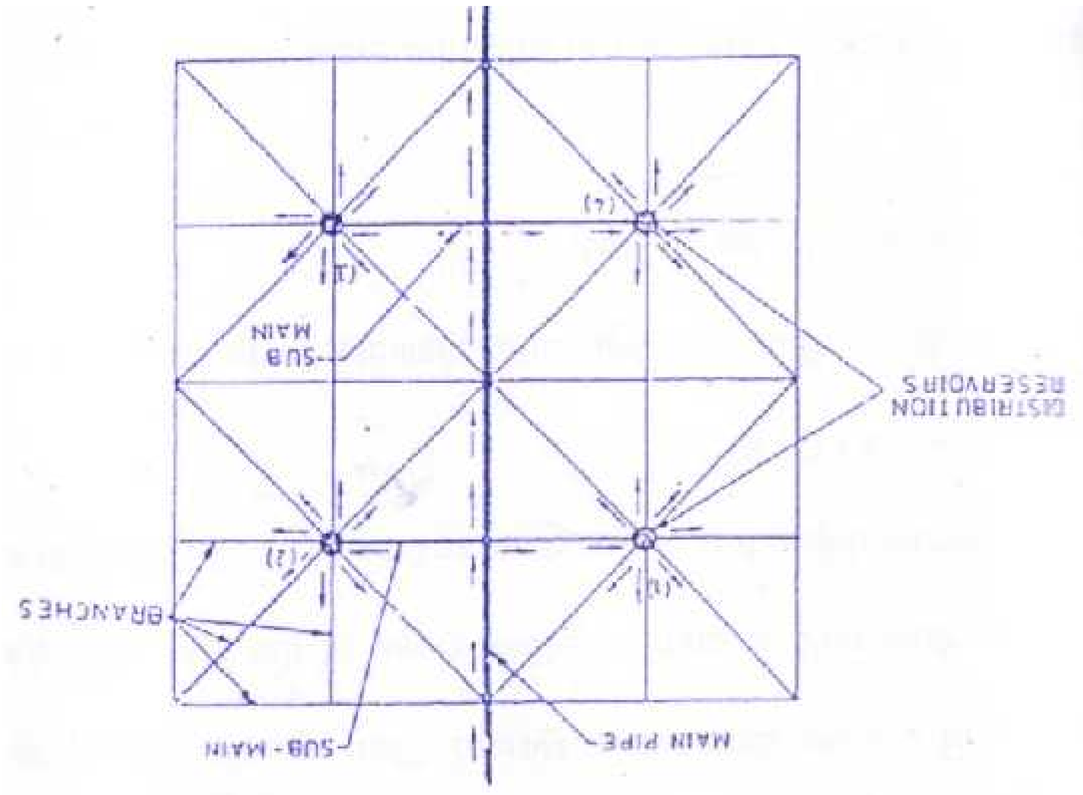


Fig (3.2d) Radial Systems

3.4 PIPE LINES

Pipelines can be categorized in different ways. In what follows, pipelines will be categorized according to the commodity transported and the type of fluid flow. Water Pipelines are used universally to bring water from treatment plants to individual households or buildings. They form an underground network of pipe beneath cities and streets. Water pipelines are usually laid a few feet (one meter or more) underground, depending on the frost line of the location and the need for protection against accidental damage by digging or construction activities.

In modern water engineering, while copper tubing is commonly used for indoor plumbing, large-diameter outdoor high-pressure water mains (trunk lines) may use steel, ductile-iron, or concrete pressure pipes. Smaller-diameter lines (branch lines) may use steel, ductile-iron, or PVC pipes. When metal pipes are used to carry drinking water, the interior of the pipe often has a plastic or cement lining to prevent rusting, which may lead to a deterioration in water quality. The exteriors of metal pipes also are coated with an asphalt product and wrapped with special tape to reduce corrosion due to contact with certain soils. In addition, direct-current electrodes are often placed along steel pipelines in what is called cathodic protection. (Britannica , 2001)

3.4.1 Pipe Materials

Distribution pipes are made of asbestos cement, cast iron, ductile iron, plastic, reinforced concrete, or steel. Although not as strong as iron, asbestos cement, because of its corrosion resistance and ease of installation, is a desirable material for secondary feeders up to 16 inches (41 cm) in diameter. Pipe sections are easily joined with a coupling sleeve and rubber-ring gasket. Cast iron has an excellent record of service, with many installations still functioning after 100 years. Ductile iron, a stronger and more elastic type of cast iron, is used in newer installations. Iron pipes are provided in diameters up to 48 inches (122 cm) and are usually coated to prevent corrosion. Underground sections are connected with bell-and-spigot joints, the spigot end of one pipe section being pushed into the bell end of an adjacent section. (Britannica , 2001)

A rubber-ring gasket in the bell end is compressed when the two sections are joined, creating a watertight, flexible connection. Flanged and bolted joints are used for aboveground installations.

The use of plastic pipes is increasing. Available in diameters up to (24) inches (61 cm), they are lightweight and easily installed. They are also corrosion-resistant, and their smoothness provides good hydraulic characteristics. Plastic pipes are connected either by a bell-and-spigot compression-type joint or by threaded screw couplings.

Precast reinforced concrete pipe sections up to (12) feet (366 cm) in diameter are used for arterial mains. Reinforced concrete pipes are strong and durable. They are joined using a bell-and-spigot-type connection that is sealed with cement mortar. Steel pipe is sometimes used for arterial mains in aboveground installations. It is very strong and lighter than concrete pipe, but it must be protected against corrosion by lining the interior and by painting and wrapping the exterior. Sections of steel pipe are joined by welding or with mechanical coupling devices. (Britannica , 2001)

3.4.2 Type of Pipes

The pipe is a circular closed conduit, used for conveying water from a point to another one, under gravity or under pressure. The pipes are generally classified into three categories of usage:

(a) Mains: A large pipes which go through the main streets in cities or towns and used to convey water to other pipes (sub-mains) in the network, or from one reservoir to another.

(b) Sub-mains: Smaller pipes connected to mains and supplies water to service pipes.

(c) Service pipes: The pipes which supply water to consumers, houses, flats, and farms and connect to mains and sub-main pipes.

(d) Plumping pipes: Pipes work within a building for the distribution of water of various appliances . (Steel,1991)

3.5 PIPE FITTING

In order to function properly, a water distribution system requires several types of fittings, including hydrants, shut-off valves, and other appurtenances. The main purpose of hydrants is to provide water for fire fighting. They also are used for flushing water mains, pressure testing, water sampling, and washing debris off public streets. (Britannica , 2001)

3.5.1 Valves

Many types of valves are used to control the quantity and direction of water flow. Gate valves are usually installed throughout the pipe network. They allow sections to be shut off and isolated during the repair of broken mains, pumps, or hydrants. A type of valve commonly used for throttling and controlling the rate of flow is the butterfly valve. Other valves used in water distribution systems include pressure-reducing valves, check valves, and air-release valves.

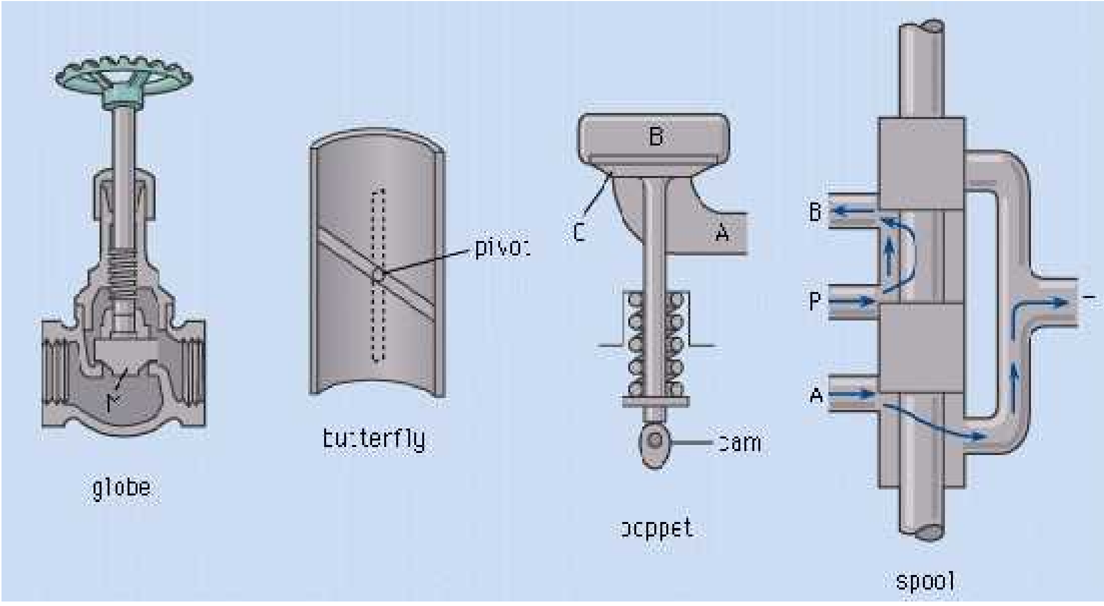
in mechanical engineering device for controlling the flow of fluids (liquids, gases, slurries in a pipe or other enclosure. Control is by means of a movable element that opens, shuts, or partially obstructs an opening in a passageway. Valves are of seven main types: globe, gate, needle, plug (cock), butterfly, poppet, and spool.

1. Globe Valve:

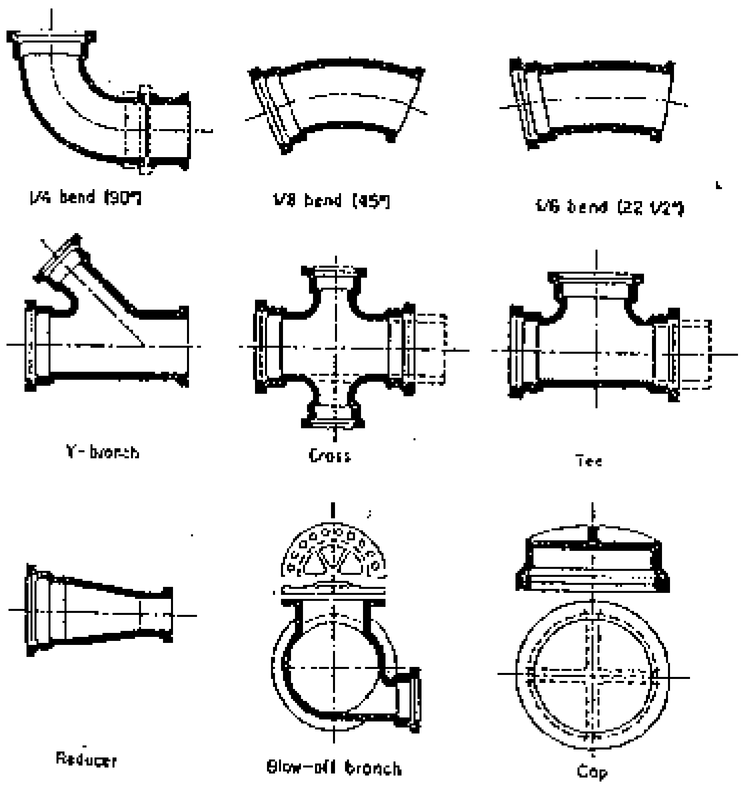
In the globe valve shown in the Figure (3.2 (a)), the movable element may be a tapered plug or a disk that fits a seat on the valve body; the disk may carry a replaceable rubber or leather washer, as in a household water faucet. In a gate valve, the movable element is a wedge-shaped disk that seats against two tapered faces in the valve body. A needle valve has a long tapered needle fitting in a tapered seat.

2. A plug Valve:

A plug valve, or cock, is a conical plug with a hole perpendicular to its axis fitting in a conical seat in the valve body at right angles to the pipe. By turning the plug the hole is either lined up with the pipe to permit flow or set at right angles to block the passage. (Britannica , 2001)



(a)



(b)

Figure (3.3) - (a) various types of valves (b) various pipe fitting

3. A Butterfly Valve

A butterfly valve is a circular disk pivoted along one diameter; the solid lines in the Figure (left centre), show one in the closed position. In the fully open position, shown dotted, the disk is parallel to the direction of flow. The damper in a stovepipe or a warm-air heating system is of this type, which is also used in the intake passage to carburetors on gasoline engines. On hydraulic turbines such valves may be (20) feet or more in diameter.

4. Nonreturn Valve :

Some valves operate automatically; check (or nonreturn) valves, for example, are self-acting and permit flow in one direction only. They are made in several types. If the movable element in the globe valve in the Figure(3.2.a) were kept on its seat by gravity or a spring, it would permit flow from left to right but not from right to left.

5. Safety Valves:

Safety valves which are usually of the poppet type, open at a predetermined pressure. The movable element may be kept on its seat by a weighted lever or a spring strong enough to hold the valve closed until the pressure is reached at which safe operation requires opening . (Britannica , 2001)

3.5.2 Hydrants

Fire hydrants are constructed in many different versions. They are generally distinguished as underground or ground installations. Under ground installations are better protected from frost and traffic damage, but on the other hand they can be covered by parked vehicle when being requested for use. Required capacity, pressure and distance for hydrants vary from case to case and they are related to the potential risks and consequences from fire. Generally, the capacities are within the range (30-500 m3/h), and the distance between (100-300 m) (UNDP,1990).

3.5.3 Water Meters

Every water networks should have some means at the pumping plant of accurately measuring all the water that is delivered to the city. If the meters are of the recording type, valuable information regarding hourly rates of consumption will be available. If all services are metered, the difference between the total amount pumped and the sum of service meter readings and any unmetered publicly used water will be the unaccounted-for water. (Peary ,1985)

Metering of services consists of placing a recording meter in the line leading from the water main to the building served , Consumers are then billed for the water that they use , The alternative to this method is charging by some form of flat rate which has no relation to the actual amount of water used or wasted. The advantages of metering are apparent , Pumping and treatment of water cost money, and wasting of water means a greater cost to be distributed among customers. If services are unmetered, the careful consumers bear some of the burden imposed by the careless and wasteful. It is almost impossible to construct a good system of water charges unless they are based upon actual consumption of water.

Lack of service meters has a definite effect upon water consumption. In fact, the installation of meters may so reduce consumption that provision of more water may be indefinitely postponed.

Metering all services of a city should reduce consumption to about (50) percent of the consumption without meters. Although metering reduces water consumption there is a tendency for consumption to increase gradually after all services are metered. (Peary ,1985)

3.5.4 Service Connections

Service connection link users within the distribution system. The standard set-up usually consists of: connection, pipe, outdoor and indoor stop valve and water meter. In newer installation, a non return valve may be added as well. (UNDP,1990).

3.6 SERVICE RESERVOIRS

Distribution storage tanks, familiar sights in many communities, serve two basic purposes: equalizing storage and emergency storage. Equalizing storage is the volume of water needed to satisfy peak hourly demands in the community. During the late night and early morning hours, when water demand is very low, high-lift pumps fill the tank. During the day, when the water demand is high, water flows out of the tank to help satisfy the peak hourly water needs. This allows for a uniform flow rate at the treatment plant and pumping station. The capacity of a distribution storage tank is about equal to the average daily water demand.

Elevated reservoirs are built at ground level on hilltops higher than the service area. In areas with flat topography, the tanks may be elevated above ground on towers in order to provide adequate water pressures, or ground-level reservoirs with booster pumping may be provided. (Garge,1998).

3.6.1 Types of Service Reservoirs

The service reservoirs may be made of steel, reinforcement cement concrete, or masonry. Depending upon their elevation with respect to the ground and local environmental conditions, storage reservoirs may be classified into the following two types:

1. Surface Reservoirs: Surface reservoirs are circular or rectangular tanks, constructed at ground level or below the ground level. They are generally constructed at high point in the city. In gravitational type of distribution system, water is stored in the ground service reservoir, and then directly sent from there into the distribution system.

2. Elevated Reservoirs: Elevated reservoirs are the rectangular, circular, or elliptical over head tank erected at a certain suitable elevation above the ground level and supported on the towers. They are constructed where the pressure requirements necessitate considerable elevation above the ground surface, and where the use of stand pipes becomes impracticable (Garge,1998).

3.6.2 Operating Storage of the Reservoirs

The total storage of a service reservoir is the summation of balancing storage (or equalizing or operating storage), breakdown storage, and fire storage. The main and primary function of a service reservoir is to meet the fluctuation in demand with a constant rate of water supply. The quantity of water required to be stored in the reservoir for balancing this variable demand against the constant supply is known as balancing storage or storage capacity of a reservoir. This balancing storage can be determined analytically or graphically. In the analytically solution method, the hourly excess of demand as well as the hourly excess of supply are worked out. The summation of maximum of the excess of demand and the maximum of excess of supply will give us the required storage capacity.

The breakdown storage or the emergency storage is the storage preserved in order to tide over the emergencies posed by the failure of pump, the electricity or any other mechanism driving the pump. The amount of breakdown storage is very difficult to assess. For this reason, a lump sum provision generally made for this storage. A value of about (25) percent of total storage capacity of the reservoir, or (2) times of the average hourly supply, may be considered as enough provision for accounting this storage, under all normal circumstances.

The third component of the total reservoir storage is the fire storage. In case of fires sufficient amount of water must remain available in the reservoir for throwing it over the fire. The total volume of water required for fire fighting is generally small, say of the order of (1) to (1.5) liters per day per person.

The total reservoir storage can finally obtained by adding all the three storage's, viz., balancing storage, emergency storage, and fire storage. (Garge , 1998)

3.7 PUMPS

Many kinds of pumps are used in distribution systems. Pumps that lift surface water and move it to a nearby treatment plant are called low-lift pumps. These move large volumes of water at relatively low discharge pressures. Pumps that discharge treated water into arterial mains are called high-lift pumps. These operate under higher pressures. Pumps that increase the pressure within the distribution system or raise water into an elevated storage tank are called booster pumps. Well pumps lift water from underground and discharge it directly into a distribution system. and the pumps may be classified into the following types :

3.7.1 Centrifugal

Most water distribution pumps are of the centrifugal type, in which a rapidly rotating impeller adds energy to the water and raises the pressure inside the pump casing.

The flow rate through a centrifugal pump depends on the pressure against which it operates. The higher the pressure, the lower the flow or discharge.

Centrifugal is device for moving liquids, The two major parts of the device are the impeller (a wheel with vanes) and the circular pump casing around it. In the most common type, called the volute centrifugal pump, fluid enters the pump at high speed near the centre of the rotating impeller and is thrown against the casing by the vanes. The centrifugal pressure forces the fluid through an opening in the casing.

This outlet widens progressively in a spiral fashion, which reduces the speed of the fluid and thereby increases pressure. Centrifugal pumps produce a continuous flow of fluid at high pressure; the pressure can be increased by linking several impellers together in one system. In such a multistage pump the outlet for each impeller casing serves as the inlet to the next impeller. Centrifugal pumps are used for a wide variety of purposes, such as pumping liquids for water supply, irrigation, and sewage disposal systems. Such devices are also utilized as gas compressors. (Britannica, 2001)

3.7.2 Positive-Displacement Type

Another kind of pump is the positive-displacement type. This pump delivers a fixed quantity of water with each cycle of a piston or rotor. The water is literally pushed or displaced from the pump casing. The flow capacity of a positive-displacement pump is unaffected by the pressure of the system in which it operates.

Positive displacement pumps, which lift a given volume for each cycle of operation, can be divided into two main classes, reciprocating and rotary. Reciprocating pumps include piston, plunger, and diaphragm types; rotary pumps include gear, lobe, screw, vane, and cam pumps.

3.8 EXCAVATION AND BACKFILLING

Water mains must be placed (3) to (6) feet (91 to 183) cm below the ground surface to protect against traffic loads and to prevent freezing. Since the water in a distribution system is under pressure, pipelines can follow the shape of the land,

uphill as well as downhill. They must be installed with proper bedding and backfill. Compaction of soil layers under the pipe (bedding) as well as above the pipe (backfill) is necessary to provide proper support (Steel and McGhee, 1991).

Backfill material should be free from cinders, refuse, or large stones. Backfill from the trench bottom to the centerline of the pipe should be with sand, gravel, shell or other satisfactory material laid in layers and tamped. This material should extend to the trench sides. Excavation material can be used as filling material depending on the type of soil excavation and this will save money. A water main should never be installed in the same trench with a sewer line. Where the two must cross, the water main should be placed above the sewer line. (Britannica, 2001)

CHAPTER FOUR

THE NETWORK MODEL

4.1 WHAT IS EPANET

4.2 THE PIPES

4.3 PUMPS

4.4 MINOR LOSSES

4.5 TIME PATTERNS

4.6 VALVES

4.7 FLOW IN PIPE SYSTEMS

4.8 NETWORK DESIGN STEPS

CHAPTER FOUR

THE NETWORK MODEL

4.1 WHAT IS EPANET

The calculation necessary for the network design are performed by the computer program EPANET. This computer program is develop by the Risk Reduction Engineering Laboratory, Office of Resource and Development, U.S Environmental protection Agency, Cincinnati, Ohio (Rossman,1994).

EPANET is a computer program that performs extended period simulation of hydraulic and water quality behavior within drinking water distribution system. A network can consists of pipes, nodes (pipe functions),pumps, valves, and storage tank or reservoirs. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of the substance throughout the network during a multi-time period simulation. In addition to substance concentration, water age and source tracing can also performed. The water quality is equipped to the model such phenomena as reactions within the bulk flow, reactions at the pipe wall, and mass transport between the bulk flow and pipe wall.

4.1.1 JUNCTION NODES:

Junctions are points in the network where links join together and where water enters or leaves the network.

The basic input data required for junctions are, elevation ,water demand ,and initial water quality, the output results computed for junctions are ,hydraulic head , pressure.

4.1.2 LINKS

Links include pipes , pumps and various valves , these are system component which connect to junctions or boundaries , and control the flow rates and energy losses between nodes.

4.2 THE PIPES

Pipes convey water from one point in the network to another. EPANET assumes that all pipes are full at all times. Flow direction is from the end at higher hydraulic head (internal energy per weight of water) to that at lower head. The principal hydraulic input parameters for pipes are, diameter ,length ,roughness coefficient ,initial status (open, closed, or contains a check valve).

The status parameter allows pipes to implicitly contain shutoff valves and check valves (which allow flow in only one direction). Computed outputs for pipes include ; flow rate velocity ,headloss , friction factor

4.3 PUMPS

Pumps are devices that impart energy to a fluid thereby raising its hydraulic head , The principal input parameter for a pump is its pump curve (the combination of heads and flows that the pump can produce).

Pumps can be turned on and off at preset times, when tank levels fall below or above certain set-points, or when nodal pressures fall below or above certain set-points through the use of controls and time patterns.

Variable speed pumps can also be considered by specifying that their speed setting be changed under these same types of conditions. By definition, the original pump curve supplied to the program has a relative speed setting of 1. If the pump speed doubles, then the relative setting would be 2; if run at half speed, the relative setting is 0.5 and so on.

EPANET can also compute the energy consumption and cost of a pump, Either pump-specific efficiency curves and energy pricing parameters can be supplied or global energy options will be used.

4.4 MINOR LOSSES

Minor head losses (also called local losses) can be associated with the added turbulence that occurs at bends, junctions, meters, and valves. The importance of such losses will depend on the layout of the pipe network and the degree of accuracy required. Minor losses are proportional to the velocity head of water flowing through a pipe or valve

($V^2/2g$). The proportionality constant is termed the "loss coefficient" and its value depends on the geometry and type of fitting.

Table (4.1) Minor Loss Coefficients

Globe valve, fully open	10.0
Angle valve, fully open	5.0
Swing check valve, fully open	2.5
Gate valve, fully open	0.2
Short-radius elbow	0.9
Medium-radius elbow	0.8
Long-radius elbow	0.6
45 degree elbow	0.4
Closed return bend	2.2
Standard tee - flow through run	0.6
Standard tee - flow through branch	1.8
Square entrance	0.5
Exit	1.0

4.5 TIME PATTERNS

A Time Pattern is a collection of multipliers that can be applied to a quantity to allow it to vary over time. Water demands, reservoir heads, pump schedules.

The time interval used in all patterns is set with the project's ,Within this interval a quantity remains at a constant level, equal to the product of its nominal value and the pattern's multiplier for that interval. Although all time patterns must utilize the same time interval, each can have a different number of periods. When the simulation clock exceeds the number of periods in a pattern, the pattern wraps around to its first period again.

As an example of how time patterns work consider a junction node with an average demand of 10 GPM. Assume that the time pattern interval has been set to 4 hours and a pattern with the following multipliers has been specified for demand at this node:

Period	***1***	***2***	***3***	***4***	***5***	***6***
Multiplier	**0.5**	**0.8**	**1.0**	**1.2**	**0.9**	**0.7**

Then during the simulation the actual demand exerted at this node will be as follows:

Hour	***0-4***	***4-8***	***8-12***	***12-16***	***16-20***	***20-24***	***24-28***
Demand	**5**	**8**	**10**	**12**	**9**	**7**	**5**

4.6 VALVES

There are several types of valves which may be present in atypical pressurized system , these valves have different behavior anddefferent responsibilities , but all valves are used for automatically controlling parts of the system , opening , closing or throttling to achieve the desired result.

Valves are used to control the pressure or flow at a specific point in the network.
Shutoff (gate) valves and check (non-return) valves, which completely open or close pipes, are not considered as separate valve components but are instead included as a property of the pipe in which they are placed .

- **PRV (Pressure Reducing Valve)**

A Pressure Reducing Valve (PRV) is used to limit the pressure at a point in the pipe network. When it partially opened (i.e., active) to achieve its pressure setting on its downstream side when the upstream pressure is above the setting , fully open if the upstream pressure is below the setting , and closed if the pressure on the downstream side exceeds that on the upstream side (i.e., reverse flow is not allowed).

- **PSV (Pressure Sustaining Valve)**

A Pressure Sustaining Valve (PSV) is used to maintain a set pressure at a specific point in the pipe network. The valve can be in one of three states:
partially opened (i.e., active) to maintain its pressure setting on its upstream side when the downstream pressure is below this value fully open if the downstream pressure is

above the setting and closed if the pressure on the downstream side exceeds that on the upstream side (i.e., reverse flow is not allowed).

- **PBV (Pressure Breaker Valve)**

A Pressure Breaker Valve (PBV) forces a specified pressure loss to occur across the valve. Flow through the valve can be in either direction. PBV's are not true physical devices but can be used to model situations where a particular pressure drop is known to exist.

- **FCV (Flow Control Valve)**

A Flow Control Valve (FCV) limits the flow through itself to a specified amount. The program produces a warning message if this flow cannot be maintained without having to add additional head at the valve (i.e., the flow cannot be maintained even with the valve fully open).

- **TCV (Throttle Control Valve)**

A Throttle Control Valve (TCV) simulates a partially closed valve by adjusting the minor head loss coefficient of the valve. A relationship between the degree to which a valve is closed and the resulting head loss coefficient is usually available from the valve manufacturer.

4.7 FLOW IN PIPE SYSTEMS

Analysis of a water distribution system includes determining quantities of flow and head losses in the various pipeline, and resulting residual pressures. Various pipe flow formulas are available to predict head loss as a function of velocity in pipes,

Epanet using different to compute the hydraulic head lost by water flowing in a pipe due to friction with the pipe walls , the three formulas:

1. Hazen-Williams Formula
2. Darcy-Weisbach Formula
3. Chezy-Manning Formula.

Each formula uses a different pipe roughness corefficient that must be determined empirically. Be aware that a pipes roughness corefficient can change considerably with age.

4.7.1 Hazen-Williams Formula:

The Hazen-Williams equation is the most frequently used in the design and analysis of pressure pipe systems for water distribuation . The equation was developed experimentally and therefore should not be used for fluids other than water (within temperature normally experienced in potable water distribuationsystem).

The Hazen-Williams equation includes aroughness factor C , which is constant over a wide range of (turbulant) flows . There isalso an empirical constant , which is different for the U.S. standard (English) and S.I. units .

$$H_L = \frac{4.727\, L\, Q^{1.852}}{C^{1.852}\, D^{4.871}}$$

Where:

H_L	=	headloss in feet
Q	=	flow in cfs
L	=	pipe length in feet
d	=	pipe diameter in feet
C	=	Roughness coefficient(Hazen-Williams C-factor)

4.7.2 Darcy-Weisbach Formula :

It is not widely used in waterworks design and evaluation because a trial and error solution is required to determine pipe size for a given flow and head loss, since the friction factor is based on the relative roughness which involves the pipe diameter.

$$H_L = \frac{f^{/}.L}{d} \quad \frac{V^2}{2g}$$

Where:

HL	=	headloss (Length)
g	=	acceleration of gravity in (Length/Time/Time)
L	=	pipe length (Length)

d = pipe diameter (Length)

v = flow velocity (Length/Time)

f = friction factor (unitless)

The friction factor is a function of (e/d) and the Reynolds number, where e is a roughness coefficient with units of length. The above formula can be used with any consistent set of units.

4.7.3 Chezy-Manning Formula :

Manning's formula, though generally used for gravity conduits like open channel, it is also applicable to turbulent flow in pressure conduits and yields good results, provided the roughness coefficient n is accurately estimated. Head loss, according to Manning's equation is given by:

$$H_L = \frac{4.66\, n^2\, L\, Q^2}{d^{533}}$$

Where:

HL = headloss in feet

Q = flow in cfs

L = pipe length in feet

d = pipe diameter in feet

n = Manning roughness coefficient

Computations for a large network can often be made easier if a series of pipes of varying diameter are replaced with equivalent pipes. An equivalent pipe is an imaginary conduit that replaces a section of a real system such that the head losses in the two systems are identical for the quantity of flow. For example pipes of differing diameters connected in series can be replaced by an equivalent pipe of one diameter as follow: assume quantity of flow and determine the head loss in each section of the line for this flow, then using the sum of the sectional head losses and the assumed flow, enter the nomogram to find the equivalent pipe diameter. For parallel pipe systems, a head loss is assumed, and the quantity of flow through each of the pipes is calculated for that head loss. Then the sum of the flows and the assumed head loss are used to determine the equivalent pipe size (Steel and McGhee, 1991).

4.8 NETWORK DESIGN STEPS

In general, the following steps must be done while planning and designing a municipal water supply scheme:

1. Estimate the future population of the study area to determine the quantity of water which is required to be provided by the project.

2. Locate a reliable sources of water, so as to fulfil the needs and requirements of the area.
3. Obtain a detailed map of the area to be served on which topographic contours and the locations of present and future are identified.
4. Based on the topography, select possible locations for distribution reservoirs. If the area to be served is large it may be divided into several sub-areas to be served with separate distribution system.
5. Estimate the average and peak water use for the area or each sub-area, allowing for fire fighting and future growth.
6. Estimate pipe size on the basis of water demand and local code requirements.
7. Lay out a skeleton system of supply mains leading from the distribution reservoir or other source of supply.
8. Analyze, using one of the several methods discussed above, the flow and pressures in the supply network.
9. Adjust pipe sizes to reduce pressure irregularities in the basic grid.
10. Add distribution mains to the grid system.
11. Reanalyze the hydraulic capacity of the system.
12. Add street mains for domestic service.
13. Locate the necessary values and fire hydrants.
14. Prepare final design drawings and quantity takeoffs.

CHAPTER FIVE

DESIGN AND PLANNING CRITERIA

5.1 GENERAL INTRODUCTION

5.2 POPULATION

5.3 PROJECTED WATER DEMAND

5.4 WATER DEMAND FORECAST

5.5 PIPE HYDRAULICS

5.6 RESERVOIRS

5.7 VALVES

CHAPTER FIVE

DESIGN AND PLANNING CRITERIA

5.1 GENERAL INTRODUCTION

In the design of any waterworks project it is necessary to estimate the amount of water that is required. This involves determining the number of people who will be served and their per capita water consumption, together with an analysis of the factors that may operate to affect consumption. In this chapter, design and planning criteria will be discussed including population and population forecasting, future water demand, approach water distribution network computational scheme, and the village structure plan.

5.2 POPULATION

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 are obtained. In the analysis of these data, demographically, 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 area under consideration.

In the village of Beit Kahel, as well as other Palestinian cities and villages, 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 1999 when the Palestinian Central Bureau of Statistics (PCBS) conducted comprehensive census covering the West Bank and Gaza Strip. The final results of this census show that the total population of Beit Kahel village is (4214) inhabitants.

Due to unstable condition of the area during the last (56) years, it would be very difficult to develop a statistical interpretation to extrapolate future population. Some reasonable assumption have therefore been made to project the future population of the village of Beit Kahel over the next (25) year.

5.2.1 Population Forecast

Prediction of the future population of Beit Kahel 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 Beit Kahel.

The base for the forecast is the (1999) population for Beit Kahel obtained form PCBS of (4214) inhabitants. The population growth rate for the purpose of our study was based on estimation used for other villages of similar population composition and characteristics. The rate of population growth in other villages in the West Bank is (3.5) %, plus (1)% for the expected refugees return. A similar rate of growth was assumed for the villages of Gaza. Therefore, a rate of (4.5)% per year was used regarding the future growth of the population of Beit Kahel.

To calculate the population for the end of the design period year (2028), a geometric increase is assumed, represented by the following equation:

$$\mathbf{P = P_0 *(1+R)^N}$$

In which:

P is the future population

P0 is the present population

R is the annual population growth

N is the period of projection.

Using the above assumptions and equation, Table (4.1) presents the population up to the design horizon of (2028). The data show that the population of Beit Kahel is estimated to be (16410) in year (2028).

Table (5.1) Population Forecast For Beit Kahel Village

Year	2003	2008	2013	2018	2023	2028
Population	5460	6863	8479	10567	13168	16410

5.2.2 Population Density

There is a statistically review study done for Beit Kahel in year (2003) concerning the village structure plan, the data obtained for the population density are shown in Figure (5.1) . Beit Kahel population density are based on village structure plan. According to this plan, the village is subdivided into three zones (1), (2), and (3). It should be noted that the population growth is (4.5) %.

Table (5.2) includes the areas and the present and future population densities in the various zones of Beit Kahel village for the year (2003) and year (2028).

Table (5.2) The Present and Future Population Densities and Total Population in the Three Zones for Year (2003) and Year (2028)

Zone	A		B		C	
Area (dounm)	297		312		700	
Year	Population Densities	Total Population	Population Densities	Total Population	Population Densities	Total Population
2003	9	2673	4	1248	2	1400
2028	18	5343	14	4368	9	6300

5.3 PROJECTED WATER DEMAND

Water demand in Beit Kahel village, like in other West Bank villages, is continuously increasing due to the continues increase in population and industrialization. The population of Beit Kahel is about (5460) for year (2003) and by year (2028) the population is estimated to be (16410). The result of all this is obvious, the total water requirement is ever on the increase, and per capita water consumption is also on the increase.

Restrictions on the Palestinian use of the annual ground water resources of the West Bank have been led to limited quantities availability of water and due to this condition, the average consumption of water in Beit Kahel village for all purposes does not exceed (24) cubic meter per capita per year.

On the basis of water consumption per family for domestic use and estimation of the future population Abu Sharkh (1994) calculated the average domestic water consumption and water demand for different villages of Hebron district. The data on water consumption and demand will be presented in the following paragraphs

5.4 WATER DEMAND FORECAST

There are several assessments must be taken into account while estimations of the future demand are made:

- Projection of total consumption from historical growth trends .
- Projection based on per capita consumption and population growth trends for domestic category.
- Forecast based on assessment of growth trends of other main consumer categories (industry, tourism, etc).
- Forecast based on development plans and programs.

All these projections naturally differ one from anther to a varying degree representing several possible scenarios consumption growth , when thinking such as about population growth , which is for developing countries still the major factor of water demand increase , the following should be analyzed :

- Composition of existing population by sex and age .
- Fertility rates for different female age groups.
- Mortality rates related to age and sex.
- Rates of migration related to age and sex to or from the area of interest.

Two models are commonly used in the calculation of demand trends: linear and exponential (equation (1) (2) respectively) .

$$Qf = Qi * (1 + n*(a/100)) \quad \ldots\ldots(1)$$

$$Qf = Qi * (1 + (a/100))^n \quad \ldots\ldots(2)$$

Qf: Water demands at year (i).

Qf: Forecasted water demand after n years.

n: Design period .

a: Average annual population growth during the design period .

Which of the models is more suitable is a question of the choice (a and n) once, some trends can be derived from the existing statistics , potential re assessment of the forecast should be identified within the design period .

Because of there is no statistics about present water demand ,we adopted (WHO) standard demand (120 liter/ capita /day) which used in the developing countries .

5.5 PIPE HYDRAULICS

As mentioned earlier, pipe hydraulic calculation have been carried out by the EPANET software which uses the Hazen- Williame's equation to calculate the
The design criteria adopted for different parameters are:

- **Velocity:**

* Minimum velocity = 0.1 m/s to prevent deposits of silt in the pipe (achieve self cleansing).

* Maximum velocity = 2.0 m/s to minimize friction loss and water hammer effect.

- **Pressure:**

* Minimum pressure = 0.5 bar (5m).

* Maximum pressure = 9 bar (90m)

The minimum and maximum pressures in the distribution lines are defined as the pressure at the nodes in the model. The minimum value of 5 m is adopted to let the water rise at least one story and overcome the frictional resistance of the house connection pipes and small diameter distribution. The upper value is limited to 90 m in order not to have excessive pressure in the net work and so minimize the leakage from the system.

- **Pipe:**

The pipes of the distribution system are chosen to be steel pipes due to their advantages. Minimum diameter of 1"(25mm) is taken. The Hazen-Williams constant of a new steel pipes is 130.

5.6 RESERVOIRS

Reservoirs are required to provide emergency storage in case there is a temporary loss of bulk supplies or in case there are exceptional demand on the system (e.g. for fire fighting). It is also required for balancing storage to take account of normal and daily fluctuation in demand compared with average demand.

In the Beit Kahel village, most households have cisterns and/or large roof tanks which provide additional storage in the system. This minimizes the need for emergency storage at the municipal reservoirs.

Reservoirs should, therefore, be sized to ensure they do not fall below 50% full at average demand conditions, and do not empty during peak day / peak month conditions. In both cases the reservoir level should recover to its initial level at the end of each day.

All reservoirs should be provided with the following:

1. High level inlet controlled by a ball float valve (or low level inlet with an altitude valve).

2. Low level outlet at a location diagonally opposite the inlet to minimize reservoir short circuiting.

3. Overflow pipe to a local drain or watercourse, sized to discharge maximum possible inflow to the reservoir.

4. Washout pipe, which should discharge into the overflow pipline.

5. Lockable access ladder (internal and external) and roof covers.

6. Vents with insect screens.

7. Roof drainage to ensure that rainwater does not seep into the reservoir.

8. Water sampling tap (in lockable cubicle) connected to outlet pipe.

As mentioned earlier, there is a reservoir in the Beit Kahel village used for storage water with (200 cubic meter) at level (982) m. as shown in the figure (5.2)

FIG. (5.2) Reservoir in Beit Kahel village

5.7 VALVES

Gate valve are placed at the street corners where lines are intersect. Air relief valves are only fitted to main pump because taps of houses work as air relief valves for the distributing lines. Pressure reducing (and sustaining) valves will be fitted with strainers and air valves on the upstream side.(Rossman, 1994)

CHAPTER SIX

ANALYSIS AND DISCUSSION OF RESULTS

6.1 GENERAL INTRODUCTION

6.2 CALCULATION SCHEME

6.3 THE EXISTING WATER DISTRIBUTION NETWORK

6.4 THE EXISTING WATER LOSSES

6.5 THE PROPOSED WATER DISTRIBUTION NETWORK

6.6 SUMMARY

CHAPTER SIX

ANALYSIS AND DISCUSSION OF RESULTS

6.1 GENERAL INTRODUCTION

In this project, an attempt is made to study and evaluate the existing water distribution network in Beit kahel village, and develop a future plans and appropriate technology for reconstruction and upgrading of the network, corresponding to population and population growth and water demand in the future (120 l/c.d), in order to supply all inhabitants of Beit kahel village with a sufficient amount of agood quality drinking water. In this chapter, the method of evaluating the existing water network will be described followed by discussion of results for the appropriate changes and modifications in the present mains and the future proposed water supply network.

6.2 CALCULATION SCHEME

As mentioned earlier, the analysis and design were carried out for Beit kahel water distribution network in three phases. First study and evaluate the existing water distribution network, secondly designing and constructing by changing the diameter in some present pipe , and thirdly designing and constructing a new network with the present storage reservoir. The calculation necessary for the network design is performed by the computer program EPANET, which make of use of Hardy-Cross method. The computations and the results of each of the three phases will be described and presented below.

6.3 THE EXISTING WATER DISTRIBUTION NETWORK

The existing water distribution network has been studied and evaluated. The existing water network consists of main pipelines and sub-mains. The main pipelines receives the water directly from a reservoir (200 cubic meter) and supplies the smaller diameters pipelines.

The calculation has been done for the existing water network and try to repair or redesign the same network for year (2028). The demand of water for each node necessary for the calculation where estimated by multiplying the population density by the area in which each node serves by water demand per capita per year. The elevation of each node from the aerial map and length of pipelines are calculated and obtained from the old pipe map The result for the existing network are given in the following paragraphs.

The computer program is used for doing the calculation and obtaining the results. The input data are given in Table (6.1) and shown in the layout of the existing network in Fig. (6.1) and Fig. (6.2). The output values of velocity, head loss, and pressure are given in Tables (6.2) and (6.3).

It may be seen that many values of the velocity are within the allowable ranges. The velocity in many pipes is less than (0.1) m/s and in others over than (2.0) m/s and the head loss is very high. The pressure in all nodes is negative pressure. At the same time, the diameters of the pipes are small especially the main pipes (3) in.

As mentioned earlier, Beit Kahel village is supplied by water coming from Asion settlement in the east north of Beit Kahel village, The water in the village is distributed by network most of which are old. The network is branch one made out of steel pipelines. The existing water distribution network is presented in Figure (5.2). The diameters of pipelines range from 1" to 3" (25-75 mm) as listed below in Table (5.5).

Table (5.5) List of the Existing Distribution Lines

Diameter(mm)	Length (m)
25	4746
50	1634
75	3672

6.4 THE EXISTING WATER LOSSES

As mentioned earlier, the amount of water lost in the distribution system or uncounted of the quantity of water supplied. In view of this high percentage of losses, it is strongly recommended to carry survey to discover leaks and carry out the necessary repairs and maintenance. Many factors determine the quantity and percentage of water losses ; these differ from net work to another or even in the same net work:

1. **Losses In Main Supply Lines**

   These losses may be defined as the quantity of water lost in the main lines between the water source and distribution net work, the losses in the main supply line result from leaks due to damage to the line or to excessive water pressure or corrosion , And these losses are only a small percentage of the total losses .

2. **Losses In The Network**

   These losses constitute the quantity of water lost between the main supply lines and the consumers meters. And there is ahigh percentage of the losses originate from the network owing to its deteriorated condition and aging pipelines which doesn’t to standards and laid either exposed.

3. Losses in Meter

These losses may be defined as the quantity of water that is being consumed without being recorded by consumers own meter ,

4. Black losses

The illegal consumption of water (black losses) is present because of present economical and social circumstances.

Table (6.1a) X and Y Coordinates of Nodes For The Existing Network

ID	X coordinate	Y coordinate	ID	X coordinate	Y coordinate
1	158039.62	108042.97	**41**	156770.57	108567.65
2	157982.84	108141.83	**42**	156713.68	108443.46
3	157887.79	108087.31	**43**	156729.41	108575.05
4	157887.86	108124.50	**44**	156720.69	108664.85
5	157817.38	108122.50	**45**	156752.98	108692.12
6	157812.77	108095.64	**46**	156707.23	108678.58
7	157499.94	108270.93	**47**	156721.35	108688.85
8	157504.54	108335.97	**48**	156667.03	108712.95
9	157277.35	108336.28	**49**	156712.59	108817.61
10	157368.21	108398.86	**50**	156633.26	108733.17
11	157184.51	108360.43	**51**	156635.98	108792.44
12	157174.08	108281.52	**52**	156568.70	108756.34
13	157163.80	108367.55	**53**	156577.13	108817.93
14	157177.85	108443.58	**54**	156499.12	108737.86
15	157128.05	108373.62	**55**	156585.92	108888.30
16	157118.18	108335.35	**56**	156428.53	108731.45
17	157048.08	108437.99	**57**	156431.09	108705.10
18	157.56.05	108332.19	**58**	156545.18	108708.70
19	157034.72	108450.36	**59**	156432.25	108672.30
20	157041.81	108494.94	**60**	156559.56	108672.37
21	157086.12	108515.37	**61**	156394.05	108667.21
22	157181.64	108504.23	**62**	156433.56	108643.80
23	157110.62	108632.46	**63**	156392.39	108739.19
24	157042.06	108563.55	**64**	156239.50	108840.26
25	157016.26	108518.34	**65**	156239.97	108879.90
26	157010.79	108465.23	**66**	156123.97	108876.38
27	156997.50	108532.64	**67**	155930.40	108914.99
28	157008.78	108430.50	**68**	156319.54	108763.15
29	156977.64	108485.73	**69**	156353.20	108700.32
30	156974.27	108377.76	**70**	156312.31	108672.95
31	156935.67	108506.41	**71**	156349.04	108655.48
32	156991.21	108593.11	**72**	156413.52	108628.70
33	156878.62	108529.71	**73**	156288.65	108655.44
34	156863.51	108636.31	**74**	156287.34	108634.53
35	156845.71	108547.63	**75**	156239.63	108664.34
36	156844.39	108487.37	**76**	156219.23	108752.73
37	156815.05	108558.96	**77**	156343.86	108609.51
38	156812.38	108661.08	**78**	156322.33	108540.60
39	156790.26	108565.24	**79**	156212.98	108630.46
40	156788.52	108617.11	**80**	156185.60	108645.85

Table (6.1a) Cont

ID	X coordinate	Y coordinate	ID	X coordinate	Y coordinate
81	156113.09	108631.43	**92**	155757.86	108806.95
82	156230.53	108582.79	**93**	155729.70	108742.50
83	156071.34	108632.62	**94**	155685.23	108794.54
84	156164.03	108540.61	**95**	155672.38	108645.99
85	156134.50	108755.71	**96**	155628.55	108782.94
86	155853.41	108880.60	**97**	155631.49	108723.09
87	155766.03	108674.02	**98**	155597.09	108780.81
88	155915.05	108705.79	**99**	155590.21	108703.34
89	155808.76	108593.25	**100**	155590.36	108953.29
90	155812.02	108776.01	**101**	155470.15	109063.31
91	155807.89	108674.50	**Reservoir**	156343.86	108038.08

Table (6.1b) Input Data For The Existing Network (Nodes)

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
1	977	0.14	**41**	873	0.05
2	975	0.07	**42**	857	0.05
3	955	0.05	**43**	871	0.09
4	957	0.3	**44**	877	0.17
5	945	0.16	**45**	879	0.06
6	940	0.05	**46**	877	0.1
7	920	0.15	**47**	878	0.04
8	928	0.2	**48**	877	0.06
9	903	0.08	**49**	867	0.04
10	922	0.09	**50**	876	0.04
11	902	0.05	**51**	874	0.04
12	890	0.02	**52**	872	0.05
13	905	0.03	**53**	872	0.04
14	895	0.08	**54**	869	0.06
15	906	0.08	**55**	867	0.06
16	903	0.02	**56**	867	0.05
17	907	0.06	**57**	864	0.06
18	896	0.02	**58**	869	0.04
19	908	0.02	**59**	859	0.09
20	912	0.03	**60**	864	0.08
21	903	0.08	**61**	855	0.02
22	890	0.09	**62**	850	0.08
23	895	0.06	**63**	866	0.07
24	913	0.03	**64**	855	0.09
25	913	0.03	**65**	850	0.03
26	908	0.03	**66**	856	0.09
27	912	0.02	**67**	834	0.03
28	905	0.02	**68**	862	0.06
29	907	0.05	**69**	863	0.06
30	889	0.02	**70**	858	0.04
31	900	0.07	**71**	854	0.03
32	915	0.05	**72**	846	0.03
33	884	0.07	**73**	857	0.03
34	890	0.05	**74**	855	0.05
35	879	0.02	**75**	860	0.1
36	874	0.03	**76**	857	0.05
37	876	0.03	**77**	843	0.10
38	884	0.02	**78**	822	0.03
39	874	0.03	**79**	860	0.05
40	880	0.02	**80**	860	0.06

Table (6.1b) Cont

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
81	851	0.09	**92**	807	0.4
82	853	0.02	**93**	813	0.03
83	845	0.08	**94**	810	0.05
84	850	0.03	**95**	805	0.03
85	854	0.30	**96**	811	0.05
86	817	0.06	**97**	809	0.02
87	830	0.09	**98**	809	0.06
88	825	0.10	**99**	805	0.04
89	811	0.03	**100**	778	0.3
90	811	0.06	**101**	767	0.3
91	827	0.05	**Reservoir**	982	-7.08

Table (6.1c) Input Data For The Existing Network (Pipes)

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
1	1	3	150	75
2	1	2	129	25
3	3	4	43	25
4	3	5	86	75
5	5	6	26	25
6	5	7	380	75
7	7	8	67	25
8	7	9	250	75
9	9	10	67	25
10	9	11	110	75
11	11	12	88	25
12	11	13	22	75
13	13	14	80	25
14	13	15	38	75
15	15	16	12	25
16	15	17	110	75
17	17	18	110	75
18	17	19	19	75
19	19	20	46	25
20	20	21	62	25
21	21	22	102	25
22	21	23	112	25
23	20	24	68	25
24	20	25	42	25
25	19	26	35	75
26	26	28	50	25
27	26	27	51	25
28	26	29	42	75
29	29	30	108	25
30	29	31	46	75
31	31	32	148	25
32	31	33	72	75
33	33	34	110	25
34	33	35	38	75
35	35	36	66	25
36	35	37	40	75
37	37	38	102	25
38	37	39	37	75
39	39	40	55	25
40	39	41	17	75

Table (6.1c) Cont

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
41	41	42	144	25
42	41	43	40	75
43	43	77	400	75
44	43	44	95	75
45	44	45	46	25
46	44	46	20	75
47	46	47	20	25
48	46	48	57	75
49	48	49	142	25
50	48	50	46	75
51	50	51	60	25
52	50	52	80	75
53	52	53	72	25
54	52	54	95	75
55	54	55	196	25
56	54	56	97	75
57	56	57	25	50
58	57	58	100	25
59	57	59	31	50
60	59	60	111	25
61	59	61	37	25
62	59	62	17	25
63	56	63	90	75
64	63	64	190	50
65	64	65	66	25
66	64	66	150	50
67	66	67	200	25
68	63	68	180	75
69	68	69	25	25
70	68	70	30	75
71	70	71	94	25
72	71	72	75	25
73	70	73	40	75
74	73	74	60	25
75	73	75	50	75
76	75	76	117	25
77	75	79	60	75
78	79	80	50	75
79	80	81	120	75
80	81	82	132	25

Table (6.1d) Cont

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
81	77	79	150	75
82	77	78	100	25
83	81	83	50	75
84	83	84	160	25
85	83	87	200	75
86	87	88	60	50
87	88	89	160	25
88	80	85	170	50
89	66	85	250	50
90	85	86	340	25
91	88	90	150	50
92	90	92	100	50
93	90	91	102	25
94	92	93	66	25
95	92	94	90	50
96	94	95	150	25
97	94	96	90	50
98	96	97	60	25
99	96	98	78	50
100	98	99	60	25
101	92	100	250	50
102	100	101	200	25
103	Reservoir	1	120	75

Table (6.2) Values of Velocity and Head Loss in Pipes for the Existing Network

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
1	75	6.87	1.56	62.77
2	25	0.07	0.04	0.09
3	25	0.3	0.15	1.38
4	75	6.52	1.48	56.96
5	25	0.05	0.03	0.05
6	75	6.31	1.43	53.61
7	25	0.2	0.41	18.93
8	75	5.96	1.35	48.24
9	25	0.09	0.18	4.31
10	75	5.79	1.31	45.72
11	25	0.02	0.04	0.27
12	75	5.72	1.29	44.7
13	25	0.08	0.16	3.47
14	75	5.61	1.27	43.12
15	25	0.02	0.04	0.27
16	75	5.51	1.25	41.71
17	25	0.02	0.04	0.27
18	75	5.43	1.23	40.59
19	25	0.32	0.65	45.21
20	25	0.23	0.47	24.52
21	25	0.09	0.18	4.31
22	25	0.06	0.12	2.04
23	25	0.03	0.06	0.56
24	25	0.03	0.06	0.57
25	75	5.09	1.15	36.01
26	25	0.02	0.04	0.27
27	25	0.02	0.04	0.27
28	75	5.02	1.14	35.1
29	25	0.02	0.04	0.27
30	75	4.95	1.12	34.2
31	25	0.05	0.1	1.45
32	75	4.83	1.09	32.68
33	25	0.05	0.1	1.45
34	75	4.71	1.07	31.19
35	25	0.03	0.06	0.56
36	75	4.66	1.05	30.58
37	25	0.02	0.04	0.27
38	75	4.61	1.04	29.98
39	25	0.02	0.04	0.27
40	75	4.56	1.03	29.38

Table (6.2) Cont

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
41	25	0.05	0.1	1.45
42	75	4.46	1.01	28.2
43	75	1.99	0.45	6.32
44	75	2.38	0.54	8.82
45	25	0.06	0.12	2.04
46	75	2.15	0.49	7.31
47	25	0.04	0.08	0.96
48	75	2.01	0.46	6.45
49	25	0.04	0.08	0.96
50	75	1.91	0.43	5.87
51	25	0.04	0.08	0.96
52	75	1.83	0.41	5.42
53	25	0.04	0.08	0.96
54	75	1.74	0.39	4.94
55	25	0.06	0.12	2.04
56	75	1.62	0.37	4.33
57	50	0.37	0.19	2.02
58	25	0.04	0.08	0.96
59	50	0.27	0.14	1.13
60	25	0.08	0.16	3.47
61	25	0.02	0.04	0.27
62	25	0.08	0.16	3.47
63	75	1.2	0.27	2.48
64	50	0.37	0.19	2.02
65	25	0.03	0.06	0.56
66	50	0.25	0.13	0.98
67	25	0.03	0.06	0.56
68	75	0.76	0.17	1.07
69	25	0.06	0.12	2.04
70	75	0.64	0.15	0.78
71	25	0.06	0.12	2.04
72	25	0.03	0.06	0.56
73	75	0.54	0.12	0.57
74	25	0.05	0.1	1.45
75	75	0.46	0.1	0.42
76	25	0.05	0.1	1.45
77	75	0.31	0.07	0.2
78	75	1.81	0.41	5.3
79	75	1.83	0.41	5.42
80	25	0.02	0.04	0.27

Table (6.2) Cont

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
81	75	-1.86	0.42	5.58
82	25	0.03	0.06	0.56
83	75	1.72	0.39	4.83
84	25	0.03	0.06	0.56
85	75	1.61	0.36	4.27
86	50	1.52	0.77	27.68
87	25	0.03	0.06	0.56
88	50	-0.23	0.12	0.84
89	50	0.13	0.07	0.29
90	25	0.06	0.12	2.04
91	50	1.39	0.71	23.45
92	50	1.28	0.65	20.13
93	25	0.05	0.1	1.45
94	25	0.03	0.06	0.56
95	50	0.25	0.13	0.98
96	25	0.03	0.06	0.56
97	50	0.17	0.09	0.48
98	25	0.02	0.04	0.27
99	50	0.1	0.05	0.18
100	25	0.04	0.08	0.96
101	50	0.6	0.31	4.95
102	25	0.3	0.61	40.11
103	75	7.08	1.6	66.37

Table (6.3) The Pressure at Each Node for the Existing Network

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
1	977	0.14	974.04	-2.96
2	975	0.07	974.02	-0.98
3	955	0.05	964.62	9.62
4	957	0.3	964.56	7.56
5	945	0.16	959.72	14.72
6	940	0.05	959.72	19.72
7	920	0.15	939.35	19.35
8	928	0.2	938.08	10.08
9	903	0.08	927.29	24.29
10	922	0.09	927	5
11	902	0.05	922.26	20.26
12	890	0.02	922.24	32.24
13	905	0.03	921.28	16.28
14	895	0.08	921	26
15	906	0.08	919.64	13.64
16	903	0.02	919.64	16.64
17	907	0.06	915.05	8.05
18	896	0.02	915.02	19.02
19	908	0.02	914.28	6.28
20	912	0.03	912.2	0.2
21	903	0.08	910.68	7.68
22	890	0.09	910.24	20.24
23	895	0.06	910.45	15.45
24	913	0.03	912.16	-0.84
25	913	0.03	912.18	-0.82
26	908	0.03	913.02	5.02
27	912	0.02	913.01	1.01
28	905	0.02	913.01	8.01
29	907	0.05	911.54	4.54
30	889	0.02	911.52	22.52
31	900	0.07	909.97	9.97
32	915	0.05	909.76	-5.24
33	884	0.07	907.62	23.62
34	890	0.05	907.46	17.46
35	879	0.02	906.43	27.43
36	874	0.03	906.4	32.4
37	876	0.03	905.21	29.21
38	884	0.02	905.18	21.18
39	874	0.03	904.1	30.1
40	880	0.02	904.09	24.09

Table (6.3) Cont

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
41	873	0.05	903.6	30.6
42	857	0.05	903.39	38.39
43	871	0.09	902.47	31.47
44	877	0.17	901.64	24.64
45	879	0.06	901.54	22.54
46	877	0.1	901.49	24.49
47	878	0.04	901.47	23.47
48	877	0.06	901.12	24.12
49	867	0.04	900.99	33.99
50	876	0.04	900.85	24.85
51	874	0.04	900.79	26.79
52	872	0.05	900.42	28.42
53	872	0.04	900.35	28.35
54	869	0.06	899.95	30.95
55	867	0.06	899.55	32.55
56	867	0.05	899.53	32.53
57	864	0.06	899.48	35.48
58	869	0.04	899.38	30.38
59	859	0.09	899.44	40.44
60	864	0.08	899.06	35.06
61	855	0.02	899.43	44.43
62	850	0.08	899.39	49.39
63	866	0.07	899.31	33.31
64	855	0.09	898.92	43.92
65	850	0.03	898.88	48.88
66	856	0.09	898.78	42.78
67	834	0.03	898.66	64.66
68	862	0.06	899.11	37.11
69	863	0.06	899.06	36.06
70	858	0.04	899.09	41.09
71	854	0.03	898.9	44.9
72	846	0.03	898.86	52.86
73	857	0.03	899.07	42.07
74	855	0.05	898.98	43.98
75	860	0.1	899.05	39.05
76	857	0.05	898.88	41.88
77	843	0.10	899.95	56.95
78	822	0.03	899.89	64.89
79	860	0.05	899.11	39.11
80	860	0.06	898.84	38.84

Table (6.3) Cont

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
81	851	0.09	898.19	47.19
82	853	0.02	898.16	45.16
83	845	0.08	897.95	52.95
84	850	0.03	897.86	47.86
85	854	0.30	898.7	44.7
86	817	0.06	898.01	81.01
87	830	0.09	897.1	67.1
88	825	0.10	895.44	70.44
89	811	0.03	895.35	84.35
90	811	0.06	891.92	80.92
91	827	0.05	891.77	64.77
92	807	0.4	889.91	82.91
93	813	0.03	889.87	76.87
94	810	0.05	889.82	79.82
95	805	0.03	889.73	84.73
96	811	0.05	889.78	78.78
97	809	0.02	889.76	80.76
98	809	0.06	889.76	80.76
99	805	0.04	889.7	84.7
100	778	0.3	888.67	110.67
101	767	0.3	880.65	113.65
Reservoir	982	-7.08	982.00	0.000

6.5 THE PROPOSED WATER DISTRIBUTION NETWORK

In year (2028), the village of Beit Kahel is in direct need of larger quantities of water and more adequate supply scheme. In the proposed study for the water distribution network, the trial is made to redesign the network for year (2028) by partly using the old network. This section deals with the results of the proposed water distribution network for year (2028).

6.4.1 The First Proposed Network

It is tried to changes the diameters of the most pipes to get the appropriate diameters with the values of velocity, head loss and pressure within the allowable ranges, and the attempt is success because it is found that most of the pipes of the first proposed water network are acceptable according to the allowable maximum and minimum pressure and velocities.

As discussed earlier, the appropriate pipe diameters are found by use of the computer program filled with basic data (nodes water demand in year (2028), elevation of the nodes, the length of each pipes). So that, the pressure in the nodes and velocity in the links will meet the requirements as close as possible. The input data for the first proposed network are found and given in Table (6.4) along with appropriate diameters the elevation and demand data. The same data are shown in Figs. (6.4) and (6.5). The calculated velocities, head loss, grads, and pressure are given in Tables (6.5) and (6.6). The first proposed water distribution network for year (2028) is plotted in Figure (6.6), the diameters and lengths of all pipes are shown in the figure.

Table (6.4a) X and Y Coordinates of Nodes For The First Proposed Network

ID	X coordinate	Y coordinate	ID	X coordinate	Y coordinate
1	158039.62	108042.97	41	156770.57	108567.65
2	157982.84	108141.83	42	156713.68	108443.46
3	157887.79	108087.31	43	156729.41	108575.05
4	157887.86	108124.50	44	156720.69	108664.85
5	157817.38	108122.50	45	156752.98	108692.12
6	157812.77	108095.64	46	156707.23	108678.58
7	157499.94	108270.93	47	156721.35	108688.85
8	157504.54	108335.97	48	156667.03	108712.95
9	157277.35	108336.28	49	156712.59	108817.61
10	157368.21	108398.86	50	156633.26	108733.17
11	157184.51	108360.43	51	156635.98	108792.44
12	157174.08	108281.52	52	156568.70	108756.34
13	157163.80	108367.55	53	156577.13	108817.93
14	157177.85	108443.58	54	156499.12	108737.86
15	157128.05	108373.62	55	156585.92	108888.30
16	157118.18	108335.35	56	156428.53	108731.45
17	157048.08	108437.99	57	156431.09	108705.10
18	157.56.05	108332.19	58	156545.18	108708.70
19	157034.72	108450.36	59	156432.25	108672.30
20	157041.81	108494.94	60	156559.56	108672.37
21	157086.12	108515.37	61	156394.05	108667.21
22	157181.64	108504.23	62	156433.56	108643.80
23	157110.62	108632.46	63	156392.39	108739.19
24	157042.06	108563.55	64	156239.50	108840.26
25	157016.26	108518.34	65	156239.97	108879.90
26	157010.79	108465.23	66	156123.97	108876.38
27	156997.50	108532.64	67	155930.40	108914.99
28	157008.78	108430.50	68	156319.54	108763.15
29	156977.64	108485.73	69	156353.20	108700.32
30	156974.27	108377.76	70	156312.31	108672.95
31	156935.67	108506.41	71	156349.04	108655.48
32	156991.21	108593.11	72	156413.52	108628.70
33	156878.62	108529.71	73	156288.65	108655.44
34	156863.51	108636.31	74	156287.34	108634.53
35	156845.71	108547.63	75	156239.63	108664.34
36	156844.39	108487.37	76	156219.23	108752.73
37	156815.05	108558.96	77	156343.86	108609.51
38	156812.38	108661.08	78	156322.33	108540.60
39	156790.26	108565.24	79	156212.98	108630.46
40	156788.52	108617.11	80	156185.60	108645.85

Table (6.4a) Cont

ID	X coordinate	Y coordinate	ID	X coordinate	Y coordinate
81	156113.09	108631.43	92	155757.86	108806.95
82	156230.53	108582.79	93	155729.70	108742.50
83	156071.34	108632.62	94	155685.23	108794.54
84	156164.03	108540.61	95	155672.38	108645.99
85	156134.50	108755.71	96	155628.55	108782.94
86	155853.41	108880.60	97	155631.49	108723.09
87	155766.03	108674.02	98	155597.09	108780.81
88	155915.05	108705.79	99	155590.21	108703.34
89	155808.76	108593.25	100	155590.36	108953.29
90	155812.02	108776.01	101	155470.15	109063.31
91	155807.89	108674.50	Reservoir	156343.86	108038.08

Table (6.4 b) Input Data For The First Proposed Network (Nodes)

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
1	977	0.55	**41**	873	0.09
2	975	0.2	**42**	857	0.13
3	955	0.11	**43**	871	0.19
4	957	0.3	**44**	877	0.34
5	945	0.64	**45**	879	0.12
6	940	0.14	**46**	877	0.32
7	920	0.58	**47**	878	0.13
8	928	0.81	**48**	877	0.11
9	903	0.32	**49**	867	0.05
10	922	0.3	**50**	876	0.08
11	902	0.9	**51**	874	0.08
12	890	0.05	**52**	872	0.1
13	905	0.06	**53**	872	0.14
14	895	0.16	**54**	869	0.11
15	906	0.17	**55**	867	0.14
16	903	0.07	**56**	867	0.1
17	907	0.12	**57**	864	0.05
18	896	0.06	**58**	869	0.08
19	908	0.03	**59**	859	0.05
20	912	0.05	**60**	864	0.2
21	903	0.17	**61**	855	0.07
22	890	0.09	**62**	850	0.2
23	895	0.07	**63**	866	0.23
24	913	0.07	**64**	855	0.18
25	913	0.09	**65**	850	0.05
26	908	0.05	**66**	856	0.37
27	912	0.05	**67**	834	0.09
28	905	0.07	**68**	862	0.18
29	907	0.1	**69**	863	0.1
30	889	0.05	**70**	858	0.04
31	900	0.23	**71**	854	0.06
32	915	0.15	**72**	846	0.07
33	884	0.24	**73**	857	0.05
34	890	0.18	**74**	855	0.1
35	879	0.05	**75**	860	0.08
36	874	0.12	**76**	857	0.13
37	876	0.1	**77**	843	0.2
38	884	0.05	**78**	822	0.07
39	874	0.07	**79**	860	0.09
40	880	0.08	**80**	860	0.12

Table (6.4b) Cont.

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
81	851	0.09	**92**	807	0.35
82	853	0.13	**93**	813	0.13
83	845	0.19	**94**	810	0.09
84	850	0.34	**95**	805	0.1
85	854	0.12	**96**	811	0.1
86	817	0.32	**97**	809	0.15
87	830	0.13	**98**	809	0.23
88	825	0.11	**99**	805	0.1
89	811	0.05	**100**	778	0.73
90	811	0.08	**101**	767	0.69
91	827	0.08	**Reservoir**	982	-17.79

Table (6.4c) Input Data For The First Proposed Network (Pipes)

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
1	1	3	150	150
2	1	2	129	50
3	3	4	43	25
4	3	5	86	150
5	5	6	26	25
6	5	7	380	150
7	7	8	67	25
8	7	9	250	100
9	9	10	67	25
10	9	11	110	100
11	11	12	88	25
12	11	13	22	100
13	13	14	80	25
14	13	15	38	100
15	15	16	12	25
16	15	17	110	100
17	17	18	110	25
18	17	19	19	100
19	19	20	46	50
20	20	21	62	25
21	21	22	102	25
22	21	23	112	25
23	20	24	68	25
24	20	25	42	25
25	19	26	35	100
26	26	28	50	25
27	26	27	51	25
28	26	29	42	100
29	29	30	108	25
30	29	31	46	100
31	31	32	148	25
32	31	33	72	100
33	33	34	110	25
34	33	35	38	100
35	35	36	66	25
36	35	37	40	100
37	37	38	102	25
38	37	39	37	100
39	39	40	55	25
40	39	41	17	100

Table(6.4c) Cont.

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
41	41	42	144	25
42	41	43	40	100
43	43	77	400	50
44	43	44	95	75
45	44	45	46	25
46	44	46	20	75
47	46	47	20	25
48	46	48	57	75
49	48	49	142	25
50	48	50	46	75
51	50	51	60	25
52	50	52	80	75
53	52	53	72	25
54	52	54	95	75
55	54	55	196	25
56	54	56	97	75
57	56	57	25	50
58	57	58	100	25
59	57	59	31	50
60	59	60	111	25
61	59	61	37	25
62	59	62	17	25
63	56	63	90	75
64	63	64	190	50
65	64	65	66	25
66	64	66	150	50
67	66	67	200	25
68	63	68	180	75
69	68	69	25	25
70	68	70	30	75
71	70	71	94	25
72	71	72	75	25
73	70	73	40	75
74	73	74	60	25
75	73	75	50	75
76	75	76	117	25
77	75	79	60	75
78	79	80	50	50
79	80	81	120	75
80	81	82	132	25

Table (6.4c) Cont.

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
81	77	79	150	50
82	77	78	100	25
83	81	83	50	75
84	83	84	160	25
85	83	87	200	50
86	87	88	60	50
87	88	89	160	25
88	80	85	170	25
89	66	85	250	25
90	85	86	340	25
91	88	90	150	50
92	90	92	100	50
93	90	91	102	25
94	92	93	66	25
95	92	94	90	50
96	94	95	150	25
97	94	96	90	50
98	96	97	60	25
99	96	98	78	50
100	98	99	60	25
101	92	100	250	50
102	100	101	200	25
103	Reservoir	1	120	200

Table (6.5) Values of Velocity and Head Loss in Pipes for the First Proposed Network

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
1	150	17.04	0.96	11.54
2	50	0.2	0.1	0.65
3	25	0.3	0.61	40.36
4	150	16.63	0.94	11.03
5	25	0.14	0.29	9.78
6	150	15.85	0.9	10.08
7	25	0.81	1.65	252.45
8	100	14.46	1.84	61.33
9	25	0.3	0.61	40.11
10	100	13.84	1.76	56.58
11	25	0.05	0.1	1.45
12	100	12.89	1.64	49.58
13	25	0.16	0.32	12.23
14	100	12.67	1.61	48
15	25	0.07	0.13	2.43
16	100	12.43	1.58	46.37
17	25	0.06	0.12	2.04
18	100	12.25	1.56	45.1
19	50	0.54	0.27	4
20	25	0.33	0.66	46.52
21	25	0.09	0.18	4.31
22	25	0.07	0.14	2.71
23	25	0.07	0.14	2.71
24	25	0.09	0.18	4.31
25	100	11.69	1.49	41.34
26	25	0.07	0.13	2.43
27	25	0.05	0.1	1.45
28	100	11.52	1.47	40.28
29	25	0.05	0.1	1.45
30	100	11.37	1.45	39.31
31	25	0.15	0.31	11.11
32	100	10.99	1.4	36.92
33	25	0.18	0.37	15.57
34	100	10.57	1.35	34.35
35	25	0.12	0.24	7.35
36	100	10.41	1.33	33.35
37	25	0.05	0.1	1.45
38	100	10.26	1.31	32.46
39	25	0.08	0.16	3.47
40	100	10.11	1.29	31.59

Table (6.5) Cont

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
41	25	0.13	0.26	8.53
42	100	9.88	1.26	30.3
43	50	2.58	1.31	73.65
44	75	7.12	1.61	67.02
45	25	0.12	0.24	7.13
46	75	6.66	1.51	59.21
47	25	0.13	0.26	8.05
48	75	6.21	1.41	52.03
49	25	0.05	0.1	1.45
50	75	6.05	1.37	49.57
51	25	0.08	0.16	3.47
52	75	5.89	1.33	47.12
53	25	0.14	0.29	10.3
54	75	5.64	1.28	43.57
55	25	0.14	0.29	9.78
56	75	5.39	1.22	40.06
57	50	0.65	0.33	5.82
58	25	0.08	0.16	3.47
59	50	0.52	0.26	3.8
60	25	0.2	0.41	18.93
61	25	0.07	0.14	2.71
62	25	0.2	0.41	18.93
63	75	4.63	1.05	30.26
64	50	1.1	0.56	15.29
65	25	0.05	0.1	1.45
66	50	0.87	0.44	9.85
67	25	0.09	0.18	4.31
68	75	3.3	0.75	16.1
69	25	0.1	0.2	5.24
70	75	3.01	0.68	13.65
71	25	0.13	0.26	8.28
72	25	0.07	0.14	2.71
73	75	2.85	0.64	12.27
74	25	0.1	0.2	5.05
75	75	2.7	0.61	11.12
76	25	0.13	0.26	8.53
77	75	2.49	0.56	9.58
78	50	2.22	1.13	55.75
79	75	4.25	0.96	25.77
80	25	0.08	0.16	3.47

Table (6.5) Cont

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
81	50	-2.31	1.18	60.01
82	25	0.07	0.14	2.71
83	75	3.99	0.9	22.93
84	25	0.06	0.12	2.04
85	50	3.66	1.86	140.9
86	50	3.38	1.72	121.59
87	25	0.1	0.2	5.24
88	25	-0.34	0.69	49.66
89	25	0.41	0.84	71.97
90	25	0.15	0.31	11.11
91	50	2.95	1.5	94.39
92	50	2.66	1.35	77.97
93	25	0.11	0.22	6.26
94	25	0.13	0.26	8.52
95	50	0.77	0.39	7.78
96	25	0.1	0.2	5.24
97	50	0.58	0.3	4.66
98	25	0.15	0.31	11.11
99	50	0.33	0.17	1.66
100	25	0.1	0.2	5.24
101	50	1.41	0.72	24.24
102	25	0.69	1.4	186.08
103	200	17.79	0.57	3.08

Table (6.6) The Pressure at Each Node for the First Proposed Network

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
1	977	0.55	981.63	4.63
2	975	0.2	981.55	6.55
3	955	0.11	979.9	24.9
4	957	0.3	978.16	21.16
5	945	0.64	978.95	33.95
6	940	0.14	978.7	38.7
7	920	0.58	975.12	55.12
8	928	0.81	958.21	30.21
9	903	0.32	959.79	56.79
10	922	0.3	957.1	35.1
11	902	0.9	953.57	51.57
12	890	0.05	953.44	63.44
13	905	0.06	952.47	47.47
14	895	0.16	951.5	56.5
15	906	0.17	950.65	44.65
16	903	0.07	950.62	47.62
17	907	0.12	945.55	38.55
18	896	0.06	945.33	49.33
19	908	0.03	944.69	36.69
20	912	0.05	944.51	32.51
21	903	0.17	941.62	38.62
22	890	0.09	941.18	51.18
23	895	0.07	941.32	46.32
24	913	0.07	944.32	31.32
25	913	0.09	944.33	31.33
26	908	0.05	943.25	35.25
27	912	0.05	943.17	31.17
28	905	0.07	943.12	38.12
29	907	0.1	941.55	34.55
30	889	0.05	941.4	52.4
31	900	0.23	939.75	39.75
32	915	0.15	938.1	23.1
33	884	0.24	937.09	53.09
34	890	0.18	935.37	45.37
35	879	0.05	935.78	56.78
36	874	0.12	935.3	61.3
37	876	0.1	934.45	58.45
38	884	0.05	934.3	50.3
39	874	0.07	933.25	59.25
40	880	0.08	933.06	53.06

Table (6.6) Cont.

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
41	873	0.09	932.71	59.71
42	857	0.13	931.48	66.48
43	871	0.19	931.5	60.5
44	877	0.34	925.13	48.13
45	879	0.12	924.8	45.8
46	877	0.32	923.95	46.95
47	878	0.13	923.79	45.79
48	877	0.11	920.98	43.98
49	867	0.05	920.77	53.77
50	876	0.08	918.7	42.7
51	874	0.08	918.49	44.49
52	872	0.1	914.93	42.93
53	872	0.14	914.19	42.19
54	869	0.11	910.79	41.79
55	867	0.14	908.88	41.88
56	867	0.1	906.91	39.91
57	864	0.05	906.76	42.76
58	869	0.08	906.41	37.41
59	859	0.05	906.64	47.64
60	864	0.2	904.54	40.54
61	855	0.07	906.54	51.54
62	850	0.2	906.32	56.32
63	866	0.23	904.18	38.18
64	855	0.18	901.28	46.28
65	850	0.05	901.18	51.18
66	856	0.37	899.80	43.80
67	834	0.09	898.94	64.94
68	862	0.18	901.28	39.28
69	863	0.1	901.15	38.15
70	858	0.04	900.88	42.88
71	854	0.06	900.10	46.10
72	846	0.07	899.89	53.89
73	857	0.05	900.38	43.38
74	855	0.1	900.08	45.08
75	860	0.08	899.83	39.83
76	857	0.13	898.83	41.83
77	843	0.2	902.04	59.04
78	822	0.07	901.77	66.77
79	860	0.09	893.03	33.04
80	860	0.12	890.25	30.25

Table (6.6) Cont.

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
81	851	0.09	887.15	36.15
82	853	0.13	886.7	33.7
83	845	0.19	886.01	41.01
84	850	0.34	885.68	35.68
85	854	0.12	881.81	27.81
86	817	0.32	878.03	61.03
87	830	0.13	857.83	27.83
88	825	0.11	850.53	25.53
89	811	0.05	849.69	38.69
90	811	0.08	836.37	25.37
91	827	0.08	835.74	8.74
92	807	0.35	828.58	21.58
93	813	0.13	828.01	15.01
94	810	0.09	827.88	17.88
95	805	0.1	827.09	22.09
96	811	0.1	827.46	16.46
97	809	0.15	826.79	17.79
98	809	0.23	827.33	18.33
99	805	0.1	827.01	22.01
100	778	0.73	822.52	44.52
101	767	0.69	785.30	18.3
Reservoir	982	-17.79	982.00	0

6.4.2 The Second Proposed Network

Filling up the computer program with basic data, varying the diameter of the links ,and increasing the number of nodes and changing many nodes positions , and obtained the calculated head losses, velocities and pressures. The procedure were repeated for the Second proposed network until the most suitable diameters that meet the water demand are found. The data obtained for the diameter and basic data are listed in Table (6.7). The layout of the proposed network is shown in Figure (6.7) and (6.8). The predicted values of velocity, head loss, pressure, and grade are given in Tables (6.8) and (6.9). Figure (6.9) depicts the final drawings of the proposed water distribution network with storage reservoir.

It may be seen in the figures the new pipelines suggested for Beit kahel water network for year (2028). By comparing the existing link diameters with that obtained for year (2028), it is found many existing pipelines are proposed to be replaced by larger pipelines and other suggested to remain same. This conclusion also agreed with our point of view of constructing new mains and using some of the existing,

6.٦ SUMMARY

In this chapter, the existing water distribution network for Beit kahel village has been studied and evaluated. The result of calculation necessary for the network design have been given and discussed. The proposed water distribution network has been presented.

We observe what is mentioned above that the difference between the first and second suggestions summarizing the following points :

1. The Cost : the cost of the first suggestion is lesser than the second suggestion because it is use is in the case of rehabilitation the existing water distribution network for Beit kahel village , but the second suggestion it is used in case of building whole new water distribution network offers all the populations needs after (25) years .

2.The pain and time : the second suggestion needs time and pain to be carried out more more than the first suggestion .

Table (6.7 a) X and Y Coordinates of Nodes For The Second Proposed Network

ID	X coordinate	Y coordinate	ID	X coordinate	Y coordinate
1	158039.62	108042.97	41	156964.86	108711.77
2	157985.83	108146.28	42	156906.45	108517.65
3	158059.16	108288.30	43	156885.20	108692.12
4	157887.79	108087.31	44	156878.02	108529.71
5	157972.44	108319.73	45	156878.95	108707.53
6	157892.57	108012.57	46	156845.71	108547.63
7	157817.38	108122.50	47	156808.57	108547.63
8	157854.65	108342.37	48	156815.05	108377.58
9	157785.51	108059.16	49	156812.38	108558.96
10	157713.07	108152.70	50	156770.14	108661.08
11	157549.53	108457.10	51	156713.68	108567.72
12	157612.30	108193.98	52	156729.41	108443.46
13	157499.94	108270.93	53	156720.80	108575.05
14	157504.54	108344.70	54	156752.98	108664.88
15	157687.25	108388.27	55	156667.03	108789.40
16	157514.49	108134.70	56	156720.20	108712.95
17	157396.29	108215.46	57	156766.18	108838.59
18	157277.35	108336.28	58	156633.26	108733.17
19	157308.41	108399.25	59	156642.36	108853.74
20	157366.53	108512.98	60	156568.35	108756.61
21	157184.80	108360.09	61	156584.87	108819.87
22	157174.08	108281.52	62	156499.12	108737.86
23	157163.80	108367.55	63	156505.87	108856.06
24	157177.85	108443.58	64	156507.67	108873.63
25	157128.05	108373.62	65	156451.43	108876.06
26	157109.65	108308.90	66	156428.53	108446.65
27	157048.08	108437.99	67	156431.09	108705.10
28	157056.02	108332.63	68	156539.91	108708.72
29	157034.72	108450.36	69	156432.25	108672.30
30	157041.81	108494.94	70	156559.56	108672.37
31	157086.12	108515.37	71	156392.39	108739.19
32	157227.65	108546.83	72	156630.63	108593.35
33	157110.62	108632.46	73	156632.11	108731.45
34	157045.66	108628.35	74	156496.90	108612.77
35	157010.79	108465.23	75	156343.46	108478.32
36	157026.84	108606.76	76	156485.22	108628.66
37	157009.93	108348.92	77	156322.33	108703.15
38	156977.64	108485.73	78	156319.54	108672.78
39	156974.27	108506.41	79	156311.91	108540.60
40	156935.67	108377.76	80	156413.53	108609.33

Table (6.7a) Cont

ID	X coordinate	Y coordinate	ID	X coordinate	Y coordinate
81	156239.55	108663.91	**103**	155808.33	108674.31
82	156219.23	108752.73	**104**	155757.71	108807.36
83	156340.10	108799.18	**105**	155761.19	108950.24
84	156405.40	108878.85	**106**	155726.50	108651.79
85	156239.50	108840.26	**107**	155685.65	108794.66
86	156254.12	108906.42	**108**	155672.38	108645.99
87	155996.32	108907.49	**109**	155628.55	108782.94
88	156123.97	108876.38	**110**	155630.84	108678.46
89	155930.40	108914.99	**111**	155597.09	108780.81
90	156134.65	108755.71	**112**	155566.78	108665.72
91	156337.33	108781.12	**113**	155242.07	108768.79
92	155853.41	108880.60	**114**	155590.36	108953.29
93	155812.10	108645.85	**115**	155641.23	109089.32
94	156113.01	108631.86	**116**	155500.29	108945.68
95	156230.53	108582.79	**117**	155410.11	108959.51
96	156071.34	108632.62	**118**	155470.15	109063.31
97	156163.62	108540.77	**119**	155452.88	109194.22
98	155965.79	108673.66	**120**	155416.15	109094.00
99	155960.54	108578.33	**121**	155324.31	109056.33
100	155915.05	108705.79	**122**	155501.04	109218.48
101	155807.86	108594.11	**Reservoir**	158166.35	108038.09
102	156185.60	108775.97			

Table (6.7 b) Input Data For The Second Proposed Network (Nodes)

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
1	976	0.6	**41**	894	0.1
2	975	0.3	**42**	890	0.11
3	967	0.1	**43**	866	0.13
4	954	0.2	**44**	884	0.13
5	960	0.1	**45**	888	0.1
6	947	0.06	**46**	879	0.19
7	945	0.22	**47**	857	0.1
8	950	0.2	**48**	876	0.18
9	930	0.1	**49**	884	0.1
10	942	0.3	**50**	872	0.13
11	897	0.06	**51**	857	0.07
12	921	0.4	**52**	870	0.18
13	920	0.2	**53**	878	0.27
14	927	0.28	**54**	879	0.14
15	933	0.15	**55**	877	0.19
16	915	0.22	**56**	871	0.07
17	898	0.11	**57**	859	0.11
18	903	0.32	**58**	876	0.14
19	907	0.27	**59**	868	0.05
20	887	0.17	**60**	872	0.17
21	898	0.05	**61**	870	0.05
22	890	0.06	**62**	869	0.09
23	906	0.07	**63**	866	0.06
24	895	0.16	**64**	858	0.05
25	904	0.17	**65**	852	0.05
26	895	0.06	**66**	867	0.19
27	908	0.12	**67**	864	0.05
28	894	0.06	**68**	868	0.1
29	909	0.02	**69**	857	0
30	911	0.07	**70**	864	0.13
31	906	0.18	**71**	866	0.13
32	875	0.2	**72**	861	0.33
33	895	0.12	**73**	846	0.12
34	913	0.05	**74**	843	0
35	908	0.04	**75**	843	0.12
36	917	0.07	**76**	831	0.1
37	888	0.06	**77**	830	0.1
38	907	0.2	**78**	862	0.1
39	888	0.07	**79**	858	0.19
40	900	0.24	**80**	846	0.19

Table (6.7b) Cont.

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
81	861	0.16	**103**	823	0.08
82	859	0.18	**104**	807	0.2
83	854	0.16	**105**	804	0.12
84	843	0.05	**106**	813	0.08
85	855	0.23	**107**	806	0.18
86	842	0.03	**108**	805	0.07
87	835	0.07	**109**	807	0.07
88	856	0.28	**110**	805	0.06
89	834	0.09	**111**	807	0.12
90	854	0.48	**112**	798	0.13
91	841	0.33	**113**	798	0.11
92	818	0.14	**114**	778	0.29
93	860	0.11	**115**	765	0.08
94	851	0.23	**116**	782	0.26
95	853	0.08	**117**	781	0.1
96	844	0.27	**118**	768	0.15
97	851	0.09	**119**	765	0.12
98	831	0.2	**120**	777	0.19
99	830	0.05	**121**	787	0.11
100	825	0.36	**122**	787	0.12
101	817	0.13	**Reservoir**	982	-17.78
102	811	0.18			

Table (6.7c) Input Data For The Second Proposed Network (Pipes)

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
1	1	2	127	50
2	2	3	162	25
3	1	4	159	150
4	4	5	251	25
5	4	6	77	25
6	4	7	79	150
7	7	8	24	25
8	7	9	71	25
9	7	10	109	150
10	10	11	190	25
11	10	12	109	100
12	12	13	136	100
13	13	14	75	25
14	14	15	200	25
15	14	16	114	25
16	13	17	118	25
17	13	18	233	100
18	18	19	70	50
19	19	20	130	25
20	18	21	96	100
21	21	22	89	25
22	21	23	22	100
23	23	24	79	25
24	23	25	37	100
25	25	26	67	25
26	25	27	103	100
27	27	28	110	25
28	27	29	18	100
29	29	30	46	50
30	30	31	54	25
31	31	32	164	25
32	31	33	138	25
33	30	34	133	25
34	29	35	28	100
35	35	36	143	25
36	35	37	117	25
37	35	38	39	100
38	38	39	108	25
39	38	40	48	100
40	40	41	229	25
41	40	42	31	100

Table (6.7c) Cont.

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
42	42	43	154	25
43	42	44	31	100
44	44	45	186	25
45	44	46	37	100
46	46	47	177	25
47	46	48	33	100
48	48	49	104	25
49	48	50	46	100
50	50	51	166	25
51	50	52	42	100
52	52	53	91	75
53	53	54	45	25
54	53	55	112	75
55	55	56	104	25
56	56	57	40	25
57	55	58	121	75
58	58	59	69	25
59	58	60	102	75
60	60	61	75	25
61	60	62	84	75
62	62	63	53	25
63	63	64	80	25
64	63	65	72	25
65	62	66	26	75
66	66	67	109	25
67	67	68	33	25
68	67	69	127	25
69	69	70	37	25
70	66	71	112	75
71	52	72	101	75
72	72	73	147	25
73	72	74	137	75
74	74	75	158	75
75	75	76	231	25
76	75	77	95	25
77	71	78	101	75
78	78	79	32	75
79	79	80	122	25
80	79	81	77	50
81	81	82	93	25
82	71	83	82	75

Table (6.7c) Cont.

Pipe#	Head Node	Tail Node	Length (m)	Diameter (mm)
83	83	84	137	25
84	83	85	110	75
85	85	86	69	25
86	86	87	83	25
87	85	88	122	75
88	88	89	201	25
89	88	90	122	50
90	90	91	143	25
91	91	92	196	25
92	90	93	122	50
93	75	93	169	75
94	93	94	75	75
95	94	95	132	25
96	94	96	42	50
97	96	97	160	25
98	96	98	115	50
99	98	99	97	25
100	98	100	60	50
101	10	101	188	25
102	100	102	126	50
103	102	103	102	25
104	102	104	63	50
105	104	106	169	25
106	104	107	75	50
107	107	108	150	25
108	107	109	58	50
109	109	110	105	25
110	104	105	145	25
111	109	111	32	50
112	111	112	119	25
113	111	113	99	25
114	104	114	244	50
115	114	115	150	25
116	114	116	91	25
117	116	117	91	25
118	114	118	166	50
119	118	119	139	25
120	118	120	62	50
121	120	121	105	25
122	120	122	217	25
123	Reservoir	1	123	200

Table (6.8) Values of Velocity and Head Loss in Pipes for the Second Proposed Network

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
1	50	0.4	0.2	2.33
2	25	0.1	0.2	5.24
3	150	16.78	0.95	11.21
4	25	0.1	0.2	5.24
5	25	0.06	0.12	2.04
6	150	16.42	0.93	10.77
7	25	0.2	0.41	18.93
8	25	0.1	0.2	5.24
9	150	15.9	0.9	10.15
10	25	0.06	0.12	2.04
11	100	15.54	1.98	70.08
12	100	15.14	1.93	66.78
13	25	0.65	1.32	167.95
14	25	0.15	0.31	11.11
15	25	0.22	0.45	22.59
16	25	0.11	0.22	6.26
17	100	14.18	1.81	59.15
18	50	0.44	0.22	2.79
19	25	0.17	0.35	14.01
20	100	13.42	1.71	53.41
21	25	0.06	0.12	2.04
22	100	13.31	1.69	52.6
23	25	0.16	0.33	12.52
24	100	13.08	1.67	50.93
25	25	0.06	0.12	2.04
26	100	12.85	1.64	49.29
27	25	0.06	0.12	2.04
28	100	12.67	1.61	48.01
29	50	0.62	0.32	5.26
30	25	0.5	1.02	103.31
31	25	0.2	0.41	18.93
32	25	0.12	0.24	7.35
33	25	0.05	0.1	1.45
34	100	12.03	1.53	43.62
35	25	0.07	0.14	2.71
36	25	0.06	0.12	2.04
37	100	11.86	1.51	42.48
38	25	0.07	0.14	2.71
39	100	11.59	1.48	40.71
40	25	0.1	0.2	5.24
41	100	11.25	1.43	38.53

Table (6.8) Cont

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
42	25	0.13	0.26	8.53
43	100	11.01	1.4	37.02
44	25	0.1	0.2	5.24
45	100	10.78	1.37	35.6
46	25	0.1	0.2	5.24
47	100	10.49	1.34	33.85
48	25	0.1	0.2	5.24
49	100	10.21	1.3	32.19
50	25	0.07	0.14	2.71
51	100	10.01	1.27	31.03
52	75	4.99	1.13	34.67
53	25	0.14	0.29	9.78
54	75	4.58	1.04	29.58
55	25	0.18	0.37	15.58
56	25	0.11	0.22	6.26
57	75	4.21	0.95	25.3
58	25	0.05	0.1	1.45
59	75	4.02	0.91	23.23
60	25	0.05	0.1	1.45
61	75	3.8	0.86	20.93
62	25	0.16	0.33	12.52
63	25	0.05	0.1	1.45
64	25	0.05	0.1	1.45
65	75	3.55	0.8	18.44
66	25	0.28	0.57	35.3
67	25	0.1	0.2	5.24
68	25	0.13	0.26	8.52
69	25	0.13	0.26	8.52
70	75	3.08	0.7	14.18
71	75	4.84	1.1	75
72	25	0.12	0.24	25
73	75	4.39	0.99	75
74	75	4.39	0.99	75
75	25	0.1	0.2	25
76	25	0.1	0.2	25
77	75	0.82	0.19	75
78	75	0.72	0.16	75
79	25	0.19	0.39	25
80	50	0.34	0.17	50
81	25	0.18	0.37	25
82	75	2.13	0.48	75

Table (6.8) Cont.

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
83	25	0.05	0.1	1.45
84	75	1.92	0.43	5.9
85	25	0.1	0.2	5.24
86	25	0.07	0.14	2.71
87	75	1.59	0.36	4.16
88	25	0.09	0.18	4.31
89	50	1.22	0.62	18.33
90	25	0.47	0.96	92.13
91	25	0.14	0.29	9.78
92	50	0.27	0.14	1.1
93	75	4.07	0.92	23.84
94	75	4.23	0.96	25.56
95	25	0.08	0.16	3.47
96	50	3.92	2	160
97	25	0.09	0.18	4.31
98	50	3.56	1.81	133.85
99	25	0.05	0.1	1.45
100	50	3.31	1.69	116.97
101	25	0.13	0.26	8.52
102	50	2.82	1.44	86.94
103	25	0.08	0.16	3.47
104	50	2.56	1.3	72.68
105	25	0.08	0.16	3.47
106	50	0.74	0.38	7.3
107	25	0.07	0.14	2.71
108	50	0.49	0.25	3.4
109	25	0.06	0.12	2.04
110	25	0.12	0.24	7.35
111	50	0.36	0.18	1.92
112	25	0.13	0.26	8.53
113	25	0.11	0.22	6.26
114	50	1.42	0.72	24.4
115	25	0.08	0.16	3.47
116	25	0.36	0.73	56.23
117	25	0.1	0.2	5.24
118	50	0.69	0.35	6.41
119	25	0.12	0.24	7.35
120	50	0.42	0.21	2.56
121	25	0.11	0.22	6.26
122	25	0.12	0.24	7.35
123	200	17.78	0.57	3.07

Table (6.9) The Pressure at Each Node for the Second Proposed Network

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
1	976	0.6	981.62	5.62
2	975	0.3	981.33	6.33
3	967	0.1	980.48	13.48
4	954	0.2	979.84	25.84
5	960	0.1	978.52	18.52
6	947	0.06	979.68	32.68
7	945	0.22	978.99	33.99
8	950	0.2	978.53	28.53
9	930	0.1	978.62	48.62
10	942	0.3	977.88	35.88
11	897	0.06	977.5	80.5
12	921	0.4	970.24	49.24
13	920	0.2	961.16	41.16
14	927	0.28	948.57	21.57
15	933	0.15	946.34	13.34
16	915	0.22	945.99	30.99
17	898	0.11	960.42	62.42
18	903	0.32	947.38	44.38
19	907	0.27	947.19	40.19
20	887	0.17	945.36	58.36
21	898	0.05	942.25	44.25
22	890	0.06	942.07	52.07
23	906	0.07	941.1	35.1
24	895	0.16	940.11	45.11
25	904	0.17	939.21	35.21
26	895	0.06	939.08	44.08
27	908	0.12	934.14	26.14
28	894	0.06	933.91	39.91
29	909	0.02	933.27	24.27
30	911	0.07	933.03	22.03
31	906	0.18	927.45	21.45
32	875	0.2	924.35	49.35
33	895	0.12	926.44	31.44
34	913	0.05	932.84	19.84
35	908	0.04	932.05	24.05
36	917	0.07	931.66	14.66
37	888	0.06	931.81	43.81
38	907	0.2	930.39	23.39
39	888	0.07	930.1	42.1
40	900	0.24	928.44	28.44
41	894	0.1	927.24	33.24

Table (6.9) Cont

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
42	890	0.11	927.24	37.24
43	866	0.13	925.93	59.93
44	884	0.13	926.1	42.1
45	888	0.1	925.12	37.12
46	879	0.19	924.78	45.78
47	857	0.1	923.85	66.85
48	876	0.18	923.66	47.66
49	884	0.1	923.12	39.12
50	872	0.13	922.18	50.18
51	857	0.07	921.73	64.73
52	870	0.18	920.88	50.88
53	878	0.27	917.72	39.72
54	879	0.14	917.28	38.28
55	877	0.19	915.59	38.59
56	871	0.07	913.85	42.85
57	859	0.11	913.2	54.2
58	876	0.14	914.58	38.58
59	868	0.05	914.41	46.41
60	872	0.17	912.98	40.98
61	870	0.05	912.83	42.83
62	869	0.09	911.41	42.41
63	866	0.06	910.36	44.36
64	858	0.05	910.28	52.28
65	852	0.05	910.24	58.24
66	867	0.19	910.08	43.08
67	864	0.05	909.16	45.16
68	868	0.1	908.59	40.59
69	857	0	908.88	51.88
70	864	0.13	907.8	43.8
71	866	0.13	909.56	43.56
72	861	0.33	917.56	56.56
73	846	0.12	916.48	70.48
74	843	0	913.8	70.8
75	843	0.12	909.47	66.47
76	831	0.1	908.26	77.26
77	830	0.1	908.97	78.97
78	862	0.1	909.43	47.43
79	858	0.19	909.4	51.4
80	846	0.19	907.3	61.3
81	861	0.16	909.27	48.27
82	859	0.18	907.82	48.82

Table (6.9) Cont

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
83	854	0.16	908.97	54.97
84	843	0.05	908.77	65.77
85	855	0.23	908.32	53.32
86	842	0.03	907.96	65.96
87	835	0.07	907.74	72.74
88	856	0.28	907.81	51.81
89	834	0.09	906.95	72.95
90	854	0.48	905.58	51.58
91	841	0.33	892.4	51.4
92	818	0.14	890.49	72.49
93	860	0.11	905.44	45.44
94	851	0.23	903.53	52.53
95	853	0.08	903.07	50.07
96	844	0.27	896.81	52.81
97	851	0.09	896.12	45.12
98	831	0.2	881.41	50.41
99	830	0.05	881.27	51.27
100	825	0.36	874.4	49.4
101	817	0.13	872.79	55.79
102	811	0.18	863.44	52.44
103	823	0.08	863.09	40.09
104	807	0.2	858.86	51.86
105	804	0.12	857.8	53.8
106	813	0.08	858.28	45.28
107	806	0.18	858.32	52.32
108	805	0.07	857.91	52.91
109	807	0.07	858.12	51.12
110	805	0.06	857.9	52.9
111	807	0.12	858.06	51.06
112	798	0.13	857.04	59.04
113	798	0.11	857.44	59.44
114	778	0.29	852.91	74.91
115	765	0.08	852.39	82.39
116	782	0.26	847.79	65.79
117	781	0.1	847.32	66.32
118	768	0.15	851.85	83.85
119	765	0.12	850.82	83.82
120	777	0.19	851.69	74.69
121	787	0.11	851.03	64.03
122	787	0.12	850.09	63.09
123	982	-17.78	982	0

CHAPTER SIX

ANALYSIS AND DISCUSSION OF RESULTS

6.1 GENERAL INTRODUCTION

In this project, an attempt is made to study and evaluate the existing water distribution network in Beit kahel village, and develop a future plans and appropriate technology for reconstruction and upgrading of the network, corresponding to population and population growth and water demand in the future (120 l/c.d), in order to supply all inhabitants of Beit kahel village with a sufficient amount of agood quality drinking water. In this chapter, the method of evaluating the existing water network will be described followed by discussion of results for the appropriate changes and modifications in the present mains and the future proposed water supply network.

6.2 CALCULATION SCHEME

As mentioned earlier, the analysis and design were carried out for Beit kahel water distribution network in three phases. First study and evaluate the existing water distribution network, secondly designing and constructing by changing the diameter in some present pipe , and thirdly designing and constructing a new network with the present storage reservoir. The calculation necessary for the network design is performed by the computer program EPANET, which make of use of Hardy-Cross method. The computations and the results of each of the three phases will be described and presented below.

6.3 THE EXISTING WATER DISTRIBUTION NETWORK

The existing water distribution network has been studied and evaluated. The existing water network consists of main pipelines and sub-mains. The main pipelines receives the water directly from a reservoir (200 cubic meter) and supplies the smaller diameters pipelines.

The calculation has been done for the existing water network and try to repair or redesign the same network for year (2028). The demand of water for each node necessary for the calculation where estimated by multiplying the population density by the area in which each node serves by water demand per capita per year. The elevation of each node from the aerial map and length of pipelines are calculated and obtained from the old pipe map The result for the existing network are given in the following paragraphs.

The computer program is used for doing the calculation and obtaining the results. The input data are given in Table (6.1) and shown in the layout of the existing network in Fig. (6.1) and Fig. (6.2). The output values of velocity, head loss, and pressure are given in Tables (6.2) and (6.3).

It may be seen that many values of the velocity are within the allowable ranges. The velocity in many pipes is less than (0.1) m/s and in others over than (2.0) m/s and the head loss is very high. The pressure in all nodes is negative pressure. At the same time, the diameters of the pipes are small especially the main pipes (3) in.

As mentioned earlier, Beit Kahel village is supplied by water coming from Asion settlement in the east north of Beit Kahel village, The water in the village is distributed by network most of which are old. The network is branch one made out of steel pipelines. The existing water distribution network is presented in Figure (5.2). The diameters of pipelines range from 1" to 3" (25-75 mm) as listed below in Table (٦.١).

Table (6.1) List of the Existing Distribution Lines

Diameter(mm)	Length (m)
25	**4746**
50	**1634**
75	**3672**

6.4 THE EXISTING WATER LOSSES

As mentioned earlier, the amount of water lost in the distribution system or uncounted of the quantity of water supplied. In view of this high percentage of losses, it is strongly recommended to carry survey to discover leaks and carry out the necessary repairs and maintenance. Many factors determine the quantity and percentage of water losses ; these differ from net work to another or even in the same net work:

1. **Losses In Main Supply Lines**

   These losses may be defined as the quantity of water lost in the main lines between the water source and distribution net work, the losses in the main supply line result from leaks due to damage to the line or to excessive water pressure or corrosion , And these losses are only a small percentage of the total losses .

2. **Losses In The Network**

   These losses constitute the quantity of water lost between the main supply lines and the consumers meters. And there is ahigh percentage of the losses originate from the network owing to its deteriorated condition and aging pipelines which doesn’t to standards and laid either exposed.

3. **Losses in Meter**

   These losses may be defined as the quantity of water that is being consumed without being recorded by consumers own meter ,

4. **Black losses**

   The illegal consumption of water (black losses) is present because of present economical and social circumstances.

Table (6.1a) X and Y Coordinates of Nodes For The Existing Network

ID	X coordinate	Y coordinate	ID	X coordinate	Y coordinate
1	158039.62	108042.97	41	156770.57	108567.65
2	157982.84	108141.83	42	156713.68	108443.46
3	157887.79	108087.31	43	156729.41	108575.05
4	157887.86	108124.50	44	156720.69	108664.85
5	157817.38	108122.50	45	156752.98	108692.12
6	157812.77	108095.64	46	156707.23	108678.58
7	157499.94	108270.93	47	156721.35	108688.85
8	157504.54	108335.97	48	156667.03	108712.95
9	157277.35	108336.28	49	156712.59	108817.61
10	157368.21	108398.86	50	156633.26	108733.17
11	157184.51	108360.43	51	156635.98	108792.44
12	157174.08	108281.52	52	156568.70	108756.34
13	157163.80	108367.55	53	156577.13	108817.93
14	157177.85	108443.58	54	156499.12	108737.86
15	157128.05	108373.62	55	156585.92	108888.30
16	157118.18	108335.35	56	156428.53	108731.45
17	157048.08	108437.99	57	156431.09	108705.10
18	157.56.05	108332.19	58	156545.18	108708.70
19	157034.72	108450.36	59	156432.25	108672.30
20	157041.81	108494.94	60	156559.56	108672.37
21	157086.12	108515.37	61	156394.05	108667.21
22	157181.64	108504.23	62	156433.56	108643.80
23	157110.62	108632.46	63	156392.39	108739.19
24	157042.06	108563.55	64	156239.50	108840.26
25	157016.26	108518.34	65	156239.97	108879.90
26	157010.79	108465.23	66	156123.97	108876.38
27	156997.50	108532.64	67	155930.40	108914.99
28	157008.78	108430.50	68	156319.54	108763.15
29	156977.64	108485.73	69	156353.20	108700.32
30	156974.27	108377.76	70	156312.31	108672.95
31	156935.67	108506.41	71	156349.04	108655.48
32	156991.21	108593.11	72	156413.52	108628.70
33	156878.62	108529.71	73	156288.65	108655.44
34	156863.51	108636.31	74	156287.34	108634.53
35	156845.71	108547.63	75	156239.63	108664.34
36	156844.39	108487.37	76	156219.23	108752.73
37	156815.05	108558.96	77	156343.86	108609.51
38	156812.38	108661.08	78	156322.33	108540.60
39	156790.26	108565.24	79	156212.98	108630.46

40	156788.52	108617.11	**80**	156185.60	108645.85

Table (6.1a) Cont

ID	X coordinate	Y coordinate	ID	X coordinate	Y coordinate
81	156113.09	108631.43	**92**	155757.86	108806.95
82	156230.53	108582.79	**93**	155729.70	108742.50
83	156071.34	108632.62	**94**	155685.23	108794.54
84	156164.03	108540.61	**95**	155672.38	108645.99
85	156134.50	108755.71	**96**	155628.55	108782.94
86	155853.41	108880.60	**97**	155631.49	108723.09
87	155766.03	108674.02	**98**	155597.09	108780.81
88	155915.05	108705.79	**99**	155590.21	108703.34
89	155808.76	108593.25	**100**	155590.36	108953.29
90	155812.02	108776.01	**101**	155470.15	109063.31
91	155807.89	108674.50	**Reservoir**	156343.86	108038.08

Table (6.1b) Input Data For The Existing Network (Nodes)

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
1	977	0.14	41	873	0.05
2	975	0.07	42	857	0.05
3	955	0.05	43	871	0.09
4	957	0.3	44	877	0.17
5	945	0.16	45	879	0.06
6	940	0.05	46	877	0.1
7	920	0.15	47	878	0.04
8	928	0.2	48	877	0.06
9	903	0.08	49	867	0.04
10	922	0.09	50	876	0.04
11	902	0.05	51	874	0.04
12	890	0.02	52	872	0.05
13	905	0.03	53	872	0.04
14	895	0.08	54	869	0.06
15	906	0.08	55	867	0.06
16	903	0.02	56	867	0.05
17	907	0.06	57	864	0.06
18	896	0.02	58	869	0.04
19	908	0.02	59	859	0.09
20	912	0.03	60	864	0.08
21	903	0.08	61	855	0.02
22	890	0.09	62	850	0.08
23	895	0.06	63	866	0.07
24	913	0.03	64	855	0.09
25	913	0.03	65	850	0.03
26	908	0.03	66	856	0.09
27	912	0.02	67	834	0.03
28	905	0.02	68	862	0.06
29	907	0.05	69	863	0.06
30	889	0.02	70	858	0.04
31	900	0.07	71	854	0.03
32	915	0.05	72	846	0.03
33	884	0.07	73	857	0.03
34	890	0.05	74	855	0.05
35	879	0.02	75	860	0.1
36	874	0.03	76	857	0.05
37	876	0.03	77	843	0.10
38	884	0.02	78	822	0.03
39	874	0.03	79	860	0.05

40	880	0.02	**80**	860	0.06

Table (6.1b) Cont

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
81	851	0.09	**92**	807	0.4
82	853	0.02	**93**	813	0.03
83	845	0.08	**94**	810	0.05
84	850	0.03	**95**	805	0.03
85	854	0.30	**96**	811	0.05
86	817	0.06	**97**	809	0.02
87	830	0.09	**98**	809	0.06
88	825	0.10	**99**	805	0.04
89	811	0.03	**100**	778	0.3
90	811	0.06	**101**	767	0.3
91	827	0.05	**Reservoir**	982	-7.08

Table (6.1c) Input Data For The Existing Network (Pipes)

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
1	1	3	150	75
2	1	2	129	25
3	3	4	43	25
4	3	5	86	75
5	5	6	26	25
6	5	7	380	75
7	7	8	67	25
8	7	9	250	75
9	9	10	67	25
10	9	11	110	75
11	11	12	88	25
12	11	13	22	75
13	13	14	80	25
14	13	15	38	75
15	15	16	12	25
16	15	17	110	75
17	17	18	110	75
18	17	19	19	75
19	19	20	46	25
20	20	21	62	25
21	21	22	102	25
22	21	23	112	25
23	20	24	68	25
24	20	25	42	25
25	19	26	35	75
26	26	28	50	25
27	26	27	51	25
28	26	29	42	75
29	29	30	108	25
30	29	31	46	75
31	31	32	148	25
32	31	33	72	75
33	33	34	110	25
34	33	35	38	75
35	35	36	66	25
36	35	37	40	75
37	37	38	102	25
38	37	39	37	75

39	39	40	55	25
40	39	41	17	75

Table (6.1c) Cont

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
41	41	42	144	25
42	41	43	40	75
43	43	77	400	75
44	43	44	95	75
45	44	45	46	25
46	44	46	20	75
47	46	47	20	25
48	46	48	57	75
49	48	49	142	25
50	48	50	46	75
51	50	51	60	25
52	50	52	80	75
53	52	53	72	25
54	52	54	95	75
55	54	55	196	25
56	54	56	97	75
57	56	57	25	50
58	57	58	100	25
59	57	59	31	50
60	59	60	111	25
61	59	61	37	25
62	59	62	17	25
63	56	63	90	75
64	63	64	190	50
65	64	65	66	25
66	64	66	150	50
67	66	67	200	25
68	63	68	180	75
69	68	69	25	25
70	68	70	30	75
71	70	71	94	25
72	71	72	75	25
73	70	73	40	75
74	73	74	60	25
75	73	75	50	75
76	75	76	117	25
77	75	79	60	75
78	79	80	50	75

79	80	81	120	75
80	81	82	132	25

Table (6.1c) Cont

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
81	77	79	150	75
82	77	78	100	25
83	81	83	50	75
84	83	84	160	25
85	83	87	200	75
86	87	88	60	50
87	88	89	160	25
88	80	85	170	50
89	66	85	250	50
90	85	86	340	25
91	88	90	150	50
92	90	92	100	50
93	90	91	102	25
94	92	93	66	25
95	92	94	90	50
96	94	95	150	25
97	94	96	90	50
98	96	97	60	25
99	96	98	78	50
100	98	99	60	25
101	92	100	250	50
102	100	101	200	25
103	Reservoir	1	120	75

Table (6.2) Values of Velocity and Head Loss in Pipes for the Existing Network

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
1	75	6.87	1.56	62.77
2	25	0.07	0.04	0.09
3	25	0.3	0.15	1.38
4	75	6.52	1.48	56.96
5	25	0.05	0.03	0.05
6	75	6.31	1.43	53.61
7	25	0.2	0.41	18.93
8	75	5.96	1.35	48.24
9	25	0.09	0.18	4.31
10	75	5.79	1.31	45.72
11	25	0.02	0.04	0.27
12	75	5.72	1.29	44.7
13	25	0.08	0.16	3.47
14	75	5.61	1.27	43.12
15	25	0.02	0.04	0.27
16	75	5.51	1.25	41.71
17	25	0.02	0.04	0.27
18	75	5.43	1.23	40.59
19	25	0.32	0.65	45.21
20	25	0.23	0.47	24.52
21	25	0.09	0.18	4.31
22	25	0.06	0.12	2.04
23	25	0.03	0.06	0.56
24	25	0.03	0.06	0.57
25	75	5.09	1.15	36.01
26	25	0.02	0.04	0.27
27	25	0.02	0.04	0.27
28	75	5.02	1.14	35.1
29	25	0.02	0.04	0.27
30	75	4.95	1.12	34.2
31	25	0.05	0.1	1.45
32	75	4.83	1.09	32.68
33	25	0.05	0.1	1.45
34	75	4.71	1.07	31.19
35	25	0.03	0.06	0.56
36	75	4.66	1.05	30.58
37	25	0.02	0.04	0.27
38	75	4.61	1.04	29.98

39	25	0.02	0.04	0.27
40	75	4.56	1.03	29.38

Table (6.2) Cont

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
41	25	0.05	0.1	1.45
42	75	4.46	1.01	28.2
43	75	1.99	0.45	6.32
44	75	2.38	0.54	8.82
45	25	0.06	0.12	2.04
46	75	2.15	0.49	7.31
47	25	0.04	0.08	0.96
48	75	2.01	0.46	6.45
49	25	0.04	0.08	0.96
50	75	1.91	0.43	5.87
51	25	0.04	0.08	0.96
52	75	1.83	0.41	5.42
53	25	0.04	0.08	0.96
54	75	1.74	0.39	4.94
55	25	0.06	0.12	2.04
56	75	1.62	0.37	4.33
57	50	0.37	0.19	2.02
58	25	0.04	0.08	0.96
59	50	0.27	0.14	1.13
60	25	0.08	0.16	3.47
61	25	0.02	0.04	0.27
62	25	0.08	0.16	3.47
63	75	1.2	0.27	2.48
64	50	0.37	0.19	2.02
65	25	0.03	0.06	0.56
66	50	0.25	0.13	0.98
67	25	0.03	0.06	0.56
68	75	0.76	0.17	1.07
69	25	0.06	0.12	2.04
70	75	0.64	0.15	0.78
71	25	0.06	0.12	2.04
72	25	0.03	0.06	0.56
73	75	0.54	0.12	0.57
74	25	0.05	0.1	1.45
75	75	0.46	0.1	0.42
76	25	0.05	0.1	1.45
77	75	0.31	0.07	0.2
78	75	1.81	0.41	5.3
79	75	1.83	0.41	5.42

80	25	0.02	0.04	0.27

Table (6.2) Cont

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
81	75	-1.86	0.42	5.58
82	25	0.03	0.06	0.56
83	75	1.72	0.39	4.83
84	25	0.03	0.06	0.56
85	75	1.61	0.36	4.27
86	50	1.52	0.77	27.68
87	25	0.03	0.06	0.56
88	50	-0.23	0.12	0.84
89	50	0.13	0.07	0.29
90	25	0.06	0.12	2.04
91	50	1.39	0.71	23.45
92	50	1.28	0.65	20.13
93	25	0.05	0.1	1.45
94	25	0.03	0.06	0.56
95	50	0.25	0.13	0.98
96	25	0.03	0.06	0.56
97	50	0.17	0.09	0.48
98	25	0.02	0.04	0.27
99	50	0.1	0.05	0.18
100	25	0.04	0.08	0.96
101	50	0.6	0.31	4.95
102	25	0.3	0.61	40.11
103	75	7.08	1.6	66.37

Table (6.3) The Pressure at Each Node for the Existing Network

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
1	977	0.14	974.04	-2.96
2	975	0.07	974.02	-0.98
3	955	0.05	964.62	9.62
4	957	0.3	964.56	7.56
5	945	0.16	959.72	14.72
6	940	0.05	959.72	19.72
7	920	0.15	939.35	19.35
8	928	0.2	938.08	10.08
9	903	0.08	927.29	24.29
10	922	0.09	927	5
11	902	0.05	922.26	20.26
12	890	0.02	922.24	32.24
13	905	0.03	921.28	16.28
14	895	0.08	921	26
15	906	0.08	919.64	13.64
16	903	0.02	919.64	16.64
17	907	0.06	915.05	8.05
18	896	0.02	915.02	19.02
19	908	0.02	914.28	6.28
20	912	0.03	912.2	0.2
21	903	0.08	910.68	7.68
22	890	0.09	910.24	20.24
23	895	0.06	910.45	15.45
24	913	0.03	912.16	-0.84
25	913	0.03	912.18	-0.82
26	908	0.03	913.02	5.02
27	912	0.02	913.01	1.01
28	905	0.02	913.01	8.01
29	907	0.05	911.54	4.54
30	889	0.02	911.52	22.52
31	900	0.07	909.97	9.97
32	915	0.05	909.76	-5.24
33	884	0.07	907.62	23.62
34	890	0.05	907.46	17.46
35	879	0.02	906.43	27.43
36	874	0.03	906.4	32.4
37	876	0.03	905.21	29.21
38	884	0.02	905.18	21.18
39	874	0.03	904.1	30.1

40	880	0.02	904.09	24.09

Table (6.3) Cont

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
41	873	0.05	903.6	30.6
42	857	0.05	903.39	38.39
43	871	0.09	902.47	31.47
44	877	0.17	901.64	24.64
45	879	0.06	901.54	22.54
46	877	0.1	901.49	24.49
47	878	0.04	901.47	23.47
48	877	0.06	901.12	24.12
49	867	0.04	900.99	33.99
50	876	0.04	900.85	24.85
51	874	0.04	900.79	26.79
52	872	0.05	900.42	28.42
53	872	0.04	900.35	28.35
54	869	0.06	899.95	30.95
55	867	0.06	899.55	32.55
56	867	0.05	899.53	32.53
57	864	0.06	899.48	35.48
58	869	0.04	899.38	30.38
59	859	0.09	899.44	40.44
60	864	0.08	899.06	35.06
61	855	0.02	899.43	44.43
62	850	0.08	899.39	49.39
63	866	0.07	899.31	33.31
64	855	0.09	898.92	43.92
65	850	0.03	898.88	48.88
66	856	0.09	898.78	42.78
67	834	0.03	898.66	64.66
68	862	0.06	899.11	37.11
69	863	0.06	899.06	36.06
70	858	0.04	899.09	41.09
71	854	0.03	898.9	44.9
72	846	0.03	898.86	52.86
73	857	0.03	899.07	42.07
74	855	0.05	898.98	43.98
75	860	0.1	899.05	39.05
76	857	0.05	898.88	41.88
77	843	0.10	899.95	56.95
78	822	0.03	899.89	64.89
79	860	0.05	899.11	39.11

80	860	0.06	898.84	38.84

Table (6.3) Cont

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
81	851	0.09	898.19	47.19
82	853	0.02	898.16	45.16
83	845	0.08	897.95	52.95
84	850	0.03	897.86	47.86
85	854	0.30	898.7	44.7
86	817	0.06	898.01	81.01
87	830	0.09	897.1	67.1
88	825	0.10	895.44	70.44
89	811	0.03	895.35	84.35
90	811	0.06	891.92	80.92
91	827	0.05	891.77	64.77
92	807	0.4	889.91	82.91
93	813	0.03	889.87	76.87
94	810	0.05	889.82	79.82
95	805	0.03	889.73	84.73
96	811	0.05	889.78	78.78
97	809	0.02	889.76	80.76
98	809	0.06	889.76	80.76
99	805	0.04	889.7	84.7
100	778	0.3	888.67	110.67
101	767	0.3	880.65	113.65
Reservoir	982	-7.08	982.00	0.000

6.5 THE PROPOSED WATER DISTRIBUTION NETWORK

In year (2028), the village of Beit Kahel is in direct need of larger quantities of water and more adequate supply scheme. In the proposed study for the water distribution network, the trial is made to redesign the network for year (2028) by partly using the old network. This section deals with the results of the proposed water distribution network for year (2028).

6.5.1 The First Proposed Network

It is tried to changes the diameters of the most pipes to get the appropriate diameters with the values of velocity, head loss and pressure within the allowable ranges, and the attempt is success because it is found that most of the pipes of the first proposed water network are acceptable according to the allowable maximum and minimum pressure and velocities.

As discussed earlier, the appropriate pipe diameters are found by use of the computer program filled with basic data (nodes water demand in year (2028), elevation of the nodes, the length of each pipes). So that, the pressure in the nodes and velocity in the links will meet the requirements as close as possible. The input data for the first proposed network are found and given in Table (6.4) along with appropriate diameters the elevation and demand data. The same data are shown in Figs. (6.4) and (6.5). The calculated velocities, head loss, grads, and pressure are given in Tables (6.5) and (6.6). The first proposed water distribution network for year (2028) is plotted in Figure (6.6), the diameters and lengths of all pipes are shown in the figure.

Table (6.4a) X and Y Coordinates of Nodes For The First Proposed Network

ID	X coordinate	Y coordinate	ID	X coordinate	Y coordinate
1	158039.62	108042.97	41	156770.57	108567.65
2	157982.84	108141.83	42	156713.68	108443.46
3	157887.79	108087.31	43	156729.41	108575.05
4	157887.86	108124.50	44	156720.69	108664.85
5	157817.38	108122.50	45	156752.98	108692.12
6	157812.77	108095.64	46	156707.23	108678.58
7	157499.94	108270.93	47	156721.35	108688.85
8	157504.54	108335.97	48	156667.03	108712.95
9	157277.35	108336.28	49	156712.59	108817.61
10	157368.21	108398.86	50	156633.26	108733.17
11	157184.51	108360.43	51	156635.98	108792.44
12	157174.08	108281.52	52	156568.70	108756.34
13	157163.80	108367.55	53	156577.13	108817.93
14	157177.85	108443.58	54	156499.12	108737.86
15	157128.05	108373.62	55	156585.92	108888.30
16	157118.18	108335.35	56	156428.53	108731.45
17	157048.08	108437.99	57	156431.09	108705.10
18	157.56.05	108332.19	58	156545.18	108708.70
19	157034.72	108450.36	59	156432.25	108672.30
20	157041.81	108494.94	60	156559.56	108672.37
21	157086.12	108515.37	61	156394.05	108667.21
22	157181.64	108504.23	62	156433.56	108643.80
23	157110.62	108632.46	63	156392.39	108739.19
24	157042.06	108563.55	64	156239.50	108840.26
25	157016.26	108518.34	65	156239.97	108879.90
26	157010.79	108465.23	66	156123.97	108876.38
27	156997.50	108532.64	67	155930.40	108914.99
28	157008.78	108430.50	68	156319.54	108763.15
29	156977.64	108485.73	69	156353.20	108700.32
30	156974.27	108377.76	70	156312.31	108672.95
31	156935.67	108506.41	71	156349.04	108655.48
32	156991.21	108593.11	72	156413.52	108628.70
33	156878.62	108529.71	73	156288.65	108655.44
34	156863.51	108636.31	74	156287.34	108634.53
35	156845.71	108547.63	75	156239.63	108664.34
36	156844.39	108487.37	76	156219.23	108752.73
37	156815.05	108558.96	77	156343.86	108609.51
38	156812.38	108661.08	78	156322.33	108540.60
39	156790.26	108565.24	79	156212.98	108630.46
40	156788.52	108617.11	80	156185.60	108645.85

Table (6.4a) Cont

ID	X coordinate	Y coordinate	ID	X coordinate	Y coordinate
81	156113.09	108631.43	**92**	155757.86	108806.95
82	156230.53	108582.79	**93**	155729.70	108742.50
83	156071.34	108632.62	**94**	155685.23	108794.54
84	156164.03	108540.61	**95**	155672.38	108645.99
85	156134.50	108755.71	**96**	155628.55	108782.94
86	155853.41	108880.60	**97**	155631.49	108723.09
87	155766.03	108674.02	**98**	155597.09	108780.81
88	155915.05	108705.79	**99**	155590.21	108703.34
89	155808.76	108593.25	**100**	155590.36	108953.29
90	155812.02	108776.01	**101**	155470.15	109063.31
91	155807.89	108674.50	**Reservoir**	156343.86	108038.08

Table (6.4 b) Input Data For The First Proposed Network (Nodes)

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
1	977	0.55	41	873	0.09
2	975	0.2	42	857	0.13
3	955	0.11	43	871	0.19
4	957	0.3	44	877	0.34
5	945	0.64	45	879	0.12
6	940	0.14	46	877	0.32
7	920	0.58	47	878	0.13
8	928	0.81	48	877	0.11
9	903	0.32	49	867	0.05
10	922	0.3	50	876	0.08
11	902	0.9	51	874	0.08
12	890	0.05	52	872	0.1
13	905	0.06	53	872	0.14
14	895	0.16	54	869	0.11
15	906	0.17	55	867	0.14
16	903	0.07	56	867	0.1
17	907	0.12	57	864	0.05
18	896	0.06	58	869	0.08
19	908	0.03	59	859	0.05
20	912	0.05	60	864	0.2
21	903	0.17	61	855	0.07
22	890	0.09	62	850	0.2
23	895	0.07	63	866	0.23
24	913	0.07	64	855	0.18
25	913	0.09	65	850	0.05
26	908	0.05	66	856	0.37
27	912	0.05	67	834	0.09
28	905	0.07	68	862	0.18
29	907	0.1	69	863	0.1
30	889	0.05	70	858	0.04
31	900	0.23	71	854	0.06
32	915	0.15	72	846	0.07
33	884	0.24	73	857	0.05
34	890	0.18	74	855	0.1
35	879	0.05	75	860	0.08
36	874	0.12	76	857	0.13
37	876	0.1	77	843	0.2
38	884	0.05	78	822	0.07
39	874	0.07	79	860	0.09
40	880	0.08	80	860	0.12

Table (6.4b) Cont.

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
81	851	0.09	**92**	807	0.35
82	853	0.13	**93**	813	0.13
83	845	0.19	**94**	810	0.09
84	850	0.34	**95**	805	0.1
85	854	0.12	**96**	811	0.1
86	817	0.32	**97**	809	0.15
87	830	0.13	**98**	809	0.23
88	825	0.11	**99**	805	0.1
89	811	0.05	**100**	778	0.73
90	811	0.08	**101**	767	0.69
91	827	0.08	**Reservoir**	982	-17.79

Table (6.4c) Input Data For The First Proposed Network (Pipes)

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
1	1	3	150	150
2	1	2	129	50
3	3	4	43	25
4	3	5	86	150
5	5	6	26	25
6	5	7	380	150
7	7	8	67	25
8	7	9	250	100
9	9	10	67	25
10	9	11	110	100
11	11	12	88	25
12	11	13	22	100
13	13	14	80	25
14	13	15	38	100
15	15	16	12	25
16	15	17	110	100
17	17	18	110	25
18	17	19	19	100
19	19	20	46	50
20	20	21	62	25
21	21	22	102	25
22	21	23	112	25
23	20	24	68	25
24	20	25	42	25
25	19	26	35	100
26	26	28	50	25
27	26	27	51	25
28	26	29	42	100
29	29	30	108	25
30	29	31	46	100
31	31	32	148	25
32	31	33	72	100
33	33	34	110	25
34	33	35	38	100
35	35	36	66	25
36	35	37	40	100
37	37	38	102	25
38	37	39	37	100
39	39	40	55	25
40	39	41	17	100

Table(6.4c) Cont.

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
41	41	42	144	25
42	41	43	40	100
43	43	77	400	50
44	43	44	95	75
45	44	45	46	25
46	44	46	20	75
47	46	47	20	25
48	46	48	57	75
49	48	49	142	25
50	48	50	46	75
51	50	51	60	25
52	50	52	80	75
53	52	53	72	25
54	52	54	95	75
55	54	55	196	25
56	54	56	97	75
57	56	57	25	50
58	57	58	100	25
59	57	59	31	50
60	59	60	111	25
61	59	61	37	25
62	59	62	17	25
63	56	63	90	75
64	63	64	190	50
65	64	65	66	25
66	64	66	150	50
67	66	67	200	25
68	63	68	180	75
69	68	69	25	25
70	68	70	30	75
71	70	71	94	25
72	71	72	75	25
73	70	73	40	75
74	73	74	60	25
75	73	75	50	75
76	75	76	117	25
77	75	79	60	75
78	79	80	50	50
79	80	81	120	75
80	81	82	132	25

Table (6.4c) Cont.

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
81	77	79	150	50
82	77	78	100	25
83	81	83	50	75
84	83	84	160	25
85	83	87	200	50
86	87	88	60	50
87	88	89	160	25
88	80	85	170	25
89	66	85	250	25
90	85	86	340	25
91	88	90	150	50
92	90	92	100	50
93	90	91	102	25
94	92	93	66	25
95	92	94	90	50
96	94	95	150	25
97	94	96	90	50
98	96	97	60	25
99	96	98	78	50
100	98	99	60	25
101	92	100	250	50
102	100	101	200	25
103	Reservoir	1	120	200

Table (6.5) Values of Velocity and Head Loss in Pipes for the First Proposed Network

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
1	150	17.04	0.96	11.54
2	50	0.2	0.1	0.65
3	25	0.3	0.61	40.36
4	150	16.63	0.94	11.03
5	25	0.14	0.29	9.78
6	150	15.85	0.9	10.08
7	25	0.81	1.65	252.45
8	100	14.46	1.84	61.33
9	25	0.3	0.61	40.11
10	100	13.84	1.76	56.58
11	25	0.05	0.1	1.45
12	100	12.89	1.64	49.58
13	25	0.16	0.32	12.23
14	100	12.67	1.61	48
15	25	0.07	0.13	2.43
16	100	12.43	1.58	46.37
17	25	0.06	0.12	2.04
18	100	12.25	1.56	45.1
19	50	0.54	0.27	4
20	25	0.33	0.66	46.52
21	25	0.09	0.18	4.31
22	25	0.07	0.14	2.71
23	25	0.07	0.14	2.71
24	25	0.09	0.18	4.31
25	100	11.69	1.49	41.34
26	25	0.07	0.13	2.43
27	25	0.05	0.1	1.45
28	100	11.52	1.47	40.28
29	25	0.05	0.1	1.45
30	100	11.37	1.45	39.31
31	25	0.15	0.31	11.11
32	100	10.99	1.4	36.92
33	25	0.18	0.37	15.57
34	100	10.57	1.35	34.35
35	25	0.12	0.24	7.35
36	100	10.41	1.33	33.35
37	25	0.05	0.1	1.45
38	100	10.26	1.31	32.46
39	25	0.08	0.16	3.47
40	100	10.11	1.29	31.59

Table (6.5) Cont

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
41	25	0.13	0.26	8.53
42	100	9.88	1.26	30.3
43	50	2.58	1.31	73.65
44	75	7.12	1.61	67.02
45	25	0.12	0.24	7.13
46	75	6.66	1.51	59.21
47	25	0.13	0.26	8.05
48	75	6.21	1.41	52.03
49	25	0.05	0.1	1.45
50	75	6.05	1.37	49.57
51	25	0.08	0.16	3.47
52	75	5.89	1.33	47.12
53	25	0.14	0.29	10.3
54	75	5.64	1.28	43.57
55	25	0.14	0.29	9.78
56	75	5.39	1.22	40.06
57	50	0.65	0.33	5.82
58	25	0.08	0.16	3.47
59	50	0.52	0.26	3.8
60	25	0.2	0.41	18.93
61	25	0.07	0.14	2.71
62	25	0.2	0.41	18.93
63	75	4.63	1.05	30.26
64	50	1.1	0.56	15.29
65	25	0.05	0.1	1.45
66	50	0.87	0.44	9.85
67	25	0.09	0.18	4.31
68	75	3.3	0.75	16.1
69	25	0.1	0.2	5.24
70	75	3.01	0.68	13.65
71	25	0.13	0.26	8.28
72	25	0.07	0.14	2.71
73	75	2.85	0.64	12.27
74	25	0.1	0.2	5.05
75	75	2.7	0.61	11.12
76	25	0.13	0.26	8.53
77	75	2.49	0.56	9.58
78	50	2.22	1.13	55.75
79	75	4.25	0.96	25.77
80	25	0.08	0.16	3.47

Table (6.5) Cont

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
81	50	-2.31	1.18	60.01
82	25	0.07	0.14	2.71
83	75	3.99	0.9	22.93
84	25	0.06	0.12	2.04
85	50	3.66	1.86	140.9
86	50	3.38	1.72	121.59
87	25	0.1	0.2	5.24
88	25	-0.34	0.69	49.66
89	25	0.41	0.84	71.97
90	25	0.15	0.31	11.11
91	50	2.95	1.5	94.39
92	50	2.66	1.35	77.97
93	25	0.11	0.22	6.26
94	25	0.13	0.26	8.52
95	50	0.77	0.39	7.78
96	25	0.1	0.2	5.24
97	50	0.58	0.3	4.66
98	25	0.15	0.31	11.11
99	50	0.33	0.17	1.66
100	25	0.1	0.2	5.24
101	50	1.41	0.72	24.24
102	25	0.69	1.4	186.08
103	200	17.79	0.57	3.08

6.4.2 The Second Proposed Network

Filling up the computer program with basic data, varying the diameter of the links ,and increasing the number of nodes and changing many nodes positions , and obtained the calculated head losses, velocities and pressures. The procedure were repeated for the Second proposed network until the most suitable diameters that meet the water demand are found. The data obtained for the diameter and basic data are listed in Table (6.7). The layout of the proposed network is shown in Figure (6.7) and (6.8). The predicted values of velocity, head loss, pressure, and grade are given in Tables (6.8) and (6.9). Figure (6.9) depicts the final drawings of the proposed water distribution network with storage reservoir.

It may be seen in the figures the new pipelines suggested for Beit kahel water network for year (2028). By comparing the existing link diameters with that obtained for year (2028), it is found many existing pipelines are proposed to be replaced by larger pipelines and other suggested to remain same. This conclusion also agreed with our point of view of constructing new mains and using some of the existing,

6.٦ SUMMARY

In this chapter, the existing water distribution network for Beit kahel village has been studied and evaluated. The result of calculation necessary for the network design have been given and discussed. The proposed water distribution network has been presented.

We observe what is mentioned above that the difference between the first and second suggestions summarizing the following points:

1. The Cost : the cost of the first suggestion is lesser than the second suggestion because it is use is in the case of rehabilitation the existing water distribution network for Beit kahel village , but the second suggestion it is used in case of building whole new water distribution network offers all the populations needs after (25) years .

2. The pain and time: the second suggestion needs time and pain to be carried out more than the first suggestion.

Table (6.7 a) X and Y Coordinates of Nodes For The Second Proposed Network

ID	X coordinate	Y coordinate	ID	X coordinate	Y coordinate
1	158039.62	108042.97	41	156964.86	108711.77
2	157985.83	108146.28	42	156906.45	108517.65
3	158059.16	108288.30	43	156885.20	108692.12
4	157887.79	108087.31	44	156878.02	108529.71
5	157972.44	108319.73	45	156878.95	108707.53
6	157892.57	108012.57	46	156845.71	108547.63
7	157817.38	108122.50	47	156808.57	108547.63
8	157854.65	108342.37	48	156815.05	108377.58
9	157785.51	108059.16	49	156812.38	108558.96
10	157713.07	108152.70	50	156770.14	108661.08
11	157549.53	108457.10	51	156713.68	108567.72
12	157612.30	108193.98	52	156729.41	108443.46
13	157499.94	108270.93	53	156720.80	108575.05
14	157504.54	108344.70	54	156752.98	108664.88
15	157687.25	108388.27	55	156667.03	108789.40
16	157514.49	108134.70	56	156720.20	108712.95
17	157396.29	108215.46	57	156766.18	108838.59
18	157277.35	108336.28	58	156633.26	108733.17
19	157308.41	108399.25	59	156642.36	108853.74
20	157366.53	108512.98	60	156568.35	108756.61
21	157184.80	108360.09	61	156584.87	108819.87
22	157174.08	108281.52	62	156499.12	108737.86
23	157163.80	108367.55	63	156505.87	108856.06
24	157177.85	108443.58	64	156507.67	108873.63
25	157128.05	108373.62	65	156451.43	108876.06
26	157109.65	108308.90	66	156428.53	108446.65
27	157048.08	108437.99	67	156431.09	108705.10
28	157056.02	108332.63	68	156539.91	108708.72
29	157034.72	108450.36	69	156432.25	108672.30
30	157041.81	108494.94	70	156559.56	108672.37
31	157086.12	108515.37	71	156392.39	108739.19
32	157227.65	108546.83	72	156630.63	108593.35
33	157110.62	108632.46	73	156632.11	108731.45
34	157045.66	108628.35	74	156496.90	108612.77
35	157010.79	108465.23	75	156343.46	108478.32
36	157026.84	108606.76	76	156485.22	108628.66
37	157009.93	108348.92	77	156322.33	108703.15
38	156977.64	108485.73	78	156319.54	108672.78
39	156974.27	108506.41	79	156311.91	108540.60
40	156935.67	108377.76	80	156413.53	108609.33

Table (6.7a) Cont

ID	X coordinate	Y coordinate	ID	X coordinate	Y coordinate
81	156239.55	108663.91	103	155808.33	108674.31
82	156219.23	108752.73	104	155757.71	108807.36
83	156340.10	108799.18	105	155761.19	108950.24
84	156405.40	108878.85	106	155726.50	108651.79
85	156239.50	108840.26	107	155685.65	108794.66
86	156254.12	108906.42	108	155672.38	108645.99
87	155996.32	108907.49	109	155628.55	108782.94
88	156123.97	108876.38	110	155630.84	108678.46
89	155930.40	108914.99	111	155597.09	108780.81
90	156134.65	108755.71	112	155566.78	108665.72
91	156337.33	108781.12	113	155242.07	108768.79
92	155853.41	108880.60	114	155590.36	108953.29
93	155812.10	108645.85	115	155641.23	109089.32
94	156113.01	108631.86	116	155500.29	108945.68
95	156230.53	108582.79	117	155410.11	108959.51
96	156071.34	108632.62	118	155470.15	109063.31
97	156163.62	108540.77	119	155452.88	109194.22
98	155965.79	108673.66	120	155416.15	109094.00
99	155960.54	108578.33	121	155324.31	109056.33
100	155915.05	108705.79	122	155501.04	109218.48
101	155807.86	108594.11	Reservoir	158166.35	108038.09
102	156185.60	108775.97			

Table (6.7 b) Input Data For The Second Proposed Network (Nodes)

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
1	976	0.6	41	894	0.1
2	975	0.3	42	890	0.11
3	967	0.1	43	866	0.13
4	954	0.2	44	884	0.13
5	960	0.1	45	888	0.1
6	947	0.06	46	879	0.19
7	945	0.22	47	857	0.1
8	950	0.2	48	876	0.18
9	930	0.1	49	884	0.1
10	942	0.3	50	872	0.13
11	897	0.06	51	857	0.07
12	921	0.4	52	870	0.18
13	920	0.2	53	878	0.27
14	927	0.28	54	879	0.14
15	933	0.15	55	877	0.19
16	915	0.22	56	871	0.07
17	898	0.11	57	859	0.11
18	903	0.32	58	876	0.14
19	907	0.27	59	868	0.05
20	887	0.17	60	872	0.17
21	898	0.05	61	870	0.05
22	890	0.06	62	869	0.09
23	906	0.07	63	866	0.06
24	895	0.16	64	858	0.05
25	904	0.17	65	852	0.05
26	895	0.06	66	867	0.19
27	908	0.12	67	864	0.05
28	894	0.06	68	868	0.1
29	909	0.02	69	857	0
30	911	0.07	70	864	0.13
31	906	0.18	71	866	0.13
32	875	0.2	72	861	0.33
33	895	0.12	73	846	0.12
34	913	0.05	74	843	0
35	908	0.04	75	843	0.12
36	917	0.07	76	831	0.1
37	888	0.06	77	830	0.1
38	907	0.2	78	862	0.1
39	888	0.07	79	858	0.19
40	900	0.24	80	846	0.19

Table (6.7b) Cont.

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
81	861	0.16	103	823	0.08
82	859	0.18	104	807	0.2
83	854	0.16	105	804	0.12
84	843	0.05	106	813	0.08
85	855	0.23	107	806	0.18
86	842	0.03	108	805	0.07
87	835	0.07	109	807	0.07
88	856	0.28	110	805	0.06
89	834	0.09	111	807	0.12
90	854	0.48	112	798	0.13
91	841	0.33	113	798	0.11
92	818	0.14	114	778	0.29
93	860	0.11	115	765	0.08
94	851	0.23	116	782	0.26
95	853	0.08	117	781	0.1
96	844	0.27	118	768	0.15
97	851	0.09	119	765	0.12
98	831	0.2	120	777	0.19
99	830	0.05	121	787	0.11
100	825	0.36	122	787	0.12
101	817	0.13	Reservoir	982	-17.78
102	811	0.18			

Table (6.7c) Input Data For The Second Proposed Network (Pipes)

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
1	1	2	127	50
2	2	3	162	25
3	1	4	159	150
4	4	5	251	25
5	4	6	77	25
6	4	7	79	150
7	7	8	24	25
8	7	9	71	25
9	7	10	109	150
10	10	11	190	25
11	10	12	109	100
12	12	13	136	100
13	13	14	75	25
14	14	15	200	25
15	14	16	114	25
16	13	17	118	25
17	13	18	233	100
18	18	19	70	50
19	19	20	130	25
20	18	21	96	100
21	21	22	89	25
22	21	23	22	100
23	23	24	79	25
24	23	25	37	100
25	25	26	67	25
26	25	27	103	100
27	27	28	110	25
28	27	29	18	100
29	29	30	46	50
30	30	31	54	25
31	31	32	164	25
32	31	33	138	25
33	30	34	133	25
34	29	35	28	100
35	35	36	143	25
36	35	37	117	25
37	35	38	39	100
38	38	39	108	25
39	38	40	48	100
40	40	41	229	25
41	40	42	31	100

Table (6.7c) Cont.

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
42	42	43	154	25
43	42	44	31	100
44	44	45	186	25
45	44	46	37	100
46	46	47	177	25
47	46	48	33	100
48	48	49	104	25
49	48	50	46	100
50	50	51	166	25
51	50	52	42	100
52	52	53	91	75
53	53	54	45	25
54	53	55	112	75
55	55	56	104	25
56	56	57	40	25
57	55	58	121	75
58	58	59	69	25
59	58	60	102	75
60	60	61	75	25
61	60	62	84	75
62	62	63	53	25
63	63	64	80	25
64	63	65	72	25
65	62	66	26	75
66	66	67	109	25
67	67	68	33	25
68	67	69	127	25
69	69	70	37	25
70	66	71	112	75
71	52	72	101	75
72	72	73	147	25
73	72	74	137	75
74	74	75	158	75
75	75	76	231	25
76	75	77	95	25
77	71	78	101	75
78	78	79	32	75
79	79	80	122	25
80	79	81	77	50
81	81	82	93	25
82	71	83	82	75

Table (6.7c) Cont.

Pipe#	Head Node	Tail Node	Length (m)	Diameter (mm)
83	83	84	137	25
84	83	85	110	75
85	85	86	69	25
86	86	87	83	25
87	85	88	122	75
88	88	89	201	25
89	88	90	122	50
90	90	91	143	25
91	91	92	196	25
92	90	93	122	50
93	75	93	169	75
94	93	94	75	75
95	94	95	132	25
96	94	96	42	50
97	96	97	160	25
98	96	98	115	50
99	98	99	97	25
100	98	100	60	50
101	10	101	188	25
102	100	102	126	50
103	102	103	102	25
104	102	104	63	50
105	104	106	169	25
106	104	107	75	50
107	107	108	150	25
108	107	109	58	50
109	109	110	105	25
110	104	105	145	25
111	109	111	32	50
112	111	112	119	25
113	111	113	99	25
114	104	114	244	50
115	114	115	150	25
116	114	116	91	25
117	116	117	91	25
118	114	118	166	50
119	118	119	139	25
120	118	120	62	50
121	120	121	105	25
122	120	122	217	25
123	Reservoir	1	123	200

Table (6.8) Values of Velocity and Head Loss in Pipes for the Second Proposed Network

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
1	50	0.4	0.2	2.33
2	25	0.1	0.2	5.24
3	150	16.78	0.95	11.21
4	25	0.1	0.2	5.24
5	25	0.06	0.12	2.04
6	150	16.42	0.93	10.77
7	25	0.2	0.41	18.93
8	25	0.1	0.2	5.24
9	150	15.9	0.9	10.15
10	25	0.06	0.12	2.04
11	100	15.54	1.98	70.08
12	100	15.14	1.93	66.78
13	25	0.65	1.32	167.95
14	25	0.15	0.31	11.11
15	25	0.22	0.45	22.59
16	25	0.11	0.22	6.26
17	100	14.18	1.81	59.15
18	50	0.44	0.22	2.79
19	25	0.17	0.35	14.01
20	100	13.42	1.71	53.41
21	25	0.06	0.12	2.04
22	100	13.31	1.69	52.6
23	25	0.16	0.33	12.52
24	100	13.08	1.67	50.93
25	25	0.06	0.12	2.04
26	100	12.85	1.64	49.29
27	25	0.06	0.12	2.04
28	100	12.67	1.61	48.01
29	50	0.62	0.32	5.26
30	25	0.5	1.02	103.31
31	25	0.2	0.41	18.93
32	25	0.12	0.24	7.35
33	25	0.05	0.1	1.45
34	100	12.03	1.53	43.62
35	25	0.07	0.14	2.71
36	25	0.06	0.12	2.04
37	100	11.86	1.51	42.48
38	25	0.07	0.14	2.71
39	100	11.59	1.48	40.71
40	25	0.1	0.2	5.24
41	100	11.25	1.43	38.53

Table (6.8) Cont

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
42	25	0.13	0.26	8.53
43	100	11.01	1.4	37.02
44	25	0.1	0.2	5.24
45	100	10.78	1.37	35.6
46	25	0.1	0.2	5.24
47	100	10.49	1.34	33.85
48	25	0.1	0.2	5.24
49	100	10.21	1.3	32.19
50	25	0.07	0.14	2.71
51	100	10.01	1.27	31.03
52	75	4.99	1.13	34.67
53	25	0.14	0.29	9.78
54	75	4.58	1.04	29.58
55	25	0.18	0.37	15.58
56	25	0.11	0.22	6.26
57	75	4.21	0.95	25.3
58	25	0.05	0.1	1.45
59	75	4.02	0.91	23.23
60	25	0.05	0.1	1.45
61	75	3.8	0.86	20.93
62	25	0.16	0.33	12.52
63	25	0.05	0.1	1.45
64	25	0.05	0.1	1.45
65	75	3.55	0.8	18.44
66	25	0.28	0.57	35.3
67	25	0.1	0.2	5.24
68	25	0.13	0.26	8.52
69	25	0.13	0.26	8.52
70	75	3.08	0.7	14.18
71	75	4.84	1.1	75
72	25	0.12	0.24	25
73	75	4.39	0.99	75
74	75	4.39	0.99	75
75	25	0.1	0.2	25
76	25	0.1	0.2	25
77	75	0.82	0.19	75
78	75	0.72	0.16	75
79	25	0.19	0.39	25
80	50	0.34	0.17	50
81	25	0.18	0.37	25
82	75	2.13	0.48	75

Table (6.8) Cont.

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
83	25	0.05	0.1	1.45
84	75	1.92	0.43	5.9
85	25	0.1	0.2	5.24
86	25	0.07	0.14	2.71
87	75	1.59	0.36	4.16
88	25	0.09	0.18	4.31
89	50	1.22	0.62	18.33
90	25	0.47	0.96	92.13
91	25	0.14	0.29	9.78
92	50	0.27	0.14	1.1
93	75	4.07	0.92	23.84
94	75	4.23	0.96	25.56
95	25	0.08	0.16	3.47
96	50	3.92	2	160
97	25	0.09	0.18	4.31
98	50	3.56	1.81	133.85
99	25	0.05	0.1	1.45
100	50	3.31	1.69	116.97
101	25	0.13	0.26	8.52
102	50	2.82	1.44	86.94
103	25	0.08	0.16	3.47
104	50	2.56	1.3	72.68
105	25	0.08	0.16	3.47
106	50	0.74	0.38	7.3
107	25	0.07	0.14	2.71
108	50	0.49	0.25	3.4
109	25	0.06	0.12	2.04
110	25	0.12	0.24	7.35
111	50	0.36	0.18	1.92
112	25	0.13	0.26	8.53
113	25	0.11	0.22	6.26
114	50	1.42	0.72	24.4
115	25	0.08	0.16	3.47
116	25	0.36	0.73	56.23
117	25	0.1	0.2	5.24
118	50	0.69	0.35	6.41
119	25	0.12	0.24	7.35
120	50	0.42	0.21	2.56
121	25	0.11	0.22	6.26
122	25	0.12	0.24	7.35
123	200	17.78	0.57	3.07

Table (6.9) The Pressure at Each Node for the Second Proposed Network

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
1	976	0.6	981.62	5.62
2	975	0.3	981.33	6.33
3	967	0.1	980.48	13.48
4	954	0.2	979.84	25.84
5	960	0.1	978.52	18.52
6	947	0.06	979.68	32.68
7	945	0.22	978.99	33.99
8	950	0.2	978.53	28.53
9	930	0.1	978.62	48.62
10	942	0.3	977.88	35.88
11	897	0.06	977.5	80.5
12	921	0.4	970.24	49.24
13	920	0.2	961.16	41.16
14	927	0.28	948.57	21.57
15	933	0.15	946.34	13.34
16	915	0.22	945.99	30.99
17	898	0.11	960.42	62.42
18	903	0.32	947.38	44.38
19	907	0.27	947.19	40.19
20	887	0.17	945.36	58.36
21	898	0.05	942.25	44.25
22	890	0.06	942.07	52.07
23	906	0.07	941.1	35.1
24	895	0.16	940.11	45.11
25	904	0.17	939.21	35.21
26	895	0.06	939.08	44.08
27	908	0.12	934.14	26.14
28	894	0.06	933.91	39.91
29	909	0.02	933.27	24.27
30	911	0.07	933.03	22.03
31	906	0.18	927.45	21.45
32	875	0.2	924.35	49.35
33	895	0.12	926.44	31.44
34	913	0.05	932.84	19.84
35	908	0.04	932.05	24.05
36	917	0.07	931.66	14.66
37	888	0.06	931.81	43.81
38	907	0.2	930.39	23.39
39	888	0.07	930.1	42.1
40	900	0.24	928.44	28.44
41	894	0.1	927.24	33.24

Table (6.9) Cont

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
42	890	0.11	927.24	37.24
43	866	0.13	925.93	59.93
44	884	0.13	926.1	42.1
45	888	0.1	925.12	37.12
46	879	0.19	924.78	45.78
47	857	0.1	923.85	66.85
48	876	0.18	923.66	47.66
49	884	0.1	923.12	39.12
50	872	0.13	922.18	50.18
51	857	0.07	921.73	64.73
52	870	0.18	920.88	50.88
53	878	0.27	917.72	39.72
54	879	0.14	917.28	38.28
55	877	0.19	915.59	38.59
56	871	0.07	913.85	42.85
57	859	0.11	913.2	54.2
58	876	0.14	914.58	38.58
59	868	0.05	914.41	46.41
60	872	0.17	912.98	40.98
61	870	0.05	912.83	42.83
62	869	0.09	911.41	42.41
63	866	0.06	910.36	44.36
64	858	0.05	910.28	52.28
65	852	0.05	910.24	58.24
66	867	0.19	910.08	43.08
67	864	0.05	909.16	45.16
68	868	0.1	908.59	40.59
69	857	0	908.88	51.88
70	864	0.13	907.8	43.8
71	866	0.13	909.56	43.56
72	861	0.33	917.56	56.56
73	846	0.12	916.48	70.48
74	843	0	913.8	70.8
75	843	0.12	909.47	66.47
76	831	0.1	908.26	77.26
77	830	0.1	908.97	78.97
78	862	0.1	909.43	47.43
79	858	0.19	909.4	51.4
80	846	0.19	907.3	61.3
81	861	0.16	909.27	48.27
82	859	0.18	907.82	48.82

Table (6.9) Cont

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
83	854	0.16	908.97	54.97
84	843	0.05	908.77	65.77
85	855	0.23	908.32	53.32
86	842	0.03	907.96	65.96
87	835	0.07	907.74	72.74
88	856	0.28	907.81	51.81
89	834	0.09	906.95	72.95
90	854	0.48	905.58	51.58
91	841	0.33	892.4	51.4
92	818	0.14	890.49	72.49
93	860	0.11	905.44	45.44
94	851	0.23	903.53	52.53
95	853	0.08	903.07	50.07
96	844	0.27	896.81	52.81
97	851	0.09	896.12	45.12
98	831	0.2	881.41	50.41
99	830	0.05	881.27	51.27
100	825	0.36	874.4	49.4
101	817	0.13	872.79	55.79
102	811	0.18	863.44	52.44
103	823	0.08	863.09	40.09
104	807	0.2	858.86	51.86
105	804	0.12	857.8	53.8
106	813	0.08	858.28	45.28
107	806	0.18	858.32	52.32
108	805	0.07	857.91	52.91
109	807	0.07	858.12	51.12
110	805	0.06	857.9	52.9
111	807	0.12	858.06	51.06
112	798	0.13	857.04	59.04
113	798	0.11	857.44	59.44
114	778	0.29	852.91	74.91
115	765	0.08	852.39	82.39
116	782	0.26	847.79	65.79
117	781	0.1	847.32	66.32
118	768	0.15	851.85	83.85
119	765	0.12	850.82	83.82
120	777	0.19	851.69	74.69
121	787	0.11	851.03	64.03
122	787	0.12	850.09	63.09

CHAPTER SIVEN

BILL OF QUANTITIES

BILL OF QUANTITIES
FOR THE PROPOSED WATER DISTRIBUTION NETWORKS

Item	Description	Unit	Case I	Case II	Rate($)
	Note: (1) The contractor shall when pricing this bill take into consideration to include and allow for all costs or expenses of all requirements stipulated (2) The exact length of the required pipes, the exact number of the required valves and the exact quantities of concrete will be determined during the implementation of the work.				
1.	**Water pipes** Supply and install straight in the trench water pipes including excavation, shoring, bidding, backfilling, testing and reinstatement. This include also all necessary parts, jointing compounds, fittings, reducers and plugs, complete as per technical specifications, to complete all the work as described in the specifications, shown in the drawing, approved and directed by the engineer for:				
	A. 8 inch dia	L.M.	123	123	
	B. 6 inch dia	L.M.	593	347	
	C. 4 inch dia	L.M.	916	1089	
	D. 3 inch dia	L.M.	1090	1543	
	E. 2 inch dia	L.M.	2143	1344	
	F. 1 inch dia	L.M.	4974	8807	
2.	**Pressure reduce valve:** Supply and install straight in the manhole pressure reduce valve of 15 bars working pressure including all necessary flanges and accessories needed installation and jointing, testing and all necessary parts and works needed to complete the work, approved and specified by the engineer .	No.	8	17	

Item	Description	Unit	Case I	Case II	Rate($)
3.	**Gate valve:**				
	Supply and install straight in the manhole gate chamber of 15 bar working pressure with all necessary flanges and accessories needed for installation, jointing, testing, and all necessary parts and work needed to complete the work. Approved and specified by the engineer for:				
	A. 200 mm dia valve	No.	1	1	
	B. 150 mm dia valve	No.	-	-	
	C. 100 mm dia valve	No.	2	2	
	D. 75 mm dia valve	No.	3	5	
	E. 50 mm dia valve	No.	7	3	
	F. 25 mm dia valve	No.	29	37	
4.	**Pipe reducer and adapter:**				
	Supply and install straight in the trench reducer adapted to connect ductile pipe including excavation, shoring , jointing, bedding, backfilling, testing, and reinstatement and all necessary works and parts needed to complete the work, approved and specified by the engineer for:				
	8 inch to 6 inch	No.	1	1	
	6 inch to 4 inch	No.	1	1	
	4 inch to 3 inch	No.	1	2	
	4 inch to 2 inch	No.	3	2	
	3 inch to 2 inch	No.	1	2	
	2 inch to 1 inch	No.	1	2	
5.	**Chambers:**				
	Supply and place cast-in-site concrete class B300 to construct valve chambers and chambers This includes excavation, shoring, formwork, compacting, jointing, backfilling, testing, reinstatement and all necessary steel reinforcement and concrete works. This includes also all necessary works and parts required to complete the work, approved and specify by the engineer.	No.	1	1	

CHAPTER EIGHT

CONCLUSIONS AND RECOMENDATION

CHAPTER EIGHT

CONCLUSIONS AND RECOMENDATION

In this project, the existing water distribution network in Beit Kahel village was studied and evaluated. The trial is also made to redesign the village network for year 2028. The results show that the improvement and upgrading of the existing water distribution network is required. Also it had been put a first suggestion changing the pipes diameter in the existing water distribution network, the second suggestion included a comprehsive change to the nodes location and increasing in its number in addition to increasing the tallest of the pipes, that the network covers all areas which is expected to be far a period (25) years habitable with citizens . It is also brought out many important conclusions. The main conclusions drawn from the present study are summarized below:

1. The existing water distribution network is old and no longer provides the village of Beit Kahel for the next (25) years with a good drinking water supply system, the network needs reconstruction and upgrading. In general, three options are available for this purpose; repair the existing network, constructing a new network, or partially using the old network and partially constructing a new pipelines; practically and economically the third solution is recommended

٢. The results of the existing water distribution network show that the most values of velocities and pressures are do not within the allowable ranges, for that most of the existing links have to be changed.

٣. Through the survey that has mad we find that the population for Beit Kahel in year (2003) are (5460){223274.9m^3/day }, in year (2028) the population will be (16410){561025.4 m^3/day}

4. In year 2028, the village of Beit Kahel is in dire need of larger quantities of water and more adequate supply scheme. In redesign the water distribution network, the results show that a new network are to be constructed.

5. The existing water distribution network with the pipes sizes which are not able to be serve the needs of the village of water after (25) years old , and this shows the negative values for pressures in some node , they also need to rehabitable in terms of increasing the diametres of the pipes or to increas the pipes tall and also renew pipes and this need to an operation according to the engineering callapse description .

6. Restrictions on the Palestinian use of the annual ground water resources of the West Bank led to limited quantities of water supplied to the village of Beit Kahel and due to this condition the average consumption of water in the village in general is very low and does not represent the present actual demand of water.

7. The operation and maintance cost for the distribution system could be estimated according to the total water delivered , and the cost of the most economically distribution pipes could be estimated according to diameters. The cost of both elevated and on ground reservoirs are estimated according to the volume of the reserviors.

8. The cost of the first suggestion is lesser than the second suggestion because it is use is in the case of rehabilitation the existing water distribution network for Beit kahel village , but the second suggestion it is used in case of building whole new water distribution network offers all the populations needs after (25) years .the second suggestion needs time and pain to be carried out more than the first suggestion .

LIST OF FIGURES

LIST OF TABLES

Table (6.1b) Input Data For The Existing Network (Nodes)

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
1	977	0.55	**41**	873	0.09
2	975	0.2	**42**	857	0.13
3	955	0.11	**43**	871	0.19
4	957	0.3	**44**	877	0.34
5	945	0.64	**45**	879	0.12
6	940	0.14	**46**	877	0.32
7	920	0.58	**47**	878	0.13
8	928	0.81	**48**	877	0.11
9	903	0.32	**49**	867	0.05
10	922	0.3	**50**	876	0.08
11	902	0.9	**51**	874	0.08
12	890	0.05	**52**	872	0.1
13	905	0.06	**53**	872	0.14
14	895	0.16	**54**	869	0.11
15	906	0.17	**55**	867	0.14
16	903	0.07	**56**	867	0.1
17	907	0.12	**57**	864	0.05
18	896	0.06	**58**	869	0.08
19	908	0.03	**59**	859	0.05
20	912	0.05	**60**	864	0.2
21	903	0.17	**61**	855	0.07
22	890	0.09	**62**	850	0.2
23	895	0.07	**63**	866	0.23
24	913	0.07	**64**	855	0.18
25	913	0.09	**65**	850	0.05
26	908	0.05	**66**	856	0.37
27	912	0.05	**67**	834	0.09
28	905	0.07	**68**	862	0.18
29	907	0.1	**69**	863	0.1
30	889	0.05	**70**	858	0.04
31	900	0.23	**71**	854	0.06
32	915	0.15	**72**	846	0.07
33	884	0.24	**73**	857	0.05
34	890	0.18	**74**	855	0.1
35	879	0.05	**75**	860	0.08
36	874	0.12	**76**	857	0.13
37	876	0.1	**77**	843	0.2
38	884	0.05	**78**	822	0.07
39	874	0.07	**79**	860	0.09
40	880	0.08	**80**	860	0.12

Table (6.1b) Cont

ID	Elevation (m)	Demand (l/s)	ID	Elevation (m)	Demand (l/s)
81	851	0.09	**92**	807	0.35
82	853	0.13	**93**	813	0.13
83	845	0.19	**94**	810	0.09
84	850	0.34	**95**	805	0.1
85	854	0.12	**96**	811	0.1
86	817	0.32	**97**	809	0.15
87	830	0.13	**98**	809	0.23
88	825	0.11	**99**	805	0.1
89	811	0.05	**100**	778	0.73
90	811	0.08	**101**	767	0.69
91	827	0.08	**Reservoir**	982	-17.79

Table (6.1c) Input Data For The Existing Network (Pipes)

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
1	1	3	150	75
2	1	2	129	25
3	3	4	43	25
4	3	5	86	75
5	5	6	26	25
6	5	7	380	75
7	7	8	67	25
8	7	9	250	75
9	9	10	67	25
10	9	11	110	75
11	11	12	88	25
12	11	13	22	75
13	13	14	80	25
14	13	15	38	75
15	15	16	12	25
16	15	17	110	75
17	17	18	110	75
18	17	19	19	75
19	19	20	46	25
20	20	21	62	25
21	21	22	102	25
22	21	23	112	25
23	20	24	68	25
24	20	25	42	25
25	19	26	35	75
26	26	28	50	25
27	26	27	51	25
28	26	29	42	75
29	29	30	108	25
30	29	31	46	75
31	31	32	148	25
32	31	33	72	75
33	33	34	110	25
34	33	35	38	75
35	35	36	66	25
36	35	37	40	75
37	37	38	102	25
38	37	39	37	75

39	39	40	55	25
40	39	41	17	75

Table (6.1c) Cont

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
41	41	42	144	25
42	41	43	40	75
43	43	77	400	75
44	43	44	95	75
45	44	45	46	25
46	44	46	20	75
47	46	47	20	25
48	46	48	57	75
49	48	49	142	25
50	48	50	46	75
51	50	51	60	25
52	50	52	80	75
53	52	53	72	25
54	52	54	95	75
55	54	55	196	25
56	54	56	97	75
57	56	57	25	50
58	57	58	100	25
59	57	59	31	50
60	59	60	111	25
61	59	61	37	25
62	59	62	17	25
63	56	63	90	75
64	63	64	190	50
65	64	65	66	25
66	64	66	150	50
67	66	67	200	25
68	63	68	180	75
69	68	69	25	25
70	68	70	30	75
71	70	71	94	25
72	71	72	75	25
73	70	73	40	75
74	73	74	60	25
75	73	75	50	75
76	75	76	117	25

77	75	79	60	75
78	79	80	50	75
79	80	81	120	75
80	81	82	132	25

Table (6.1d) Cont

Pipe #	Head Node	Tail Node	Length (m)	Diameter (mm)
81	77	79	150	75
82	77	78	100	25
83	81	83	50	75
84	83	84	160	25
85	83	87	200	75
86	87	88	60	50
87	88	89	160	25
88	80	85	170	50
89	66	85	250	50
90	85	86	340	25
91	88	90	150	50
92	90	92	100	50
93	90	91	102	25
94	92	93	66	25
95	92	94	90	50
96	94	95	150	25
97	94	96	90	50
98	96	97	60	25
99	96	98	78	50
100	98	99	60	25
101	92	100	250	50
102	100	101	200	25
103	Reservoir	1	120	75

Table (6.2) Values of Velocity and Head Loss in Pipes for the Existing Network

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
1	75	17.04	3.86	337.55
2	25	0.2	0.1	0.65
3	25	0.3	0.15	1.38
4	75	16.63	3.76	322.63
5	25	0.14	0.07	0.33
6	75	15.85	3.59	295.06
7	25	0.81	1.65	252.45
8	75	14.46	3.27	249.02
9	25	0.3	0.61	40.11
10	75	13.84	3.13	229.73
11	25	0.05	0.1	1.45
12	75	12.89	2.92	201.31
13	25	0.16	0.32	12.23
14	75	12.67	2.87	194.91
15	25	0.07	0.13	2.42
16	75	12.43	2.81	188.29
17	25	0.06	0.12	2.04
18	75	12.25	2.77	183.13
19	25	0.54	1.09	117.11
20	25	0.33	0.66	46.52
21	25	0.09	0.18	4.31
22	25	0.07	0.14	2.71
23	25	0.07	0.14	2.71
24	25	0.09	0.18	4.31
25	75	11.69	2.65	167.85
26	25	11.69	2.65	167.85
27	25	11.69	2.65	167.85
28	75	11.69	2.65	167.85
29	25	11.69	2.65	167.85
30	75	11.69	2.65	167.85
31	25	11.69	2.65	167.85
32	75	11.69	2.65	167.85

33	25	11.69	2.65	167.85
34	75	11.69	2.65	167.85
35	25	11.69	2.65	167.85
36	75	11.69	2.65	167.85
37	25	0.05	0.1	1.45
38	75	10.26	2.32	131.81
39	25	0.08	0.16	3.47
40	75	10.11	2.29	128.28

Table (6.2) Cont

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
41	25	0.13	0.26	8.52
42	75	9.88	2.24	123.04
43	75	4.43	1	27.86
44	75	5.27	1.19	38.35
45	25	0.12	0.24	7.13
46	75	4.8	1.09	32.36
47	25	0.13	0.26	8.05
48	75	4.36	0.99	26.99
49	25	0.05	0.1	1.45
50	75	4.2	0.95	25.18
51	25	0.08	0.16	3.47
52	75	4.03	0.91	23.4
53	25	0.14	0.29	10.3
54	75	3.79	0.86	20.84
55	25	0.14	0.29	9.78
56	75	3.54	0.8	18.37
57	50	0.65	0.33	5.82
58	25	0.08	0.16	3.47
59	50	0.52	0.26	3.8
60	25	0.2	0.41	18.93
61	25	0.07	0.14	2.71
62	25	0.2	0.41	18.93
63	75	2.78	0.63	11.75
64	50	0.9	0.46	10.48
65	25	0.05	0.1	1.45
66	50	0.67	0.34	6.02
67	25	0.09	0.18	4.31
68	75	1.65	0.37	4.45
69	25	0.1	0.2	5.24
70	75	1.37	0.31	3.15
71	25	0.13	0.26	8.28

72	25	0.07	0.14	2.71
73	75	1.2	0.27	2.47
74	25	0.1	0.2	5.05
75	75	1.05	0.24	1.93
76	25	0.13	0.26	8.52
77	75	0.84	0.19	1.28
78	75	4.07	0.92	23.81
79	75	4.25	0.96	25.77
80	25	0.08	0.16	3.47

Table (6.2) Cont

Pipe #	DIAMETER (mm)	FLOW (L/s)	VELOCITY (m/sec)	HEAD LOSS (m/km)
81	75	-4.16	0.94	24.8
82	25	0.07	0.14	2.71
83	75	3.99	0.9	22.93
84	25	0.06	0.12	2.04
85	75	3.66	0.83	19.55
86	50	3.38	1.72	121.59
87	25	0.1	0.2	5.24
88	50	-0.54	0.28	4.07
89	50	0.21	0.11	0.69
90	25	0.15	0.31	11.11
91	50	2.95	1.5	94.39
92	50	2.66	1.35	77.97
93	25	0.11	0.22	6.26
94	25	0.13	0.26	8.52
95	50	0.77	0.39	7.78
96	25	0.1	0.2	5.24
97	50	0.58	0.3	4.66
98	25	0.15	0.31	11.11
99	50	0.33	0.17	1.66
100	25	0.1	0.2	5.24
101	50	1.41	0.72	24.24
102	25	0.69	1.4	186.08
103	75	17.79	4.03	365.58

Table (6.3) The Pressure at Each Node for the Existing Network

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
1	977	0.55	938.13	-38.87
2	975	0.2	938.05	-36.95
3	955	0.11	887.5	-67.5
4	957	0.3	887.44	-69.56
5	945	0.64	859.75	-85.25
6	940	0.14	859.74	-80.26
7	920	0.58	747.63	-172.37
8	928	0.81	730.72	-197.28
9	903	0.32	685.37	-217.63
10	922	0.3	682.69	-239.31
11	902	0.9	660.1	-241.9
12	890	0.05	659.98	-230.02
13	905	0.06	655.67	-249.33
14	895	0.16	654.7	-240.3
15	906	0.17	648.27	-257.73
16	903	0.07	648.24	-254.76
17	907	0.12	627.56	-279.44
18	896	0.06	627.33	-268.67
19	908	0.03	624.08	-283.92
20	912	0.05	618.69	-293.31
21	903	0.17	615.81	-287.19
22	890	0.09	615.37	-274.63
23	895	0.07	615.5	-279.5
24	913	0.07	618.51	-294.49
25	913	0.09	618.51	-294.49
26	908	0.05	618.2	-289.8
27	912	0.05	618.13	-293.87

28	905	0.07	618.08	-286.92
29	907	0.1	611.33	-295.67
30	889	0.05	611.18	-277.82
31	900	0.23	603.99	-296.01
32	915	0.15	602.35	-312.65
33	884	0.24	593.2	-290.8
34	890	0.18	591.48	-298.52
35	879	0.05	587.9	-291.1
36	874	0.12	587.41	-286.59
37	876	0.1	582.48	-293.52
38	884	0.05	582.33	-301.67
39	874	0.07	577.6	-296.4
40	880	0.08	577.41	-302.59

Table (6.3) Cont

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
41	873	0.09	575.42	-297.58
42	857	0.13	574.2	-290.8
43	871	0.19	570.5	-300.5
44	877	0.34	566.86	-310.14
45	879	0.12	566.53	-312.47
46	877	0.32	566.21	-310.79
47	878	0.13	566.05	-311.95
48	877	0.11	564.67	-312.33
49	867	0.05	564.47	-302.53
50	876	0.08	563.51	-312.49
51	874	0.08	563.31	-310.69
52	872	0.1	561.64	-310.36
53	872	0.14	560.9	-311.1
54	869	0.11	559.66	-309.34
55	867	0.14	557.75	-309.25
56	867	0.1	557.88	-309.12
57	864	0.05	557.73	-306.27
58	869	0.08	557.39	-311.61
59	859	0.05	557.62	-301.38
60	864	0.2	555.52	-308.48
61	855	0.07	557.52	-297.48
62	850	0.2	557.29	-292.71
63	866	0.23	556.82	-309.18
64	855	0.18	554.83	-300.17
65	850	0.05	554.73	-295.27

66	856	0.37	553.93	-302.07
67	834	0.09	553.07	-280.93
68	862	0.18	556.02	-305.98
69	863	0.1	555.89	-307.11
70	858	0.04	555.93	-302.07
71	854	0.06	555.15	-298.85
72	846	0.07	554.94	-291.06
73	857	0.05	555.83	-301.17
74	855	0.1	555.52	-299.48
75	860	0.08	555.73	-304.27
76	857	0.13	554.73	-302.27
77	843	0.2	559.36	-283.64
78	822	0.07	559.09	-301.17
79	860	0.09	555.64	-299.48
80	860	0.12	554.45	-304.27

Table (6.3) Cont

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
81	851	0.09	551.35	-299.65
82	853	0.13	550.9	-302.1
83	845	0.19	550.21	-294.79
84	850	0.34	549.88	-300.12
85	854	0.12	553.75	-300.25
86	817	0.32	549.98	-267.02
87	830	0.13	546.3	-283.7
88	825	0.11	539	-286
89	811	0.05	538.16	-272.84
90	811	0.08	524.84	-286.16
91	827	0.08	524.21	-302.79
92	807	0.35	517.05	-289.95
93	813	0.13	516.48	-296.52
94	810	0.09	516.35	-293.65
95	805	0.1	515.56	-289.44
96	811	0.1	515.93	-295.07
97	809	0.15	515.26	-293.74
98	809	0.23	515.8	-293.2
99	805	0.1	515.48	-289.52
100	778	0.73	510.99	-267.01
101	767	0.69	473.77	-293.23
Reservoir	982	-17.79	982	0

Table (6.6) The Pressure at Each Node for the First Proposed Network

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
1	977	0.55	981.63	4.63
2	975	0.2	981.55	6.55
3	955	0.11	979.9	24.9
4	957	0.3	978.16	21.16
5	945	0.64	978.95	33.95
6	940	0.14	978.7	38.7
7	920	0.58	975.12	55.12
8	928	0.81	958.21	30.21
9	903	0.32	959.79	56.79
10	922	0.3	957.1	35.1
11	902	0.9	953.57	51.57
12	890	0.05	953.44	63.44
13	905	0.06	952.47	47.47
14	895	0.16	951.5	56.5
15	906	0.17	950.65	44.65
16	903	0.07	950.62	47.62
17	907	0.12	945.55	38.55
18	896	0.06	945.33	49.33
19	908	0.03	944.69	36.69
20	912	0.05	944.51	32.51
21	903	0.17	941.62	38.62
22	890	0.09	941.18	51.18
23	895	0.07	941.32	46.32
24	913	0.07	944.32	31.32
25	913	0.09	944.33	31.33
26	908	0.05	943.25	35.25
27	912	0.05	943.17	31.17
28	905	0.07	943.12	38.12
29	907	0.1	941.55	34.55
30	889	0.05	941.4	52.4
31	900	0.23	939.75	39.75
32	915	0.15	938.1	23.1
33	884	0.24	937.09	53.09
34	890	0.18	935.37	45.37
35	879	0.05	935.78	56.78
36	874	0.12	935.3	61.3
37	876	0.1	934.45	58.45
38	884	0.05	934.3	50.3
39	874	0.07	933.25	59.25
40	880	0.08	933.06	53.06

Table (6.6) Cont.

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
41	873	0.09	932.71	59.71
42	857	0.13	931.48	66.48
43	871	0.19	931.5	60.5
44	877	0.34	925.13	48.13
45	879	0.12	924.8	45.8
46	877	0.32	923.95	46.95
47	878	0.13	923.79	45.79
48	877	0.11	920.98	43.98
49	867	0.05	920.77	53.77
50	876	0.08	918.7	42.7
51	874	0.08	918.49	44.49
52	872	0.1	914.93	42.93
53	872	0.14	914.19	42.19
54	869	0.11	910.79	41.79
55	867	0.14	908.88	41.88
56	867	0.1	906.91	39.91
57	864	0.05	906.76	42.76
58	869	0.08	906.41	37.41
59	859	0.05	906.64	47.64
60	864	0.2	904.54	40.54
61	855	0.07	906.54	51.54
62	850	0.2	906.32	56.32
63	866	0.23	904.18	38.18
64	855	0.18	901.28	46.28
65	850	0.05	901.18	51.18
66	856	0.37	899.80	43.80
67	834	0.09	898.94	64.94
68	862	0.18	901.28	39.28
69	863	0.1	901.15	38.15
70	858	0.04	900.88	42.88
71	854	0.06	900.10	46.10
72	846	0.07	899.89	53.89
73	857	0.05	900.38	43.38
74	855	0.1	900.08	45.08
75	860	0.08	899.83	39.83
76	857	0.13	898.83	41.83
77	843	0.2	902.04	59.04
78	822	0.07	901.77	66.77
79	860	0.09	893.03	33.04
80	860	0.12	890.25	30.25

Table (6.6) Cont.

Node #	Elevation (m)	Demand (l/s)	Grade (m)	Pressure (m)
81	851	0.09	887.15	36.15
82	853	0.13	886.7	33.7
83	845	0.19	886.01	41.01
84	850	0.34	885.68	35.68
85	854	0.12	881.81	27.81
86	817	0.32	878.03	61.03
87	830	0.13	857.83	27.83
88	825	0.11	850.53	25.53
89	811	0.05	849.69	38.69
90	811	0.08	836.37	25.37
91	827	0.08	835.74	8.74
92	807	0.35	828.58	21.58
93	813	0.13	828.01	15.01
94	810	0.09	827.88	17.88
95	805	0.1	827.09	22.09
96	811	0.1	827.46	16.46
97	809	0.15	826.79	17.79
98	809	0.23	827.33	18.33
99	805	0.1	827.01	22.01
100	778	0.73	822.52	44.52
101	767	0.69	785.30	18.3
Reservoir	982	-17.79	982.00	0

APPENDIX

INPUT AND OUTPUT DATA

TITLE

Jop Description (existing network)

Network Table - Nodes at 0:00 Hrs

Node ID	Elevation m	Demand LPS
Junc 1	977	0.14
Junc 2	975	0.07
Junc 3	955	0.05
Junc 4	957	0.30
Junc 5	945	0.16
Junc 6	940	0.05
Junc 7	920	0.15
Junc 8	928	0.20
Junc 9	903	0.08
Junc 10	922	0.09
Junc 11	902	0.05
Junc 12	890	0.02
Junc 13	905	0.03
Junc 14	895	0.08
Junc 15	906	0.08
Junc 16	903	0.02
Junc 17	907	0.06
Junc 18	896	0.02
Junc 19	908	0.02
Junc 20	912	0.03
Junc 21	903	0.08
Junc 22	890	0.09
Junc 23	895	0.06
Junc 24	913	0.03
Junc 25	913	0.03
Junc 26	908	0.03
Junc 27	912	0.02
Junc 28	905	0.02
Junc 29	907	0.05
Junc 30	889	0.02
Junc 31	900	0.07
Junc 32	915	0.05
Junc 33	884	0.07
Junc 34	890	0.05

Junc 35	879	0.02
Junc 36	874	0.03
Junc 37	876	0.03
Junc 38	884	0.02
Junc 39	874	0.03
Junc 40	880	0.02
Junc 41	873	0.05
Junc 42	865	0.05
Junc 43	871	0.09
Junc 44	877	0.17
Junc 45	879	0.06
Junc 46	877	0.10
Junc 47	878	0.04
Junc 48	877	0.06
Junc 49	867	0.04
Junc 50	876	0.04
Junc 51	874	0.04
Junc 52	872	0.05
Junc 53	872	0.04
Junc 54	869	0.06
Junc 55	867	0.06
Junc 56	867	0.05
Junc 57	864	0.06
Junc 58	869	0.04
Junc 59	859	0.09
Junc 60	864	0.08
Junc 61	855	0.02
Junc 62	850	0.08
Junc 63	866	0.07
Junc 64	855	0.09
Junc 65	850	0.03
Junc 66	856	0.09
Junc 67	834	0.03
Junc 68	862	0.06
Junc 69	863	0.06
Junc 70	858	0.04
Junc 71	854	0.03
Junc 72	846	0.03
Junc 73	857	0.03
Junc 74	855	0.05
Junc 75	860	0.10
Junc 76	857	0.05
Junc 78	835	0.03

Junc 79	860	0.05
Junc 80	860	0.06
Junc 81	851	0.09
Junc 82	853	0.02
Junc 77	843	0.10
Junc 83	845	0.08
Junc 84	850	0.03
Junc 85	854	0.30
Junc 86	817	0.06
Junc 87	830	0.09
Junc 88	825	0.10
Junc 89	811	0.03
Junc 90	811	0.06
Junc 91	827	0.05
Junc 92	807	0.40
Junc 93	813	0.03
Junc 94	810	0.05
Junc 95	805	0.03
Junc 96	811	0.05
Junc 97	809	0.02
Junc 98	809	0.06
Junc 99	805	0.04
Junc 100	778	0.30
Junc 101	767	0.30
Resvr Reservoir	982	-7.08

Network Table - Links at 0:00 Hrs

Link ID	Length m	Diameter mm	Roughness
Pipe 1	150	75	100
Pipe 2	129	50	100
Pipe 3	43	50	100
Pipe 4	86	75	100
Pipe 5	26	50	100
Pipe 6	380	75	100
Pipe 7	67	25	100
Pipe 8	250	75	100
Pipe 9	67	25	100
Pipe 10	110	75	100
Pipe 11	88	25	100
Pipe 12	22	75	100
Pipe 14	38	75	100
Pipe 15	12	25	100
Pipe 16	110	75	100
Pipe 18	19	75	100
Pipe 17	110	25	100
Pipe 13	80	25	100
Pipe 25	35	75	100
Pipe 19	46	25	100
Pipe 20	62	25	100
Pipe 21	102	25	100
Pipe 22	112	25	100
Pipe 24	42	25	100
Pipe 23	68	25	100
Pipe 26	50	25	100
Pipe 27	51	25	100
Pipe 28	42	75	100
Pipe 29	108	25	100
Pipe 30	46	75	100
Pipe 31	148	25	100
Pipe 32	72	75	100
Pipe 33	110	25	100
Pipe 34	38	75	100
Pipe 35	66	25	100
Pipe 36	40	75	100
Pipe 38	37	75	100
Pipe 37	102	25	100
Pipe 39	55	25	100
Pipe 40	17	75	100

Pipe 41	144	25	100
Pipe 42	40	75	100
Pipe 44	95	75	100
Pipe 45	46	25	100
Pipe 46	20	75	100
Pipe 47	20	25	100
Pipe 48	57	75	100
Pipe 49	142	25	100
Pipe 50	46	75	100
Pipe 51	60	25	100
Pipe 52	80	75	100
Pipe 53	72	25	100
Pipe 54	95	75	100
Pipe 55	196	25	100
Pipe 56	97	75	100
Pipe 57	25	50	100
Pipe 58	100	25	100
Pipe 59	31	50	100
Pipe 60	111	25	100
Pipe 61	37	25	100
Pipe 62	17	25	100
Pipe 63	90	75	100
Pipe 64	190	50	100
Pipe 65	66	25	100
Pipe 66	150	50	100
Pipe 67	200	25	100
Pipe 68	180	75	100
Pipe 69	25	25	100
Pipe 70	30	75	100
Pipe 71	94	25	100
Pipe 72	75	25	100
Pipe 73	40	75	100
Pipe 74	60	25	100
Pipe 75	50	75	100
Pipe 76	117	25	100
Pipe 78	50	75	100
Pipe 79	120	75	100
Pipe 80	132	25	100
Pipe 81	150	75	100
Pipe 82	100	25	100
Pipe 83	50	75	100
Pipe 84	160	25	100
Pipe 85	200	75	100

Pipe 86	60	50	100
Pipe 87	160	25	100
Pipe 88	170	50	100
Pipe 89	250	50	100
Pipe 90	340	25	100
Pipe 91	150	50	100
Pipe 92	100	50	100
Pipe 93	102	25	100
Pipe 94	66	25	100
Pipe 95	90	50	100
Pipe 96	150	25	100
Pipe 97	90	50	100
Pipe 98	60	25	100
Pipe 99	78	50	100
Pipe 100	60	25	100
Pipe 101	250	50	100
Pipe 102	200	25	100
Pipe 43	400	75	100
Pipe 103	120	75	100
Pipe 77	1000	75	100

Network Table - Nodes at 0:00 Hrs

Node ID	Demand LPS	Head m	Pressure m
Junc 1	0.14	974.04	-2.96
Junc 2	0.07	974.02	-0.98
Junc 3	0.05	964.62	9.62
Junc 4	0.30	964.56	7.56
Junc 5	0.16	959.72	14.72
Junc 6	0.05	959.72	19.72
Junc 7	0.15	939.35	19.35
Junc 8	0.20	938.08	10.08
Junc 9	0.08	927.29	24.29
Junc 10	0.09	927.00	5.00
Junc 11	0.05	922.26	20.26
Junc 12	0.02	922.24	32.24
Junc 13	0.03	921.28	16.28
Junc 14	0.08	921.00	26.00
Junc 15	0.08	919.64	13.64
Junc 16	0.02	919.64	16.64
Junc 17	0.06	915.05	8.05
Junc 18	0.02	915.02	19.02
Junc 19	0.02	914.28	6.28
Junc 20	0.03	912.20	0.20
Junc 21	0.08	910.68	7.68
Junc 22	0.09	910.24	20.24
Junc 23	0.06	910.45	15.45
Junc 24	0.03	912.16	-0.84
Junc 25	0.03	912.18	-0.82
Junc 26	0.03	913.02	5.02
Junc 27	0.02	913.01	1.01
Junc 28	0.02	913.01	8.01
Junc 29	0.05	911.54	4.54
Junc 30	0.02	911.52	22.52
Junc 31	0.07	909.97	9.97
Junc 32	0.05	909.76	-5.24
Junc 33	0.07	907.62	23.62
Junc 34	0.05	907.46	17.46
Junc 35	0.02	906.43	27.43
Junc 36	0.03	906.40	32.40
Junc 37	0.03	905.21	29.21
Junc 38	0.02	905.18	21.18
Junc 39	0.03	904.10	30.10
Junc 40	0.02	904.09	24.09

Junc 41	0.05	903.60	30.60
Junc 42	0.05	903.39	38.39
Junc 43	0.09	902.47	31.47
Junc 44	0.17	901.64	24.64
Junc 45	0.06	901.54	22.54
Junc 46	0.10	901.49	24.49
Junc 47	0.04	901.47	23.47
Junc 48	0.06	901.12	24.12
Junc 49	0.04	900.99	33.99
Junc 50	0.04	900.85	24.85
Junc 51	0.04	900.79	26.79
Junc 52	0.05	900.42	28.42
Junc 53	0.04	900.35	28.35
Junc 54	0.06	899.95	30.95
Junc 55	0.06	899.55	32.55
Junc 56	0.05	899.53	32.53
Junc 57	0.06	899.48	35.48
Junc 58	0.04	899.38	30.38
Junc 59	0.09	899.44	40.44
Junc 60	0.08	899.06	35.06
Junc 61	0.02	899.43	44.43
Junc 62	0.08	899.39	49.39
Junc 63	0.07	899.31	33.31
Junc 64	0.09	898.92	43.92
Junc 65	0.03	898.88	48.88
Junc 66	0.09	898.78	42.78
Junc 67	0.03	898.66	64.66
Junc 68	0.06	899.11	37.11
Junc 69	0.06	899.06	36.06
Junc 70	0.04	899.09	41.09
Junc 71	0.03	898.90	44.90
Junc 72	0.03	898.86	52.86
Junc 73	0.03	899.07	42.07
Junc 74	0.05	898.98	43.98
Junc 75	0.10	899.05	39.05
Junc 76	0.05	898.88	41.88
Junc 78	0.03	899.89	64.89
Junc 79	0.05	899.11	39.11
Junc 80	0.06	898.84	38.84
Junc 81	0.09	898.19	47.19
Junc 82	0.02	898.16	45.16
Junc 77	0.10	899.95	56.95
Junc 83	0.08	897.95	52.95

Junc 84	0.03	897.86	47.86
Junc 85	0.30	898.70	44.70
Junc 86	0.06	898.01	81.01
Junc 87	0.09	897.10	67.10
Junc 88	0.10	895.44	70.44
Junc 89	0.03	895.35	84.35
Junc 90	0.06	891.92	80.92
Junc 91	0.05	891.77	64.77
Junc 92	0.40	889.91	82.91
Junc 93	0.03	889.87	76.87
Junc 94	0.05	889.82	79.82
Junc 95	0.03	889.73	84.73
Junc 96	0.05	889.78	78.78
Junc 97	0.02	889.76	80.76
Junc 98	0.06	889.76	80.76
Junc 99	0.04	889.70	84.70
Junc 100	0.30	888.67	110.67
Junc 101	0.30	880.65	113.65
Resvr Reservoir	-7.08	982.00	0.00

Network Table - Links at 0:00 Hrs

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Friction Factor
Pipe 1	6.87	1.56	62.77	0.038
Pipe 2	0.07	0.04	0.09	0.071
Pipe 3	0.30	0.15	1.38	0.058
Pipe 4	6.52	1.48	56.96	0.039
Pipe 5	0.05	0.03	0.05	0.074
Pipe 6	6.31	1.43	53.61	0.039
Pipe 7	0.20	0.41	18.93	0.056
Pipe 8	5.96	1.35	48.24	0.039
Pipe 9	0.09	0.18	4.31	0.063
Pipe 10	5.79	1.31	45.72	0.039
Pipe 11	0.02	0.04	0.27	0.079
Pipe 12	5.72	1.29	44.70	0.039
Pipe 14	5.61	1.27	43.12	0.039
Pipe 15	0.02	0.04	0.27	0.079
Pipe 16	5.51	1.25	41.71	0.039
Pipe 18	5.43	1.23	40.59	0.040
Pipe 17	0.02	0.04	0.27	0.079
Pipe 13	0.08	0.16	3.47	0.064
Pipe 25	5.09	1.15	36.01	0.040
Pipe 19	0.32	0.65	45.21	0.052
Pipe 20	0.23	0.47	24.52	0.055
Pipe 21	0.09	0.18	4.31	0.063
Pipe 22	0.06	0.12	2.04	0.067
Pipe 24	0.03	0.06	0.57	0.074
Pipe 23	0.03	0.06	0.56	0.074
Pipe 26	0.02	0.04	0.27	0.079
Pipe 27	0.02	0.04	0.27	0.079
Pipe 28	5.02	1.14	35.10	0.040
Pipe 29	0.02	0.04	0.27	0.079
Pipe 30	4.95	1.12	34.20	0.040
Pipe 31	0.05	0.10	1.45	0.069
Pipe 32	4.83	1.09	32.68	0.040
Pipe 33	0.05	0.10	1.45	0.069
Pipe 34	4.71	1.07	31.19	0.040
Pipe 35	0.03	0.06	0.56	0.074
Pipe 36	4.66	1.05	30.58	0.040
Pipe 38	4.61	1.04	29.98	0.041
Pipe 37	0.02	0.04	0.27	0.079
Pipe 39	0.02	0.04	0.27	0.079
Pipe 40	4.56	1.03	29.38	0.041

Pipe 41	0.05	0.10	1.45	0.069
Pipe 42	4.46	1.01	28.20	0.041
Pipe 44	2.38	0.54	8.82	0.045
Pipe 45	0.06	0.12	2.04	0.067
Pipe 46	2.15	0.49	7.31	0.045
Pipe 47	0.04	0.08	0.96	0.071
Pipe 48	2.01	0.46	6.45	0.046
Pipe 49	0.04	0.08	0.96	0.071
Pipe 50	1.91	0.43	5.87	0.046
Pipe 51	0.04	0.08	0.96	0.071
Pipe 52	1.83	0.41	5.42	0.046
Pipe 53	0.04	0.08	0.96	0.071
Pipe 54	1.74	0.39	4.94	0.047
Pipe 55	0.06	0.12	2.04	0.067
Pipe 56	1.62	0.37	4.33	0.047
Pipe 57	0.37	0.19	2.02	0.056
Pipe 58	0.04	0.08	0.96	0.071
Pipe 59	0.27	0.14	1.13	0.059
Pipe 60	0.08	0.16	3.47	0.064
Pipe 61	0.02	0.04	0.27	0.078
Pipe 62	0.08	0.16	3.47	0.064
Pipe 63	1.20	0.27	2.48	0.049
Pipe 64	0.37	0.19	2.02	0.056
Pipe 65	0.03	0.06	0.56	0.074
Pipe 66	0.25	0.13	0.98	0.059
Pipe 67	0.03	0.06	0.56	0.074
Pipe 68	0.76	0.17	1.07	0.053
Pipe 69	0.06	0.12	2.04	0.067
Pipe 70	0.64	0.15	0.78	0.054
Pipe 71	0.06	0.12	2.04	0.067
Pipe 72	0.03	0.06	0.56	0.074
Pipe 73	0.54	0.12	0.57	0.056
Pipe 74	0.05	0.10	1.45	0.069
Pipe 75	0.46	0.10	0.42	0.057
Pipe 76	0.05	0.10	1.45	0.069
Pipe 78	1.81	0.41	5.30	0.047
Pipe 79	1.83	0.41	5.42	0.046
Pipe 80	0.02	0.04	0.27	0.079
Pipe 81	-1.86	0.42	5.58	0.046
Pipe 82	0.03	0.06	0.56	0.074
Pipe 83	1.72	0.39	4.83	0.047
Pipe 84	0.03	0.06	0.56	0.074
Pipe 85	1.61	0.36	4.27	0.047

Pipe 86	1.52	0.77	27.68	0.045
Pipe 87	0.03	0.06	0.56	0.074
Pipe 88	-0.23	0.12	0.84	0.060
Pipe 89	0.13	0.07	0.29	0.065
Pipe 90	0.06	0.12	2.04	0.067
Pipe 91	1.39	0.71	23.45	0.046
Pipe 92	1.28	0.65	20.13	0.046
Pipe 93	0.05	0.10	1.45	0.069
Pipe 94	0.03	0.06	0.56	0.074
Pipe 95	0.25	0.13	0.98	0.059
Pipe 96	0.03	0.06	0.56	0.074
Pipe 97	0.17	0.09	0.48	0.063
Pipe 98	0.02	0.04	0.27	0.079
Pipe 99	0.10	0.05	0.18	0.068
Pipe 100	0.04	0.08	0.96	0.071
Pipe 101	0.60	0.31	4.95	0.052
Pipe 102	0.30	0.61	40.11	0.053
Pipe 43	1.99	0.45	6.32	0.046
Pipe 103	7.08	1.60	66.37	0.038
Pipe 77	0.31	0.07	0.20	0.060

TITLE

Jop Description (THE FIRST PROPOSED WATER DISTRIBUTION NETWORK)

Network Table - Nodes at 0:00 Hrs

Node ID	Elevation m	Demand LPS
Junc 1	977	0.55
Junc 2	975	0.20
Junc 3	955	0.11
Junc 4	957	0.30
Junc 5	945	0.64
Junc 6	940	0.14
Junc 7	920	0.58
Junc 8	928	0.81
Junc 9	903	0.32
Junc 10	922	0.30
Junc 11	902	0.90
Junc 12	890	0.05
Junc 13	905	0.06
Junc 14	895	0.16
Junc 15	906	0.17
Junc 16	903	0.07
Junc 17	907	0.12
Junc 18	896	0.06
Junc 19	908	0.03
Junc 20	912	0.05
Junc 21	903	0.17
Junc 22	890	0.09
Junc 23	895	0.07
Junc 24	913	0.07
Junc 25	913	0.09
Junc 26	908	0.05
Junc 27	912	0.05
Junc 28	905	0.07
Junc 29	907	0.10
Junc 30	889	0.05
Junc 31	900	0.23
Junc 32	915	0.15
Junc 33	884	0.24
Junc 34	890	0.18
Junc 35	879	0.05

Junc 36	874	0.12
Junc 37	876	0.10
Junc 38	884	0.05
Junc 39	874	0.07
Junc 40	880	0.08
Junc 41	873	0.09
Junc 42	865	0.13
Junc 43	871	0.19
Junc 44	877	0.34
Junc 45	879	0.12
Junc 46	877	0.32
Junc 47	878	0.13
Junc 48	877	0.11
Junc 49	867	0.05
Junc 50	876	0.08
Junc 51	874	0.08
Junc 52	872	0.10
Junc 53	872	0.14
Junc 54	869	0.11
Junc 55	867	0.14
Junc 56	867	0.10
Junc 57	864	0.05
Junc 58	869	0.08
Junc 59	859	0.05
Junc 60	864	0.20
Junc 61	855	0.07
Junc 62	850	0.20
Junc 63	866	0.23
Junc 64	855	0.18
Junc 65	850	0.05
Junc 66	856	0.37
Junc 67	834	0.09
Junc 68	862	0.18
Junc 69	863	0.10
Junc 70	858	0.04
Junc 71	854	0.06
Junc 72	846	0.07
Junc 73	857	0.05
Junc 74	855	0.10
Junc 75	860	0.08
Junc 76	857	0.13
Junc 78	835	0.07
Junc 79	860	0.09

Junc 80	860	0.12
Junc 81	851	0.18
Junc 82	853	0.08
Junc 77	843	0.20
Junc 83	845	0.27
Junc 84	850	0.06
Junc 85	854	0.60
Junc 86	817	0.15
Junc 87	830	0.28
Junc 88	825	0.33
Junc 89	811	0.10
Junc 90	811	0.18
Junc 91	827	0.11
Junc 92	807	0.35
Junc 93	813	0.13
Junc 94	810	0.09
Junc 95	805	0.10
Junc 96	811	0.10
Junc 97	809	0.15
Junc 98	809	0.23
Junc 99	805	0.10
Junc 100	778	0.73
Junc 101	767	0.69
Resvr reser	982	-17.79

Network Table - Links at 0:00 Hrs

Link ID	Length m	Diameter mm	Roughness
Pipe 1	150	150	100
Pipe 2	129	50	100
Pipe 3	43	25	100
Pipe 4	86	150	100
Pipe 5	26	25	100
Pipe 6	380	150	100
Pipe 7	67	25	100
Pipe 8	250	100	100
Pipe 9	67	25	100
Pipe 10	110	100	100
Pipe 11	88	25	100
Pipe 12	22	100	100
Pipe 14	38	100	100
Pipe 15	12	25	100
Pipe 16	110	100	100
Pipe 18	19	100	100
Pipe 17	110	25	100
Pipe 13	80	25	100
Pipe 25	35	100	100
Pipe 19	46	50	100
Pipe 20	62	25	100
Pipe 21	102	25	100
Pipe 22	112	25	100
Pipe 24	42	25	100
Pipe 23	68	25	100
Pipe 26	50	25	100
Pipe 27	51	25	100
Pipe 28	42	100	100
Pipe 29	108	25	100
Pipe 30	46	100	100
Pipe 31	148	25	100
Pipe 32	72	100	100
Pipe 33	110	25	100
Pipe 34	38	100	100
Pipe 35	66	25	100
Pipe 36	40	100	100
Pipe 38	37	100	100
Pipe 37	102	25	100
Pipe 39	55	25	100
Pipe 40	17	100	100

Pipe 41	144	25	100
Pipe 42	40	100	100
Pipe 44	95	75	100
Pipe 45	46	25	100
Pipe 46	20	75	100
Pipe 47	20	25	100
Pipe 48	57	75	100
Pipe 49	142	25	100
Pipe 50	46	75	100
Pipe 51	60	25	100
Pipe 52	80	75	100
Pipe 53	72	25	100
Pipe 54	95	75	100
Pipe 55	196	25	100
Pipe 56	97	75	100
Pipe 57	25	50	100
Pipe 58	100	25	100
Pipe 59	31	50	100
Pipe 60	111	25	100
Pipe 61	37	25	100
Pipe 62	17	25	100
Pipe 63	90	75	100
Pipe 64	190	50	100
Pipe 65	66	25	100
Pipe 66	150	50	100
Pipe 67	200	25	100
Pipe 68	180	75	100
Pipe 69	25	25	100
Pipe 70	30	75	100
Pipe 71	94	25	100
Pipe 72	75	25	100
Pipe 73	40	75	100
Pipe 74	60	25	100
Pipe 75	50	75	100
Pipe 76	117	25	100
Pipe 78	50	50	100
Pipe 79	120	75	100
Pipe 80	132	25	100
Pipe 81	150	50	100
Pipe 82	100	25	100
Pipe 83	50	75	100
Pipe 84	160	25	100
Pipe 85	200	50	100

Pipe 86	60	50	100
Pipe 87	160	25	100
Pipe 88	170	25	100
Pipe 89	250	25	100
Pipe 90	340	25	100
Pipe 91	150	50	100
Pipe 92	100	50	100
Pipe 93	102	25	100
Pipe 94	66	25	100
Pipe 95	90	50	100
Pipe 96	150	25	100
Pipe 97	90	50	100
Pipe 98	60	25	100
Pipe 99	78	50	100
Pipe 100	60	25	100
Pipe 101	250	50	100
Pipe 102	200	25	100
Pipe 43	400	50	100
Pipe 103	120	200	100
Pipe 77	1000	75	100

Network Table - Nodes at 0:00 Hrs

Node ID	Demand LPS	Head m	Pressure m
Junc 1	0.55	981.63	4.63
Junc 2	0.20	981.55	6.55
Junc 3	0.11	979.90	24.90
Junc 4	0.30	978.16	21.16
Junc 5	0.64	978.95	33.95
Junc 6	0.14	978.70	38.70
Junc 7	0.58	975.12	55.12
Junc 8	0.81	958.21	30.21
Junc 9	0.32	959.79	56.79
Junc 10	0.30	957.10	35.10
Junc 11	0.90	953.57	51.57
Junc 12	0.05	953.44	63.44
Junc 13	0.06	952.47	47.47
Junc 14	0.16	951.50	56.50
Junc 15	0.17	950.65	44.65
Junc 16	0.07	950.62	47.62
Junc 17	0.12	945.55	38.55
Junc 18	0.06	945.33	49.33
Junc 19	0.03	944.69	36.69
Junc 20	0.05	944.51	32.51
Junc 21	0.17	941.62	38.62
Junc 22	0.09	941.18	51.18
Junc 23	0.07	941.32	46.32
Junc 24	0.07	944.32	31.32
Junc 25	0.09	944.33	31.33
Junc 26	0.05	943.25	35.25
Junc 27	0.05	943.17	31.17
Junc 28	0.07	943.12	38.12
Junc 29	0.10	941.55	34.55
Junc 30	0.05	941.40	52.40
Junc 31	0.23	939.75	39.75
Junc 32	0.15	938.10	23.10
Junc 33	0.24	937.09	53.09
Junc 34	0.18	935.37	45.37
Junc 35	0.05	935.78	56.78
Junc 36	0.12	935.30	61.30
Junc 37	0.10	934.45	58.45
Junc 38	0.05	934.30	50.30
Junc 39	0.07	933.25	59.25

Junc 40	0.08	933.06	53.06
Junc 41	0.09	932.71	59.71
Junc 42	0.13	931.48	66.48
Junc 43	0.19	931.50	60.50
Junc 44	0.34	925.13	48.13
Junc 45	0.12	924.80	45.80
Junc 46	0.32	923.95	46.95
Junc 47	0.13	923.79	45.79
Junc 48	0.11	920.98	43.98
Junc 49	0.05	920.77	53.77
Junc 50	0.08	918.70	42.70
Junc 51	0.08	918.49	44.49
Junc 52	0.10	914.93	42.93
Junc 53	0.14	914.19	42.19
Junc 54	0.11	910.79	41.79
Junc 55	0.14	908.88	41.88
Junc 56	0.10	906.91	39.91
Junc 57	0.05	906.76	42.76
Junc 58	0.08	906.41	37.41
Junc 59	0.05	906.64	47.64
Junc 60	0.20	904.54	40.54
Junc 61	0.07	906.54	51.54
Junc 62	0.20	906.32	56.32
Junc 63	0.23	904.18	38.18
Junc 64	0.18	901.28	46.28
Junc 65	0.05	901.18	51.18
Junc 66	0.37	899.80	43.80
Junc 67	0.09	898.94	64.94
Junc 68	0.18	901.28	39.28
Junc 69	0.10	901.15	38.15
Junc 70	0.04	900.88	42.88
Junc 71	0.06	900.10	46.10
Junc 72	0.07	899.89	53.89
Junc 73	0.05	900.38	43.38
Junc 74	0.10	900.08	45.08
Junc 75	0.08	899.83	39.83
Junc 76	0.13	898.83	41.83
Junc 78	0.07	901.77	66.77
Junc 79	0.09	893.03	33.04
Junc 80	0.12	890.25	30.25
Junc 81	0.18	887.15	36.15
Junc 82	0.08	886.70	33.70
Junc 77	0.20	902.04	59.04

Junc 83	0.27	886.01	41.01
Junc 84	0.06	885.68	35.68
Junc 85	0.60	881.81	27.81
Junc 86	0.15	878.03	61.03
Junc 87	0.28	857.83	27.83
Junc 88	0.33	850.53	25.53
Junc 89	0.10	849.69	38.69
Junc 90	0.18	836.37	25.37
Junc 91	0.11	835.74	8.74
Junc 92	0.35	828.58	21.58
Junc 93	0.13	828.01	15.01
Junc 94	0.09	827.88	17.88
Junc 95	0.10	827.09	22.09
Junc 96	0.10	827.46	16.46
Junc 97	0.15	826.79	17.79
Junc 98	0.23	827.33	18.33
Junc 99	0.10	827.01	22.01
Junc 100	0.73	822.52	44.52
Junc 101	0.69	785.30	18.30
Resvr reser	-17.79	982.00	0.00

Network Table - Links at 0:00 Hrs

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Friction Factor
Pipe 1	17.04	0.96	11.54	0.037
Pipe 2	0.20	0.10	0.65	0.061
Pipe 3	0.30	0.61	40.36	0.053
Pipe 4	16.63	0.94	11.03	0.037
Pipe 5	0.14	0.29	9.78	0.059
Pipe 6	15.85	0.90	10.08	0.037
Pipe 7	0.81	1.65	252.45	0.045
Pipe 8	14.46	1.84	61.33	0.036
Pipe 9	0.30	0.61	40.11	0.053
Pipe 10	13.84	1.76	56.58	0.036
Pipe 11	0.05	0.10	1.45	0.069
Pipe 12	12.89	1.64	49.58	0.036
Pipe 14	12.67	1.61	48.00	0.036
Pipe 15	0.07	0.13	2.43	0.066
Pipe 16	12.43	1.58	46.37	0.036
Pipe 18	12.25	1.56	45.10	0.036
Pipe 17	0.06	0.12	2.04	0.067
Pipe 13	0.16	0.32	12.23	0.058
Pipe 25	11.69	1.49	41.34	0.037
Pipe 19	0.54	0.27	4.00	0.053
Pipe 20	0.33	0.66	46.52	0.052
Pipe 21	0.09	0.18	4.31	0.063
Pipe 22	0.07	0.14	2.71	0.065
Pipe 24	0.09	0.18	4.31	0.063
Pipe 23	0.07	0.14	2.71	0.065
Pipe 26	0.07	0.13	2.43	0.066
Pipe 27	0.05	0.10	1.45	0.069
Pipe 28	11.52	1.47	40.28	0.037
Pipe 29	0.05	0.10	1.45	0.069
Pipe 30	11.37	1.45	39.31	0.037
Pipe 31	0.15	0.31	11.11	0.058
Pipe 32	10.99	1.40	36.92	0.037
Pipe 33	0.18	0.37	15.57	0.057
Pipe 34	10.57	1.35	34.35	0.037
Pipe 35	0.12	0.24	7.35	0.060
Pipe 36	10.41	1.33	33.35	0.037
Pipe 38	10.26	1.31	32.46	0.037
Pipe 37	0.05	0.10	1.45	0.069
Pipe 39	0.08	0.16	3.47	0.064

Pipe 40	10.11	1.29	31.59	0.037
Pipe 41	0.13	0.26	8.53	0.060
Pipe 42	9.88	1.26	30.30	0.038
Pipe 44	7.12	1.61	67.02	0.038
Pipe 45	0.12	0.24	7.13	0.061
Pipe 46	6.66	1.51	59.21	0.038
Pipe 47	0.13	0.26	8.05	0.060
Pipe 48	6.21	1.41	52.03	0.039
Pipe 49	0.05	0.10	1.45	0.069
Pipe 50	6.05	1.37	49.57	0.039
Pipe 51	0.08	0.16	3.47	0.064
Pipe 52	5.89	1.33	47.12	0.039
Pipe 53	0.14	0.29	10.30	0.059
Pipe 54	5.64	1.28	43.57	0.039
Pipe 55	0.14	0.29	9.78	0.059
Pipe 56	5.39	1.22	40.06	0.040
Pipe 57	0.65	0.33	5.82	0.051
Pipe 58	0.08	0.16	3.47	0.064
Pipe 59	0.52	0.26	3.80	0.053
Pipe 60	0.20	0.41	18.93	0.056
Pipe 61	0.07	0.14	2.71	0.065
Pipe 62	0.20	0.41	18.93	0.056
Pipe 63	4.63	1.05	30.26	0.040
Pipe 64	1.10	0.56	15.29	0.048
Pipe 65	0.05	0.10	1.45	0.069
Pipe 66	0.87	0.44	9.85	0.049
Pipe 67	0.09	0.18	4.31	0.063
Pipe 68	3.30	0.75	16.10	0.043
Pipe 69	0.10	0.20	5.24	0.062
Pipe 70	3.01	0.68	13.65	0.043
Pipe 71	0.13	0.26	8.28	0.060
Pipe 72	0.07	0.14	2.71	0.065
Pipe 73	2.85	0.64	12.27	0.044
Pipe 74	0.10	0.20	5.05	0.062
Pipe 75	2.70	0.61	11.12	0.044
Pipe 76	0.13	0.26	8.53	0.060
Pipe 78	2.22	1.13	55.75	0.043
Pipe 79	4.25	0.96	25.77	0.041
Pipe 80	0.08	0.16	3.47	0.064
Pipe 81	-2.31	1.18	60.01	0.043
Pipe 82	0.07	0.14	2.71	0.065
Pipe 83	3.99	0.90	22.93	0.041
Pipe 84	0.06	0.12	2.04	0.067

Pipe 85	3.66	1.86	140.90	0.040
Pipe 86	3.38	1.72	121.59	0.040
Pipe 87	0.10	0.20	5.24	0.062
Pipe 88	-0.34	0.69	49.66	0.052
Pipe 89	0.41	0.84	71.97	0.050
Pipe 90	0.15	0.31	11.11	0.058
Pipe 91	2.95	1.50	94.39	0.041
Pipe 92	2.66	1.35	77.97	0.042
Pipe 93	0.11	0.22	6.26	0.061
Pipe 94	0.13	0.26	8.52	0.060
Pipe 95	0.77	0.39	7.78	0.050
Pipe 96	0.10	0.20	5.24	0.062
Pipe 97	0.58	0.30	4.66	0.052
Pipe 98	0.15	0.31	11.11	0.058
Pipe 99	0.33	0.17	1.66	0.057
Pipe 100	0.10	0.20	5.24	0.062
Pipe 101	1.41	0.72	24.24	0.046
Pipe 102	0.69	1.40	186.08	0.047
Pipe 43	2.58	1.31	73.65	0.042
Pipe 103	17.79	0.57	3.08	0.038
Pipe 77	2.49	0.56	9.58	0.044

TITLE

Jop Description (THE SECOND PROPOSED WATER DISTRIBUTION NETWORK)

Network Table - Nodes

Node ID	Elevation m	Demand LPS
Junc 1	976	0.60
Junc 2	975	0.30
Junc 3	967	0.10
Junc 4	954	0.20
Junc 5	960	0.10
Junc 6	947	0.06
Junc 7	945	0.22
Junc 8	950	0.20
Junc 9	930	0.10
Junc 10	942	0.30
Junc 11	897	0.06
Junc 12	921	0.40
Junc 13	920	0.20
Junc 14	927	0.28
Junc 15	933	0.15
Junc 16	915	0.22
Junc 17	898	0.11
Junc 18	903	0.32
Junc 19	907	0.27
Junc 20	887	0.17
Junc 21	898	0.05
Junc 22	890	0.06
Junc 23	906	0.07
Junc 24	895	0.16
Junc 25	904	0.17
Junc 26	895	0.06
Junc 27	908	0.12
Junc 28	894	0.06
Junc 29	909	0.02
Junc 30	911	0.07
Junc 31	906	0.18
Junc 32	875	0.20
Junc 33	895	0.12

Junc 34	913	0.05
Junc 35	908	0.04
Junc 36	917	0.07
Junc 37	888	0.06
Junc 38	907	0.20
Junc 39	888	0.07
Junc 40	900	0.24
Junc 41	894	0.10
Junc 42	890	0.11
Junc 43	866	0.13
Junc 44	884	0.13
Junc 45	888	0.10
Junc 46	879	0.19
Junc 47	857	0.10
Junc 48	876	0.18
Junc 49	884	0.10
Junc 50	872	0.13
Junc 51	857	0.07
Junc 52	870	0.18
Junc 53	878	0.27
Junc 54	879	0.14
Junc 55	877	0.19
Junc 56	871	0.07
Junc 57	859	0.11
Junc 58	876	0.14
Junc 59	868	0.05
Junc 60	872	0.17
Junc 61	870	0.05
Junc 62	869	0.09
Junc 63	866	0.06
Junc 64	858	0.05
Junc 65	852	0.05
Junc 66	867	0.19
Junc 67	864	0.05
Junc 68	868	0.10
Junc 69	857	0.00
Junc 70	864	0.13
Junc 71	866	0.13
Junc 72	861	0.33
Junc 73	846	0.12
Junc 74	843	0.00
Junc 75	843	0.12
Junc 76	831	0.10

Junc 77	830	0.10
Junc 78	862	0.10
Junc 79	858	0.19
Junc 80	846	0.19
Junc 81	861	0.16
Junc 82	859	0.18
Junc 83	854	0.16
Junc 84	843	0.05
Junc 85	855	0.23
Junc 86	842	0.03
Junc 87	835	0.07
Junc 88	856	0.28
Junc 89	834	0.09
Junc 90	854	0.48
Junc 91	841	0.33
Junc 92	818	0.14
Junc 93	860	0.11
Junc 94	851	0.23
Junc 95	853	0.08
Junc 96	844	0.27
Junc 97	851	0.09
Junc 98	831	0.20
Junc 99	830	0.05
Junc 100	825	0.36
Junc 101	817	0.13
Junc 102	811	0.18
Junc 103	823	0.08
Junc 104	807	0.20
Junc 105	804	0.12
Junc 106	813	0.08
Junc 107	806	0.18
Junc 108	805	0.07
Junc 109	807	0.07
Junc 110	805	0.06
Junc 111	807	0.12
Junc 112	798	0.13
Junc 113	798	0.11
Junc 114	778	0.29
Junc 115	770	0.08
Junc 116	782	0.26
Junc 117	781	0.10
Junc 118	768	0.15
Junc 119	767	0.12

Junc 120	777	0.19
Junc 121	787	0.11
Junc 122	787	0.12
Resvr Reservoir	982	-17.78

Network Table - Links

Link ID	Length m	Diameter mm	Friction Factor
Pipe 1	127	50	0.055
Pipe 2	162	25	0.062
Pipe 3	159	150	0.037
Pipe 4	251	25	0.062
Pipe 5	77	25	0.067
Pipe 6	79	150	0.037
Pipe 7	24	25	0.056
Pipe 8	71	25	0.062
Pipe 9	109	150	0.037
Pipe 10	190	25	0.067
Pipe 11	109	100	0.035
Pipe 12	136	100	0.035
Pipe 13	75	25	0.047
Pipe 14	200	25	0.058
Pipe 15	114	25	0.055
Pipe 16	118	25	0.061
Pipe 17	233	100	0.036
Pipe 18	70	50	0.054
Pipe 19	130	25	0.057
Pipe 20	96	100	0.036
Pipe 21	89	25	0.067
Pipe 22	22	100	0.036
Pipe 23	79	25	0.058
Pipe 24	37	100	0.036
Pipe 25	67	25	0.067
Pipe 26	103	100	0.036
Pipe 27	110	25	0.067
Pipe 28	18	100	0.036
Pipe 29	46	50	0.052
Pipe 30	54	25	0.049
Pipe 31	164	25	0.056
Pipe 32	138	25	0.060
Pipe 33	133	25	0.069

Pipe 34	28	100	0.036
Pipe 35	143	25	0.065
Pipe 36	117	25	0.067
Pipe 37	39	100	0.037
Pipe 38	108	25	0.065
Pipe 39	48	100	0.037
Pipe 40	229	25	0.062
Pipe 41	31	100	0.037
Pipe 42	154	25	0.060
Pipe 43	31	100	0.037
Pipe 44	186	25	0.062
Pipe 45	37	100	0.037
Pipe 46	177	25	0.062
Pipe 47	33	100	0.037
Pipe 48	104	25	0.062
Pipe 49	46	100	0.037
Pipe 50	166	25	0.065
Pipe 51	42	100	0.038
Pipe 52	91	75	0.040
Pipe 54	72	75	0.041
Pipe 55	112	25	0.057
Pipe 56	104	25	0.061
Pipe 57	40	75	0.041
Pipe 58	121	25	0.069
Pipe 59	69	75	0.041
Pipe 60	102	25	0.069
Pipe 61	75	75	0.042
Pipe 62	84	25	0.058
Pipe 63	53	25	0.069
Pipe 64	80	25	0.069
Pipe 65	72	75	0.042
Pipe 66	26	25	0.053
Pipe 67	109	25	0.062
Pipe 68	33	25	0.060
Pipe 69	127	25	0.060
Pipe 70	37	75	0.043
Pipe 53	45	25	0.059
Pipe 71	101	75	0.040
Pipe 72	147	25	0.060
Pipe 73	137	75	0.041
Pipe 74	158	75	0.041
Pipe 75	231	25	0.062
Pipe 76	95	25	0.062

Pipe 77	101	75	0.052
Pipe 78	32	75	0.053
Pipe 79	122	25	0.056
Pipe 80	77	50	0.057
Pipe 81	93	25	0.057
Pipe 82	82	75	0.045
Pipe 83	137	25	0.069
Pipe 84	110	75	0.046
Pipe 85	69	25	0.062
Pipe 86	83	25	0.065
Pipe 87	122	75	0.047
Pipe 88	201	25	0.063
Pipe 89	122	50	0.047
Pipe 90	143	25	0.049
Pipe 91	196	25	0.059
Pipe 92	122	50	0.059
Pipe 93	169	75	0.041
Pipe 94	75	75	0.041
Pipe 95	132	25	0.064
Pipe 96	42	50	0.039
Pipe 97	160	25	0.063
Pipe 98	115	50	0.040
Pipe 99	97	25	0.069
Pipe 100	60	50	0.040
Pipe 101	188	25	0.060
Pipe 102	126	50	0.041
Pipe 103	102	25	0.064
Pipe 104	63	50	0.042
Pipe 105	169	25	0.064
Pipe 106	75	50	0.050
Pipe 107	150	25	0.065
Pipe 108	58	50	0.054
Pipe 109	105	25	0.067
Pipe 110	145	25	0.060
Pipe 111	32	50	0.056
Pipe 112	119	25	0.060
Pipe 113	99	25	0.061
Pipe 114	244	50	0.046
Pipe 115	150	25	0.064
Pipe 116	91	25	0.051
Pipe 117	91	25	0.062
Pipe 118	166	50	0.051
Pipe 119	139	25	0.060

Pipe 120	62	50	0.055
Pipe 121	105	25	0.061
Pipe 122	217	25	0.060
Pipe 123	123	200	0.038

Network Table - Nodes

Node ID	Demand LPS	Head m	Pressure m
Junc 1	0.60	981.62	5.62
Junc 2	0.30	981.33	6.33
Junc 3	0.10	980.48	13.48
Junc 4	0.20	979.84	25.84
Junc 5	0.10	978.52	18.52
Junc 6	0.06	979.68	32.68
Junc 7	0.22	978.99	33.99
Junc 8	0.20	978.53	28.53
Junc 9	0.10	978.62	48.62
Junc 10	0.30	977.88	35.88
Junc 11	0.06	977.50	80.50
Junc 12	0.40	970.24	49.24
Junc 13	0.20	961.16	41.16
Junc 14	0.28	948.57	21.57
Junc 15	0.15	946.34	13.34
Junc 16	0.22	945.99	30.99
Junc 17	0.11	960.42	62.42
Junc 18	0.32	947.38	44.38
Junc 19	0.27	947.19	40.19
Junc 20	0.17	945.36	58.36
Junc 21	0.05	942.25	44.25
Junc 22	0.06	942.07	52.07
Junc 23	0.07	941.10	35.10
Junc 24	0.16	940.11	45.11
Junc 25	0.17	939.21	35.21
Junc 26	0.06	939.08	44.08
Junc 27	0.12	934.14	26.14
Junc 28	0.06	933.91	39.91
Junc 29	0.02	933.27	24.27
Junc 30	0.07	933.03	22.03
Junc 31	0.18	927.45	21.45
Junc 32	0.20	924.35	49.35
Junc 33	0.12	926.44	31.44
Junc 34	0.05	932.84	19.84

Junc 35	0.04	932.05	24.05
Junc 36	0.07	931.66	14.66
Junc 37	0.06	931.81	43.81
Junc 38	0.20	930.39	23.39
Junc 39	0.07	930.10	42.10
Junc 40	0.24	928.44	28.44
Junc 41	0.10	927.24	33.24
Junc 42	0.11	927.24	37.24
Junc 43	0.13	925.93	59.93
Junc 44	0.13	926.10	42.10
Junc 45	0.10	925.12	37.12
Junc 46	0.19	924.78	45.78
Junc 47	0.10	923.85	66.85
Junc 48	0.18	923.66	47.66
Junc 49	0.10	923.12	39.12
Junc 50	0.13	922.18	50.18
Junc 51	0.07	921.73	64.73
Junc 52	0.18	920.88	50.88
Junc 53	0.27	917.72	39.72
Junc 54	0.14	917.28	38.28
Junc 55	0.19	915.59	38.59
Junc 56	0.07	913.85	42.85
Junc 57	0.11	913.20	54.20
Junc 58	0.14	914.58	38.58
Junc 59	0.05	914.41	46.41
Junc 60	0.17	912.98	40.98
Junc 61	0.05	912.83	42.83
Junc 62	0.09	911.41	42.41
Junc 63	0.06	910.36	44.36
Junc 64	0.05	910.28	52.28
Junc 65	0.05	910.24	58.24
Junc 66	0.19	910.08	43.08
Junc 67	0.05	909.16	45.16
Junc 68	0.10	908.59	40.59
Junc 69	0.00	908.88	51.88
Junc 70	0.13	907.80	43.80
Junc 71	0.13	909.56	43.56
Junc 72	0.33	917.56	56.56
Junc 73	0.12	916.48	70.48
Junc 74	0.00	913.80	70.80
Junc 75	0.12	909.47	66.47
Junc 76	0.10	908.26	77.26
Junc 77	0.10	908.97	78.97

Junc 78	0.10	909.43	47.43
Junc 79	0.19	909.40	51.40
Junc 80	0.19	907.30	61.30
Junc 81	0.16	909.27	48.27
Junc 82	0.18	907.82	48.82
Junc 83	0.16	908.97	54.97
Junc 84	0.05	908.77	65.77
Junc 85	0.23	908.32	53.32
Junc 86	0.03	907.96	65.96
Junc 87	0.07	907.74	72.74
Junc 88	0.28	907.81	51.81
Junc 89	0.09	906.95	72.95
Junc 90	0.48	905.58	51.58
Junc 91	0.33	892.40	51.40
Junc 92	0.14	890.49	72.49
Junc 93	0.11	905.44	45.44
Junc 94	0.23	903.53	52.53
Junc 95	0.08	903.07	50.07
Junc 96	0.27	896.81	52.81
Junc 97	0.09	896.12	45.12
Junc 98	0.20	881.41	50.41
Junc 99	0.05	881.27	51.27
Junc 100	0.36	874.40	49.40
Junc 101	0.13	872.79	55.79
Junc 102	0.18	863.44	52.44
Junc 103	0.08	863.09	40.09
Junc 104	0.20	858.86	51.86
Junc 105	0.12	857.80	53.80
Junc 106	0.08	858.28	45.28
Junc 107	0.18	858.32	52.32
Junc 108	0.07	857.91	52.91
Junc 109	0.07	858.12	51.12
Junc 110	0.06	857.90	52.90
Junc 111	0.12	858.06	51.06
Junc 112	0.13	857.04	59.04
Junc 113	0.11	857.44	59.44
Junc 114	0.29	852.91	74.91
Junc 115	0.08	852.39	82.39
Junc 116	0.26	847.79	65.79
Junc 117	0.10	847.32	66.32
Junc 118	0.15	851.85	83.85
Junc 119	0.12	850.82	83.82
Junc 120	0.19	851.69	74.69

Junc 121	0.11	851.03	64.03
Junc 122	0.12	850.09	63.09
Resvr Reservoir	-17.78	982.00	0.00

Network Table - Links

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Friction Factor
Pipe 1	0.40	0.20	2.33	0.055
Pipe 2	0.10	0.20	5.24	0.062
Pipe 3	16.78	0.95	11.21	0.037
Pipe 4	0.10	0.20	5.24	0.062
Pipe 5	0.06	0.12	2.04	0.067
Pipe 6	16.42	0.93	10.77	0.037
Pipe 7	0.20	0.41	18.93	0.056
Pipe 8	0.10	0.20	5.24	0.062
Pipe 9	15.90	0.90	10.15	0.037
Pipe 10	0.06	0.12	2.04	0.067
Pipe 11	15.54	1.98	70.08	0.035
Pipe 12	15.14	1.93	66.78	0.035
Pipe 13	0.65	1.32	167.95	0.047
Pipe 14	0.15	0.31	11.11	0.058
Pipe 15	0.22	0.45	22.59	0.055
Pipe 16	0.11	0.22	6.26	0.061
Pipe 17	14.18	1.81	59.15	0.036
Pipe 18	0.44	0.22	2.79	0.054
Pipe 19	0.17	0.35	14.01	0.057
Pipe 20	13.42	1.71	53.41	0.036
Pipe 21	0.06	0.12	2.04	0.067
Pipe 22	13.31	1.69	52.60	0.036
Pipe 23	0.16	0.33	12.52	0.058
Pipe 24	13.08	1.67	50.93	0.036
Pipe 25	0.06	0.12	2.04	0.067
Pipe 26	12.85	1.64	49.29	0.036
Pipe 27	0.06	0.12	2.04	0.067
Pipe 28	12.67	1.61	48.01	0.036
Pipe 29	0.62	0.32	5.26	0.052
Pipe 30	0.50	1.02	103.31	0.049
Pipe 31	0.20	0.41	18.93	0.056
Pipe 32	0.12	0.24	7.35	0.060
Pipe 33	0.05	0.10	1.45	0.069
Pipe 34	12.03	1.53	43.62	0.036

Pipe 35	0.07	0.14	2.71	0.065
Pipe 36	0.06	0.12	2.04	0.067
Pipe 37	11.86	1.51	42.48	0.037
Pipe 38	0.07	0.14	2.71	0.065
Pipe 39	11.59	1.48	40.71	0.037
Pipe 40	0.10	0.20	5.24	0.062
Pipe 41	11.25	1.43	38.53	0.037
Pipe 42	0.13	0.26	8.53	0.060
Pipe 43	11.01	1.40	37.02	0.037
Pipe 44	0.10	0.20	5.24	0.062
Pipe 45	10.78	1.37	35.60	0.037
Pipe 46	0.10	0.20	5.24	0.062
Pipe 47	10.49	1.34	33.85	0.037
Pipe 48	0.10	0.20	5.24	0.062
Pipe 49	10.21	1.30	32.19	0.037
Pipe 50	0.07	0.14	2.71	0.065
Pipe 51	10.01	1.27	31.03	0.038
Pipe 52	4.99	1.13	34.67	0.040
Pipe 54	4.58	1.04	29.58	0.041
Pipe 55	0.18	0.37	15.58	0.057
Pipe 56	0.11	0.22	6.26	0.061
Pipe 57	4.21	0.95	25.30	0.041
Pipe 58	0.05	0.10	1.45	0.069
Pipe 59	4.02	0.91	23.23	0.041
Pipe 60	0.05	0.10	1.45	0.069
Pipe 61	3.80	0.86	20.93	0.042
Pipe 62	0.16	0.33	12.52	0.058
Pipe 63	0.05	0.10	1.45	0.069
Pipe 64	0.05	0.10	1.45	0.069
Pipe 65	3.55	0.80	18.44	0.042
Pipe 66	0.28	0.57	35.30	0.053
Pipe 67	0.10	0.20	5.24	0.062
Pipe 68	0.13	0.26	8.52	0.060
Pipe 69	0.13	0.26	8.52	0.060
Pipe 70	3.08	0.70	14.18	0.043
Pipe 53	0.14	0.29	9.78	0.059
Pipe 71	4.84	1.10	32.85	0.040
Pipe 72	0.12	0.24	7.35	0.060
Pipe 73	4.39	0.99	27.42	0.041
Pipe 74	4.39	0.99	27.42	0.041
Pipe 75	0.10	0.20	5.24	0.062
Pipe 76	0.10	0.20	5.24	0.062
Pipe 77	0.82	0.19	1.22	0.052

Pipe 78	0.72	0.16	0.96	0.053
Pipe 79	0.19	0.39	17.22	0.056
Pipe 80	0.34	0.17	1.73	0.057
Pipe 81	0.18	0.37	15.57	0.057
Pipe 82	2.13	0.48	7.15	0.045
Pipe 83	0.05	0.10	1.45	0.069
Pipe 84	1.92	0.43	5.90	0.046
Pipe 85	0.10	0.20	5.24	0.062
Pipe 86	0.07	0.14	2.71	0.065
Pipe 87	1.59	0.36	4.16	0.047
Pipe 88	0.09	0.18	4.31	0.063
Pipe 89	1.22	0.62	18.33	0.047
Pipe 90	0.47	0.96	92.13	0.049
Pipe 91	0.14	0.29	9.78	0.059
Pipe 92	0.27	0.14	1.10	0.059
Pipe 93	4.07	0.92	23.84	0.041
Pipe 94	4.23	0.96	25.56	0.041
Pipe 95	0.08	0.16	3.47	0.064
Pipe 96	3.92	2.00	160.00	0.039
Pipe 97	0.09	0.18	4.31	0.063
Pipe 98	3.56	1.81	133.85	0.040
Pipe 99	0.05	0.10	1.45	0.069
Pipe 100	3.31	1.69	116.97	0.040
Pipe 101	0.13	0.26	8.52	0.060
Pipe 102	2.82	1.44	86.94	0.041
Pipe 103	0.08	0.16	3.47	0.064
Pipe 104	2.56	1.30	72.68	0.042
Pipe 105	0.08	0.16	3.47	0.064
Pipe 106	0.74	0.38	7.30	0.050
Pipe 107	0.07	0.14	2.71	0.065
Pipe 108	0.49	0.25	3.40	0.054
Pipe 109	0.06	0.12	2.04	0.067
Pipe 110	0.12	0.24	7.35	0.060
Pipe 111	0.36	0.18	1.92	0.056
Pipe 112	0.13	0.26	8.53	0.060
Pipe 113	0.11	0.22	6.26	0.061
Pipe 114	1.42	0.72	24.40	0.046
Pipe 115	0.08	0.16	3.47	0.064
Pipe 116	0.36	0.73	56.23	0.051
Pipe 117	0.10	0.20	5.24	0.062
Pipe 118	0.69	0.35	6.41	0.051
Pipe 119	0.12	0.24	7.35	0.060
Pipe 120	0.42	0.21	2.56	0.055

Pipe 121	0.11	0.22	6.26	0.061
Pipe 122	0.12	0.24	7.35	0.060
Pipe 123	17.78	0.57	3.07	0.038

Network Table - Links

Link ID	Diameter mm	Roughness	Reaction Rate mg/L/d	Status
Pipe 1	50	100	0.00	Open
Pipe 2	25	100	0.00	Open
Pipe 3	150	100	0.00	Open
Pipe 4	25	100	0.00	Open
Pipe 5	25	100	0.00	Open
Pipe 6	150	100	0.00	Open
Pipe 7	25	100	0.00	Open
Pipe 8	25	100	0.00	Open
Pipe 9	150	100	0.00	Open
Pipe 10	25	100	0.00	Open
Pipe 11	100	100	0.00	Open
Pipe 12	100	100	0.00	Open
Pipe 13	25	100	0.00	Open
Pipe 14	25	100	0.00	Open
Pipe 15	25	100	0.00	Open
Pipe 16	25	100	0.00	Open
Pipe 17	100	100	0.00	Open
Pipe 18	50	100	0.00	Open
Pipe 19	25	100	0.00	Open
Pipe 20	100	100	0.00	Open
Pipe 21	25	100	0.00	Open
Pipe 22	100	100	0.00	Open
Pipe 23	25	100	0.00	Open
Pipe 24	100	100	0.00	Open
Pipe 25	25	100	0.00	Open
Pipe 26	100	100	0.00	Open
Pipe 27	25	100	0.00	Open
Pipe 28	100	100	0.00	Open
Pipe 29	50	100	0.00	Open
Pipe 30	25	100	0.00	Open
Pipe 31	25	100	0.00	Open
Pipe 32	25	100	0.00	Open
Pipe 33	25	100	0.00	Open

Pipe 34	100	100	0.00	Open
Pipe 35	25	100	0.00	Open
Pipe 36	25	100	0.00	Open
Pipe 37	100	100	0.00	Open
Pipe 38	25	100	0.00	Open
Pipe 39	100	100	0.00	Open
Pipe 40	25	100	0.00	Open
Pipe 41	100	100	0.00	Open
Pipe 42	25	100	0.00	Open
Pipe 43	100	100	0.00	Open
Pipe 44	25	100	0.00	Open
Pipe 45	100	100	0.00	Open
Pipe 46	25	100	0.00	Open
Pipe 47	100	100	0.00	Open
Pipe 48	25	100	0.00	Open
Pipe 49	100	100	0.00	Open
Pipe 50	25	100	0.00	Open
Pipe 51	100	100	0.00	Open
Pipe 52	75	100	0.00	Open
Pipe 54	75	100	0.00	Open
Pipe 55	25	100	0.00	Open
Pipe 56	25	100	0.00	Open
Pipe 57	75	100	0.00	Open
Pipe 58	25	100	0.00	Open
Pipe 59	75	100	0.00	Open
Pipe 60	25	100	0.00	Open
Pipe 61	75	100	0.00	Open
Pipe 62	25	100	0.00	Open
Pipe 63	25	100	0.00	Open
Pipe 64	25	100	0.00	Open
Pipe 65	75	100	0.00	Open
Pipe 66	25	100	0.00	Open
Pipe 67	25	100	0.00	Open
Pipe 68	25	100	0.00	Open
Pipe 69	25	100	0.00	Open
Pipe 70	75	100	0.00	Open
Pipe 53	25	100	0.00	Open
Pipe 71	75	100	0.00	Open
Pipe 72	25	100	0.00	Open
Pipe 73	75	100	0.00	Open
Pipe 74	75	100	0.00	Open
Pipe 75	25	100	0.00	Open
Pipe 76	25	100	0.00	Open

Pipe 77	75	100	0.00	Open
Pipe 78	75	100	0.00	Open
Pipe 79	25	100	0.00	Open
Pipe 80	50	100	0.00	Open
Pipe 81	25	100	0.00	Open
Pipe 82	75	100	0.00	Open
Pipe 83	25	100	0.00	Open
Pipe 84	75	100	0.00	Open
Pipe 85	25	100	0.00	Open
Pipe 86	25	100	0.00	Open
Pipe 87	75	100	0.00	Open
Pipe 88	25	100	0.00	Open
Pipe 89	50	100	0.00	Open
Pipe 90	25	100	0.00	Open
Pipe 91	25	100	0.00	Open
Pipe 92	50	100	0.00	Open
Pipe 93	75	100	0.00	Open
Pipe 94	75	100	0.00	Open
Pipe 95	25	100	0.00	Open
Pipe 96	50	100	0.00	Open
Pipe 97	25	100	0.00	Open
Pipe 98	50	100	0.00	Open
Pipe 99	25	100	0.00	Open
Pipe 100	50	100	0.00	Open
Pipe 101	25	100	0.00	Open
Pipe 102	50	100	0.00	Open
Pipe 103	25	100	0.00	Open
Pipe 104	50	100	0.00	Open
Pipe 105	25	100	0.00	Open
Pipe 106	50	100	0.00	Open
Pipe 107	25	100	0.00	Open
Pipe 108	50	100	0.00	Open
Pipe 109	25	100	0.00	Open
Pipe 110	25	100	0.00	Open
Pipe 111	50	100	0.00	Open
Pipe 112	25	100	0.00	Open
Pipe 113	25	100	0.00	Open
Pipe 114	50	100	0.00	Open
Pipe 115	25	100	0.00	Open
Pipe 116	25	100	0.00	Open
Pipe 117	25	100	0.00	Open
Pipe 118	50	100	0.00	Open
Pipe 119	25	100	0.00	Open

Pipe 120	50	100	0.00	Open
Pipe 121	25	100	0.00	Open
Pipe 122	25	100	0.00	Open
Pipe 123	200	100	0.00	Open