ANALYSIS AND DESIGN OF WATER DISTRIBUTION NETWORK FOR AL-SAMOU' TOWN

BY

DOAA JAHSHAN **HANEEN NASER ALDEEN**

NEDAA ALQAM

CIVIL & ARCHITECTURAL ENGINEERING DEPARTMENT

COLLEGE OF ENGINEERING AND TECHNOLOGY

PALESTINE POLYTECHNIC UNIVERSITY

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SUPERVISED BY

DR. WAFAA AL HASAN

CIVIL & ARCHITECTURAL ENGINEERING DEPARTMENT

COLLEGE OF ENGINEERING AND TECHNOLOGY

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ANALYSIS AND DESIGN OF WATER DISTRIBUTION NETWORK FOR AL-SAMOU' TOWN

Prepeared By:

DOAA JAHSHAN **HANEEN NASER ALDEEN**

NEDAA ALQAM

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

Project Supervisors **Department Chairman**

الإهداء

إلى شهداءنا الأبرار الذين قدموا **أرواحهم** رخيصة في سبيل الله ثم الوطن

إلى الرجل الرجل إلى الأسود الرابضة خلف القضبان
إلى كل الأسرى

إلى كل من ضحى من اجل دينه وأرضه وعرضه

إلى خنساوات العصر
إليكن أمهات الشهداء و **الأسرى والجرحى**

إليكم جميعا نهدي هذا العمل المتواضع

فريق **العمل**

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

Work Team

ABSTRACT

Analysis and Design of Water Distribution Network for Al-Samou' Town

By:

Doaa Jahshan **Haneen Naser Aldeen** **Nedaa Alqam**

Palestine Polytechnic University

Supervisor

Dr. WAFAA ALHASAN

Alsamou' town faces big problems in water supply and water services due to population growth. Hence, the water distribution network is not servicing all the areas in the town, and many pipes are old. The people in the town depend mainly on water coming through the network and on water tanking and constructed cisterns for water supply. In view of this bad condition, the need for water supply scheme that will supply the entire area of Al-Samou' town with water requirements become pressing, and subsequently this work was conducted to study and evaluate the present situation and redesign of the existing water distribution network using water-cad software.

The present study considered the annual population growth and their water demand for the coming 25 years that will be the design period, along. The hydraulic calculation needed for the design of the main and sub main pipelines was carried out using water-cad software version 6.5.

By the end the project, a complete design for water distribution network for Al-Samou' town will be ready along with bill of quantities, cost estimate, and the suggested phases of construction.

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1 *INTRODUCTION*

CHAPTER ONE
INTRODUCTION

1.1 General

Al-Samou' town is located 23 Km to the south of the Hebron city. It is area with an average height of 700 m with respect to sea level. The temperature is relatively high in summer 34°C and winter temperature is 9°C .The average rainfall is around 300 mm per year and the present population is around 21,750 persons in the year 2011.

Al-Samou' town faces -like other cities and towns in the West Bank- water shortage. Water demand in the town is increasing from year to year due to increase in the population. At the same time, the development of additional water supplies has been however, far short of the increase in water demand.

The amount of water supplies to the town is very little (900 m^3/day), and the existing water supply network is old and does not satisfy the need of water. The amount of water that is lost in the distribution system is about 25% of the quantity of water supplied. Palestinian Water Authority (which supplies town with water) 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 scheme that will, supply reliably adequate amounts of water has become pressing and subsequently, this study is conducted to assess the existing water supply for Al-Samou' town and design a new water distribution network.

1.2 Problem Definition

Water is indispensable to human life and is also a vital necessity of plant and animal life. The wide expansion and accelerated development of Al-Samou' town had led to an increase in amount of water consumption for domestic, public and irrigation uses. The average consumption of water in the town for all purposes does not exceed 20 cubic meters per year (55 liter per day) due to limited quantities of water and the existing water distribution system. This water demand was mostly met by underground water.

Al-Samou' faces great difficulties and different problems in water supply and water services due to population growth. Hence, the amount of water supplies to the town is very little and the existing water supply network is old and does not satisfy the needs of water. And as mentioned earlier, the 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 of Al-Samou' town is almost supplied by water coming from Palestinian Water Authority main pipe passing near the town (600 cubic meter per day) and from Al Siymia groundwater well (300 cubic meter per day). The water in the town is distributed directly by a network of steel pipelines, most of them are old and exposed to the traffic. The pipelines range from 0.5" to 4" in diameter and many are in bad state of repair. The amount of water that is lost in the distributing system or is unaccounted for is about 25% of the quantity of water supplied.

1.3 Technical Objectives

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

1. Estimate the annual amount of water required per capita for all purposes up to the planning horizon of 2035 taking into consideration the present and future population.
2. Study and evaluation of the existing water network in Al-Samou' town, and display the difficulties, which the municipality faces in order to develop and improve the existing water mains.
3. 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 around 24 hour water supply.

4. Development of several plans for the construction of the proposed water supply scheme and prepare bill of quantities.
5. Finally, providing suggestions and recommendations regarding Al-Samou town water supply.

1.4 Project Area

Al-Samou' town is located 23 Km south of the Hebron city in Hebron Governorate along the Green Line as shown in location map Figure (1.1). The general view of the town is presented in Figure (1.2). It is bordered by Yatta town to the east, Ar Rihiya and Yatta to the north, Al Dhahiriya town to the west and the Green Line to the south as illustrated in Figure (1.3).

Al-Samou' town sits at an elevation of 700 m above sea level. The mean annual rainfall in the town is 300 mm, the average temperature is about 28 ºC in summer and 15 ºC in winter and the average annual humidity is 61%. The per capita water consumption for domestic use does not exceed 60 liter per day. The present total administrative area of the town is about 39000 dounm, where 1800 dounm are residential area and the remaining are agricultural lands. According to the Palestinian Central Bureau of Statistics, in 2011, the total population of Al-Samou' town was 23000. The total population is expected to grow substantially up to year 2035, which is planning horizon of this project.

Most of the water supply to Al-Samou' town comes from underground water wells. The pipe lines, which conveyed water from the source to the municipal bounder are owned and operated by the Palestinian water authority. These pipelines also supply other Palestinian communities. Small scales of the water supply come from local production wells. At present, there are inadequate water resources to meet all the water demand, with these results Al-Samou' municipality finds it necessary to distribute water according to rational program during the summer on the demand increase and water supply is limited. The total water supplied to the town from Abu Al Ashoosh main reservoir is 600 m^3/day, and from Al Siymia well is 300 m^3/day. The leakage in the water network is around 25%.

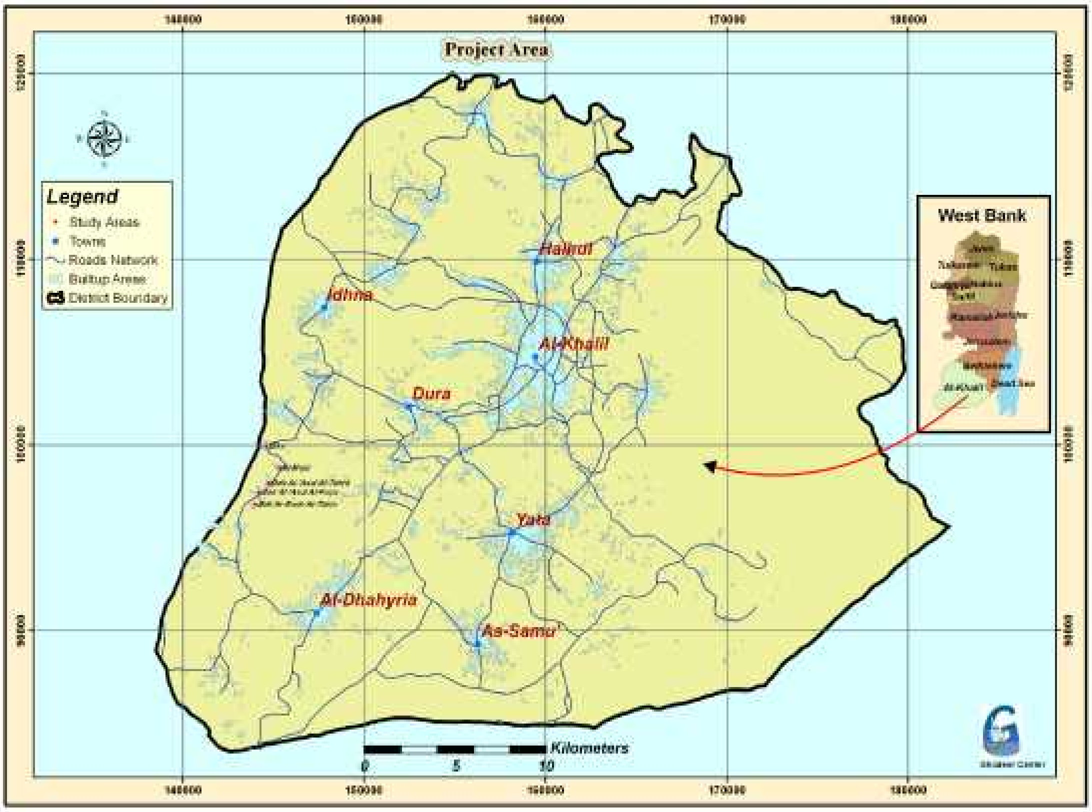

Figure (1.1): Location Map for the Project Area (Al-Samou' Town)

Figure (1.2): General View of Al Samou' Town

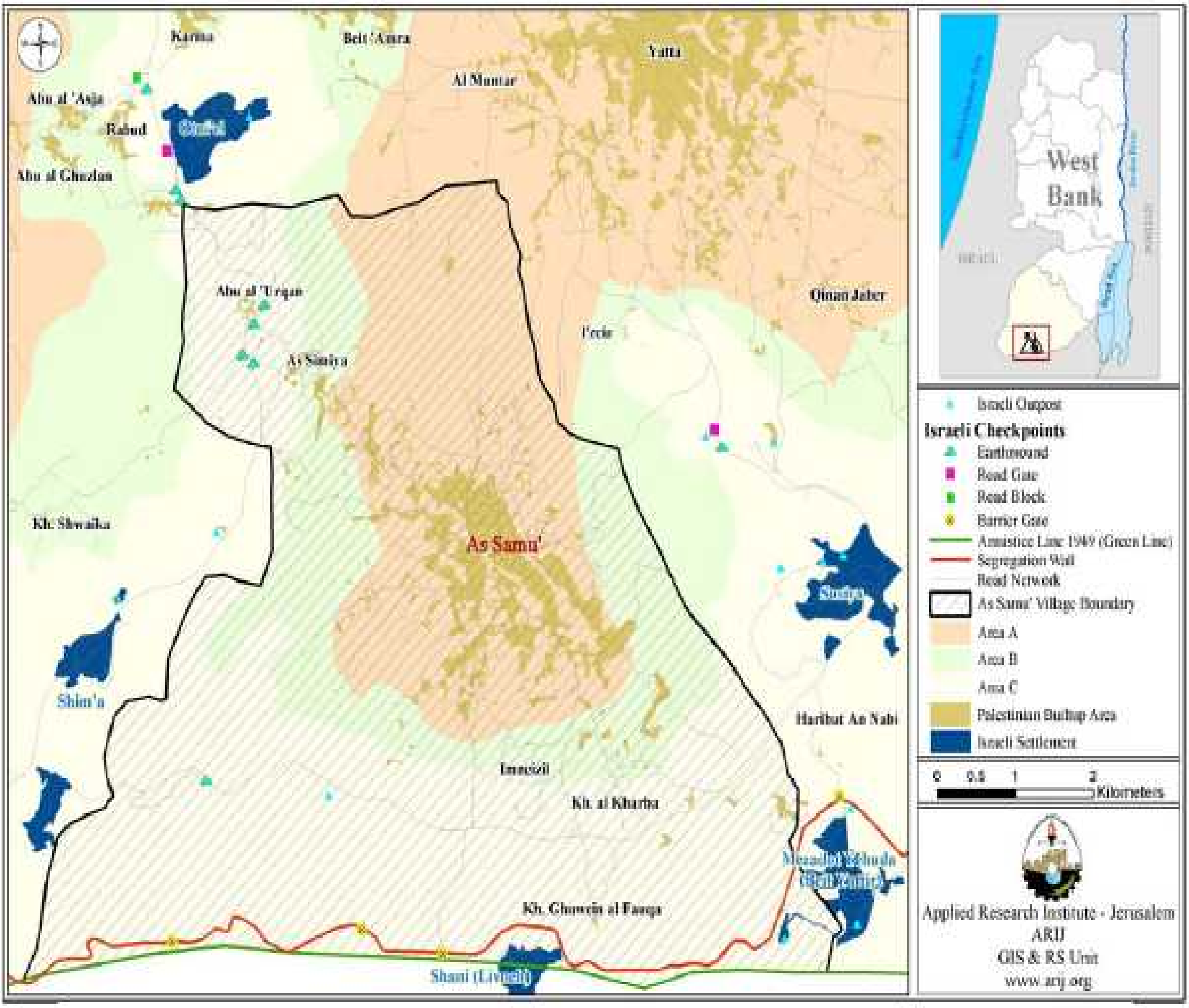

Figure (1.2): Al Samou' Town Location and Borders

1.5 Work Plan

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

1. Make some visits to Al Samou' municipality and town public committee to discuss the problems that the existing water network faces, and knowing the complaints which the consumers reports.
2. Obtaining on the existing water network map from Al Samou' municipality along with the detail Aerial photogrammetric map which shows the 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 Al Samou' town.
4. Estimate the water demand for the town up to the design period of 2035 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 and WaterCad computer softwares for the analysis and design of the network.
7. Design a new pipelines network completely for 25 years toward with all requirements.
8. Prepare bill of quantities to the proposed new water distribution network.
9. Writing the Final report.

Table 1.1: project time for Al-Samou' town.

Phase No.	Title	Duration								
		9/11	10/11	11/11	12/11	2/12	3/12	4/12	5/12	
One	Field visit and collection of data and maps									
Two	Study and evaluate the existing network.									
Three	Analysis and design of new network using water cad software									
Four	Prepare the drawings and bill of quantities									
Five	Writing the Report.									

1.5 Structure of the Report

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

The title of ***Chapter One "Introduction"*** outlines the general background, problem definition, technical objectives, project area, work plan and structure of the report.

Chapter Two entitled ***"Water Distribution Systems"*** deals with methods of water distribution, types of pipes, pipe appurtenances, service reservoirs pumps and pumping, and excavation and backing fill.

Chapter Three entitled ***"Design and Planning Criteria"*** presents population and population forecast, projected water demand, water sources, and design parameters.

Chapter Four entitled ***"Analysis and Design"*** is devoted to the method of calculation, , network design steps, the existing water distribution network, and analysis and discussion of results and development of future plans and appropriate technology for reconstruction and upgrading of the existing water network in Al Samou' town.

Chapter five entitled ***"Bill of Quantity"***.

The overall “***Conclusions"*** are given in ***Chapter six***.

CHAPTER

2 WATER DISTRIBUTION SYSTEMS

2.1 General

2.2 Methods of Distribution

2.3 Types of Pipes

2.4 Pipes Appurtenances

2.5 Service Reservoirs

2.6 Pumps and Pumping

2.7 Excavation and Backing fill

CHAPTER TWO
WATER DISTRIBUTION SYSTEMS

2.1 General

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

2.2 Methods of Distribution

Depending upon the topography, location of the source, and other considerations, water can be transported to a community in a number of ways. For transportation of water, canals, flumes, tunnels, and pressure pipes can be employed. Water can be supplied to the consumers with adequate pressure either by means of gravity, pumping, or a combination of both (see Figure 3.1)(Peary, Rowe and Techobanolous, 1985).

2.2.1 Gravity Distribution System

In this system, the water from the high leveled source is distributed to the consumers at lower levels, by the mere action of gravity without any pumping. For proper functioning of this system, the difference of head available between the source and localities, must be sufficient enough, as maintain adequate pressure at the consumer's door –steps, after allowing the frictional and other loss in the pipes. This method is the most economical and reliable, since no pumping is involved at any stage. However, it needs a lake or reservoir as a source of supply (Garge,1998).

2.2.2 Pumping With Storage System

In this system, the water is pumped at a constant rate and stored into an elevated distribution reservoir, from where it distributed to the consumers by the mere action of gravity. Sometimes, the entire water is first of all pumped into the distribution reservoir, many times, it is pumped into the distribution mains and reservoirs simultaneously. This method thus, combined as well as gravity flow (Garge,1998).

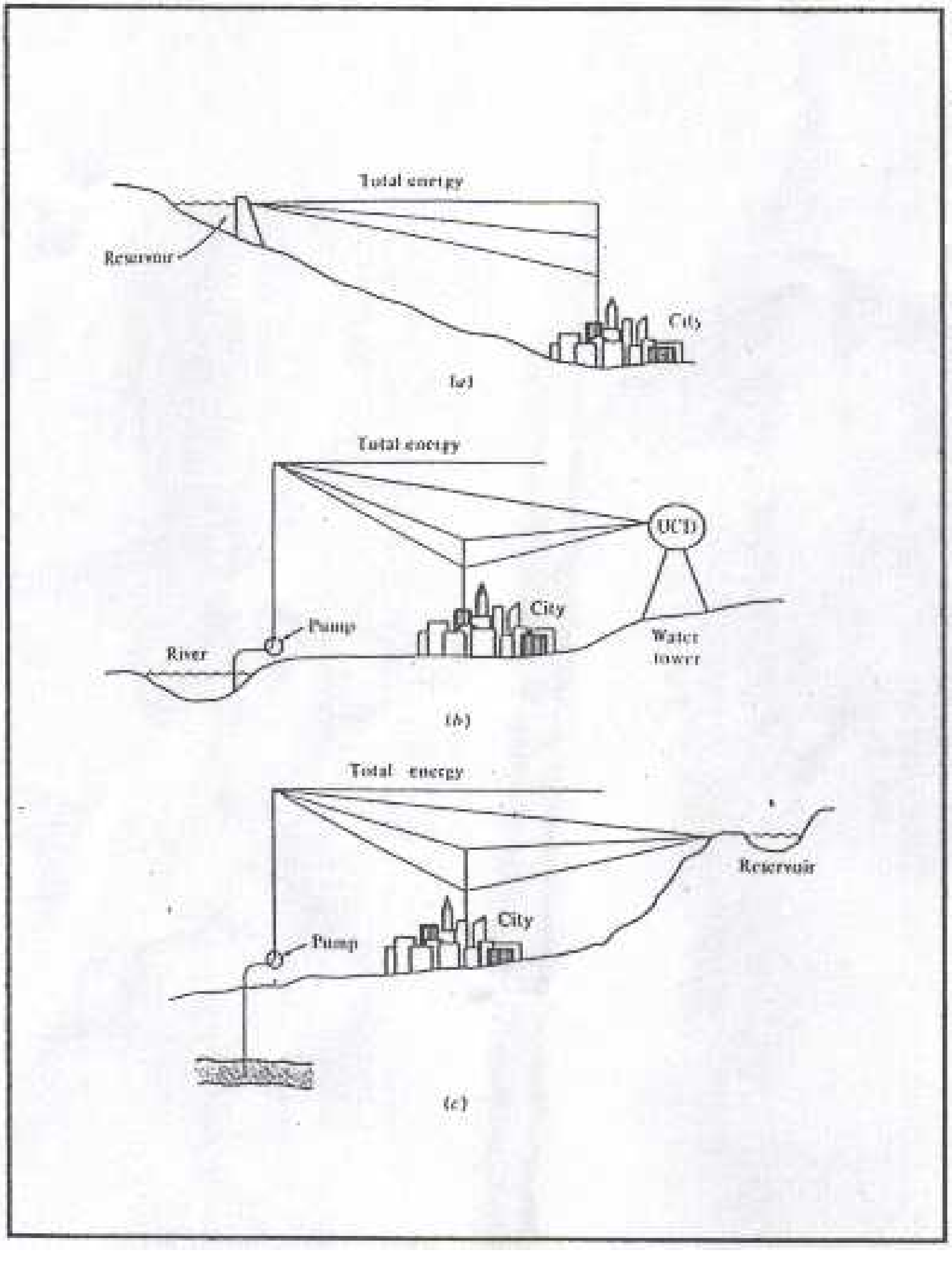

Figure (2.1): Typical Distribution System: (a) Gravity, (b) Pumped, and (c) Combined

2.2.3 Pumping Without Storage System

In the pumping system, the water is directly pumped into the distribution mains without storing it anywhere. High lift pumps are required in this system, which have to operate at variable speeds, so as to meet the variable demand of water. Thus a continuous attendance is needed at the pumping station, so to ensure the desired flow in the distribution system (Garge,1998). Moreover, if the power supply fails there will be complete stoppage of water supply, and if by chance, a fire breaks out at such a time, it will bring disaster. This method is therefore, generally not used. However, the only advantage of this method is that during fires, it can force large volumes of water under high pressure in the required direction, so that the motor pumps may be eliminated.

2.3 Types 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:

(i) 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.

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

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

(iv) Plumping pipes: Pipes work within a building for the distribution of water of various appliances.

Pipes are also classified according to their material of construction. The following types of pipes are in use for construction of mains:

1. Cast iron pipes
2. Asbestos cement pipes
3. Steel pipes
4. Reinforced concrete pipes
5. Plastic pipes

The selection of particular types of material for a pipe depends mainly upon the first cost, maintenance cost, durability, carrying capacity, the maximum pressure, the maximum permissible size, availability of materials and labor for their construction, etc. The type of water to be conveyed and its possible corrosive effect upon the pipe material must be taken into account.

In Palestine, the use of steel pipes is more favorable considering the rocky terrain and steep slopes along most of the lines. Steel pipelines under such conditions are less exposed to damages by subsequent construction activities than other material pipes.

2.4 Pipes Appurtenances

In order to isolate and drain the pipeline sections for tests, inspection, cleaning and repairs, a number of appurtenances such as pipe fittings, valves, manholes, etc. are provided at various suitable places along the pipelines, as described below.

2.4.1 Pipe Fittings

The various pipe fittings such as bends, crosses, tees, elbows, wye, union, capes, reducers, plugs, etc. are frequently used in making service connections and bigger sized mains or sub-mains. Fittings are supplied in case of interruption of pipelines, such as change in diameters, materials, pipeline direction or if valve and water meters have to be installed. Various types of bends and other important pipe fittings are shown in Fig. 3.2 Proper selection and installation of joints and fittings is very important because they are often source of leakage (Steel and McGhee 1991).

2.4.2 Valves

A large number of different types of valves are required for the proper functioning of the pipelines. Generally, valves have three main tasks: flow and/or regulation (e.g. flow control valves, pressure reducing valves, etc.), exclusion of the parts of the network due to emergency or maintenance reasons, and protection of reservoirs and pumps in the system (e.g. float valves, non-return valves). With respect to the purpose, the following types of valves can be distinguished.

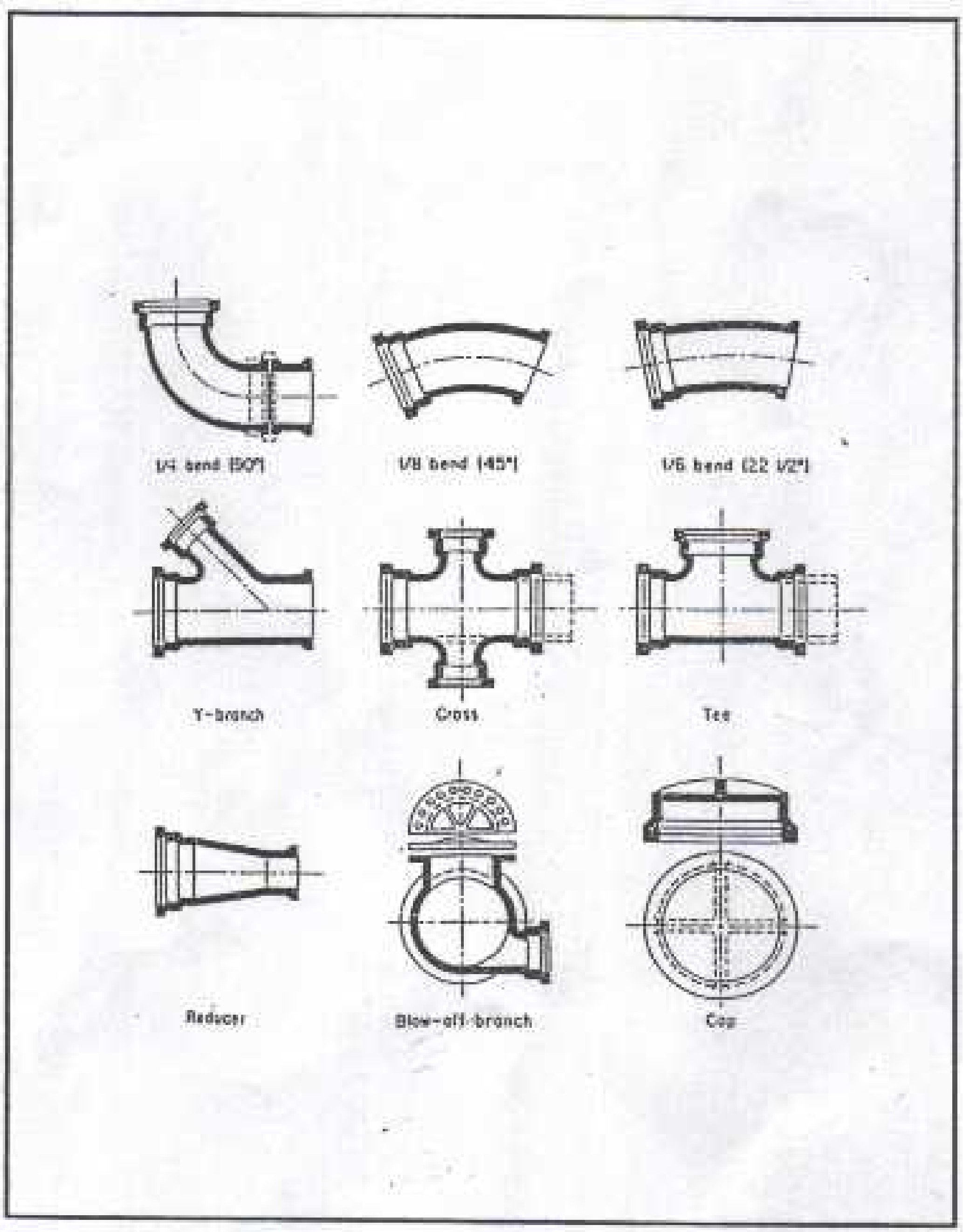

Figure (2.2):Various Pipe Fitting

1. **Gate Valves or Sluice Valves:** They are isolating valves, used most often in the distribution system to shut off the flow whenever desired, especially, when repairs are needed in the system, they are also helpful in dividing the water mains into suitable sections. Gate valves have the advantage of low cost, availability and low head losses when fully opened. In general, these valves are installed at street crossing where lines intersect.

2. **Pressure Reduce Valves:** They are installed at locations along the pipelines where pressure is high, especially at low point in the network and those that are near the pump station. When pressure in the pipe exceeds the maximum allowed limit, the valve relive pressure through cross pipe. An adjustable control permits setting downstream pressure at the desired level and the valve will throttle itself until that pressure is attained.

3. **Air Relief Valves:** Water flowing through a pipelines always contain some air which tries to accumulate at high points, and may interface with the flow. Air relief valves are therefore provided at the summit along the pipe, these valves are needed to discharge air when a main is being filled and to admit air when it is being emptied.

4. **Scour or Blow off Valves:** These are ordinary sluice valves that are located either at dead end or at the lowest point of the main. They are provided to blow off or remove the sand and silt deposited in pipelines. They are operated manually.

5. **Non-Return Valves:** These valves are used to primate the flow of water in one direction only. They consist of flat disc within the pipeline, when they are forced by water they are opened. They are used through the main pipes to the pumping station to prevent reverse flowing, and at the end of suction line to prevent draining the suction when the pump stops.

6. **Float Valves:** These valves are installed at the entrance of the storage reservoirs. There task is to close or open depending on the movement of a floating sphere on water to control the water surface inside the reservoir.

2.4.3 Water Meters

Purpose of metering in water distribution systems is twofold: it provides information about hydraulic behavior of the network, useful for the future design, as well as, it basis for water billing. In both cases the accuracy is vital, so the quality and good maintenance of these devices are very important (UNDP,1990).

2.4.4 Fire 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 m^3/h), and the distance between (100-300 m) (UNDP,1990).

2.4.5 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.

2.5 Service Reservoirs

2.5.1 Functions

Distribution reservoirs are the storage reservoirs ,which store the water for supplying water during emergencies, such as break-down of pumps, heavy fire demand, repairs, etc. and to help in absorbing the hourly fluctuation in the normal water demand. Storage reservoirs are also used to maintain pressure and reduce pressure variation within the distribution system. In large cites, distribution reservoirs may be used at several location within the system. Regardless of the locations, the water level in the reservoir must be at sufficient elevation to permit gravity flow at an adequate pressure. Types and storage capacity of the service reservoirs is explained in the following sections.

2.5.2 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).

2.5.3 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.

2.6 Pumps and Pumping

The transport of water from low lying sources, e.g. underground water, rivers and lakes, to the elevated water towers, reservoirs, directly to the consumers under pressure is accomplished with the help pumps. In a water supply scheme, pumps are required at one or more stages.

In the design of pumping works, stand-by units must be provided that in case of break dawn or during repairs the water supply is not effected. The number of units in reserve will depend upon the particular station and operational conditions.

2.6.1 Types of Pumps

There are various types of pumps, but the two types which the hydraulic engineers generally encounter, are :

1. **Roto-dynamic pumps:** A rotodynamic pump has a wheel or a rotating elements which rotates the water in a casing, and thus imparting energy to the water. Such a pump may be of the following two types:

   a) Centrifugal pumps

   b) Axial-flow pumps

2. Displacement pumps

A displacement pumps works on the principle of mechanically inducing vacum in a chamber, thereby drawing in a volume of water which is then mechanically displaced and forced out of the chamber. Such a pump may be of the following two types:

a) The reciprocating pump

b) The rotary type pump

In addition to these two major types of pumps, other types, such as air lift pumps, jet pumps, hydraulic rams, etc. are also used under special conditions.

2.6.2 Guide for Selection of Pumps

The various factors which must be thoroughly considered while selecting a particular type of pump for a particular project are :

a) Capacity of pumps

b) Importance of water supply scheme

c) Initial cost of pumping arrangement

d) Maintenance cost

e) Space requirements for locating the pump

f) Number of units required

g) Total lift of water required

h) Quantity of water to be pumped

2.6.3 Pumping Station

The location of a pumping station is primarily governed by the location of the place from where it is to receive water, and also by the location of the place where it is to supply that water. The various points which are to be kept in mind while selecting a suitable site are enumerated below :

a) The site should be a ways from all the sources of contamination or pollution.

b) The site should be above the highest flood level of the rivers.

c) It should be so selected that its future growth and expansion is easily possible.

d) Possibilities of fire hazard should also be considered while selecting the site for the pumping stations.

e) The proximity of the site to the railways, from where the coal can be quickly made available for producing power, may also have be considered.

2.7 Excavation and Backing Fill

Great care is not necessary in lying water pipes accurately to grade, but sufficient cover is necessary to give protection against traffic loads and to prevent freezing. The filling height is usually between 1 to 1.5 m measured from the upper tip of the pipe, this depends mainly on the volume and density of the traffics in the area of the project, in addition to the material of pipes and type of filling materials.

Trenches or ditches should be wide enough to allow good workmanship. Required widths range from 0.5 to 1.2 m depends on pipe size. In rock excavation the rock should be removed so that it is at least 150 mm away from the finished pipeline. A cushion of sand or earth should be placed between rock and the pipe (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.

CHAPTER

3 *DESIGN AND PLANNING CRITERIA*

CHAPTER THREE
DESIGN AND PLANNING CRITERIA

3.1 General

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

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

In Al-Samou' town, there is great uncertainty in the political and economical future. Additionally there were no accurate population data since the occupation of the West Bank in 1967, until 1997 and later in different years when the Palestinian Central Bureau of Statistic (PCBS) conducted comprehensive census covering the West Bank and Gaza Strip.The final results of this census show that the total population of Al-Samou' town is 21750 for year 2010 inhabitants.

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

3.2.1 Population Forecast

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

The base for the forecast is the 2010 population for Al-Samou' town obtained from PCBS of 21750 inhabitants. The rate of population growth for the purpose of our study was based on estimation used for other towns of similar population composition and characteristics. The rate of population growth in other towns in the West Bank is between 3.0-3.5%. Therefore, the rate of 3.5% per year was used for the future growth of the population of Al-Samou' town.

To calculate the population at the end of the design period (year 2035), a geometric increase is assumed, represented by the following equation:

$$P = Po * (1 + r)^{n} \tag{3.1}$$

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

Using the above assumption and equation, Table 3.1 presents the population projection up to the design horizon of 2035. The data show that the population of Al-Samou' town is estimated to be 51400 in year 2035.

Table 3.1: Population Forecasts for Al-Samou' Town

Year	2010	2020	2025	2030	2035
Population	21750	30681	36439	43278	51400

3.2.2 Population Density

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

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

The peopled area divided to three sectors A (dense area as 50% of capacity), B (partial dense area as 75%) and C (Weak density as 85%).

Developing area of the AL- Samou' town = 1624 hectare.

Area of sector A= 221 h , B= 596 h , C= 807 h.

Number of houses in sector A/10 hectare = 257 = 25/ha.

Number of houses in sector B/10 hectare = 40 = 4/ha.

Number of houses in sector C/10 hectare = 20 = 2/ha.

Currently there are no buildings in the sector C and there is no accommodation, but there is expected within 25 years to become the region population. The current population density of sectors above calculated as follow:

In sector A (mid town) approximately each building has two storey. Assumed that in each storey live six persons and the full capacity of each building four floors, the maximum density will be 24 persons/building in the future as no enough space to new constructions. Dependent on this analysis the current population density calculated as

The sector A in this day for each building has 2 storeys.

26x2x6=312p/ha.

The total population number in this sector = 312x221=68952p.

The sector B in this day for each building has 2 storeys.

In sector B there's 4 houses/hectare, assuming 6 people live in each house.

The current population density =4x1 x6=24p/h.

The total population number in this sector = 24x596=14304p.

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

In sector C there's 1 houses/hectare, assuming 6 person live in each house the

Current population density =2x 1x6=12p/h.

The total population number in this sector = 12x807=9684 p.

The current population number in AL- Samou' is 21750.

The calculated number above =68952+ 14304+9684=92940p.

Correction factor 21750/92940 = 0.234.

The realistic population number in each sectors:

Sector A 68952x 0.234 = 16135p.

Sector B 14304 x 0.234 =3347p.

Sector C 9684 x 0.234 =2266.

Sum. 16135+3347+2266=21750p.

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

$P_f = P_c(1+I)^n$

P_f : Population in future.

P_c : Current population.

I: Natural increasing ratio /year The natural increasing of population according the central statistic department = 3.5%.

n: Design period (years).

$P_f = 16135 (1+0.035)^{25} = 38131$p.

In sector (A)

but the maximum =16135 x2=32270p ➔p. density 32270/221=146p/ha.

So:

38131-32270=5861p should be divided on sectors B&C 0.75 on B and 0.25 on C

Assume in each building has 4storey.

In sector (B) P_f =3347x4 +(0.75x5861)=17784p.

➔Density 17784/596=30p/ha.

In sector(C) P_f =2266x4 +(0.25x5861)=10529p.

➔Density 10529/807=13p/ha.

The total population in 2035 as estimated (146x221)+(30x596)+(13x807)=60637p.

$P_f = 21750(1+0.035)^{25} = 51400p < 60637$ p ……. OK.

3.3 Future Water Demand

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

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

Restrictions on the Palestinian use of the annual ground water resources of the West Bank led to the availability limited quantities of water and due to this condition, the average consumption of water in Al-Samou' town for all purposes does not exceed 25.55 cubic meter per capita per year. Given these circumstances, the approach to determine per capita water consumption depends on the analysis of the existing information. The existing per capita consumption has already been assessed at (70 litter/capita.day).

The present average consumption of water for domestic use in Al-Samou' town is low (70 liter/capita.day) and does not represent the present and actual demand of water. The future water demand should be calculted with the assumption of better living standard and economic condition, but the Muncipilty doses not expect any increase in the quantity of water in the near future expect that which meet with the increase in the population. So, the present and future water demand for domestic purposes of Al-Samou' town will be the same as 70 liter/capita.day.

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

Table 3.2: Future Water Demand for Al-Samou' Town

Year	Population	Water Demand(m^3/year)		Water Demand(l/c.d)
		Per Capita	Total	
2010	21750	25.55	555713	70
2020	30681	36.5	1876100	100
2030	43278	36.5	1876100	100
2035	51400	36.5	1876100	100

It may be noted from Table 3.2 that the projected water demand for the design period (year 2035) is 1876100cubic meter per year which is equivalent to 5000 cubic meter per day.

3.4 Water Sources

The water supply for Al-Samou' town falls short of the requirements due to insufficient water sources and due to limited quantities of water supplied to the towns and villages by the Palestinian Water Authortiy. The water is provided to the town by cisterns, water tanking, and underground water. The town receive water from two source, from Al Siymia underground, and Wadi Al Saeer ground water well. The total water supplied to the town from Abu Al Ashoosh main reservoir is 600 m3/day, and from Al Siymia well is 300 m3/day. The leakage in the water network is around 25%. The future water demand will be increased and meet from undegriund well located in Wadi Al Saeer.

3.5 Design Parameters

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

1. Design period 25 year (from 2010-2035).
2. Present (2010) population of municipality of Al-Samou' town is 21750 capita.
3. The growth rate will be 3.5% .
4. The existing per capita water consumption has been assessed 70 l/c.d.
5. Total administrative area of municipality of Al-Samou' town 39000 dounm.

6. Future 2035 population of Al-Samou' town 51400 capita.
7. Per capita water consumption by 2035 will remain 100 l/c.d.
8. Formula to be used in design of pipes :(Hazen- William's formula)

$$V = 0.85\ C_H\ R^{0.63}\ S^{0.54} \tag{3.2}$$

9. Dimensionless coefficient (C_H) ranges between 110-150 according to the material of the pipes.
10. Minimum velocity 0.2 m/sec.
11. Maximum velocity 2 m/sec.
12. Minimum pressure = 0.5 bar (5 m)
13. Maximum pressure = 9 bar (90 m)
14. Minimum diameter of 2"(50 mm)

CHAPTER

4 *ANALYSIS AND DESIGN*

4.1 General

4.2 Method of Calaculation

4.3 Network Design Steps

4.4 The ExistingWater Distribution Network

4.5 The Proposed Water Distribution Network

CHAPTER FOUR
ANALYSIS AND DESIGN

4.1 General

In this project, an attempt is made to study and evaluate the proposed water distribution network in Al-Samou' town 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, in order to supply all the inhabitants of Al-Samou' town with a sufficient amount of good quality drinking water. In this chapter, the method of calculation will be described followed by discussion of the existing and proposed main water network.

4.2 Method of Calculation

4.2.1 Water-CAD Software

The computer program Water-CAD V6.5 XM Edition performs the calculations necessary for the water distribution network design. This computer program is developed by Bentley, USA.

Water-CAD is a computer program that performs extended period simulation of hydraulic and waters quality behavior within drinking water distribution system. A network can consist of pipes, nodes (pipe functions), pumps, valves, and storage tank or reservoirs. Water-CAD 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 perform. 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.

The algorithm makes of the Hardy-Cross method. This method makes use of either the Hazen- Williams’s formula or Darcy-Weisbach equation. The computer program assumes distribution of flow in the network and balances the head losses. Pipe flow formulas are used to determine the actual head losses, correction will then be made in the flow until the heads losses are balanced. The flow corrections are based on the concept that the flow at a node will continue, which means that the sum of the incoming flows equals the sum of the outgoing flows.

The computer program facilitates the selection of the appropriate pipe diameter. A number of data is required before the program can start its calculations. The length of pipes, the reservoir level, the demand per node, the elevation of the nodes, the Hazen–Williams and Darcy-Weisbach coefficients for the friction, the stopping criterion for the Hardy- Cross algorithm, and the expected diameter for each pipe are required for this computer program. The program uses a simplified layout of the network. All significant components in the network were marked by nodes.

The pipelines are divided from node to node. The reservoir is represented as a node. At these nodes the water supply or consumption of the surrounding area is linked.

The result of this approach is that every node has its share in (l/s) of the demand of the total area. The friction of the pipeline is taken into account by using the Hazen-William or Darcy-Weisbach coefficient. This dimensionless coefficient (C) ranges between 110-150 according to the material of the pipes. The chosen coefficient for this network is 130. The stopping criterion for the Hardy –Cross is chosen at 0.01.

Filling up the computer program only the pipe diameters remain. Varying these diameters enables then computer program to calculate the head losses, the velocity, the flow in each pipe and the pressure at each node. The velocity and the pressure are restricted between margins. These margins should be considered, but can be crossed if sensible. Finally the most suitable diameters are found, so that the pressure in the nodes will meet the requirements as close as possible (5-90 m) and the velocities will mostly be between the range of (0.2-2 m/s).

4.2.2 Pipe Hydraulics

As mentioned earlier, pipe hydraulic calculation has been carried out by the EPANET and WATERCAD software, which uses the Hazen-Williams equation to calculate the friction head loss. The design criteria adopted for different parameters are:

(i)Velocity:

- Minimum velocity = 0.2 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.

(ii) 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 to have excessive pressure in the network and so minimize the leakage from the system.

(iii) Pipe: The pipes of the distribution system are chosen to be steel pipes due to their advantages. Minimum diameter of 2"(50 mm) is taken. The Hazen –Williams constant of a new steel pipes is 130.

4.2.3 Reservoir

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 Al-Samou' town, big municipal water reservoir are available. Most households have cisterns and/or large roof tanks that provide additional storage in the system. At the same time, the availability of funds and land needed to build the reservoir are factors to be considered in deciding whether we need reservoir or not. In this project, it is suggested to build one large reservoir on available land located in one of the highest point of Al-Samou' town.

4.2.4 Valves

Gate valves are placed at the street corners where lines are intersected. Air relief valves are placed at the highest node on the line . pressure reduce valves are placed at the lowest node.

4.3 Network Design Steps

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

1. Estimated the future population of the study area to determine the quantity of water which is required to be provided by the project.
2. Located a reliable source of water, so as to fulfill the needs and requirements of the area.
3. Obtained 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, selected 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. Estimated the average and peak water use for the area or each sub-area, allowing for fire fighting and future growth.
6. Estimated pipe size on the basis of water demand and local code requirements.
7. Laid out a skeleton system of supply mains leading from the distribution reservoir or other source of supply.
8. Analyzed the flow and pressures in the supply network.
9. Suggested pipe sizes to reduce pressure irregularities in the basic grid.
10. Added distribution mains to the grid system.
11. Reanalyzed the hydraulic capacity of the system.
12. Added street mains for domestic service.
13. Located the necessary values and fire hydrants.
14. Prepared final design drawings and quantity takeoffs.

4.4 The Existing Water Distribution Network

In the proposed study for the water distribution network, the trial is made to design the network for year 2035. The appropriate pipe diameters will be found using the computer program filled with basic data (nodes water demand in year 2035, elevation of the nodes, and the length of each pipe). So that, the pressure in each node, and the velocity in the links will meet the requirements as close as possible. The existing water distribution network is plotted in Figure 4.1.

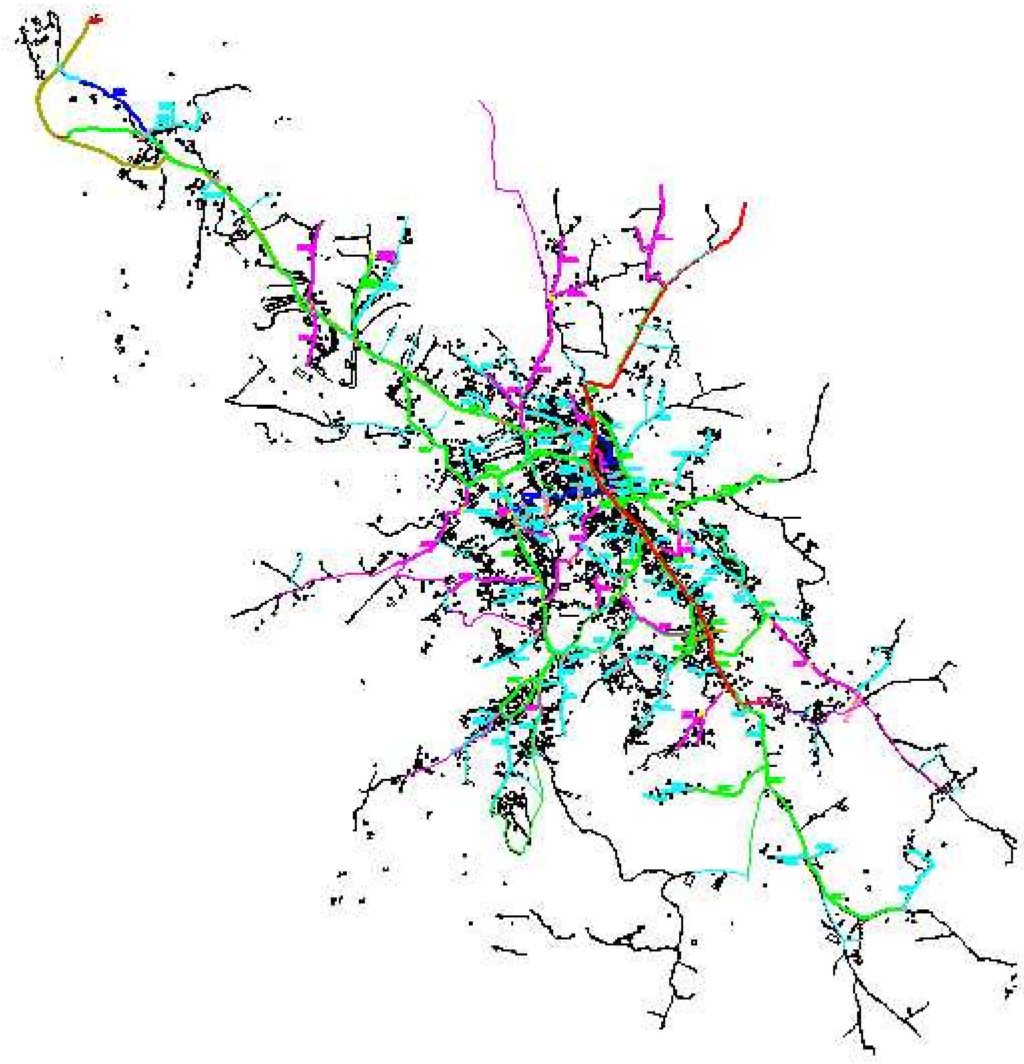

Figure 4.1 : General layout of proposed water distribution system system for Alsamou' town.

4.5 The Proposed Main Network:

In the proposed study for the water distribution network, the trial is made to design the network for year 2035 . the appropriate pipe diameter are found by use of the computer program filled with basic data (nodes water demand in year 2035 , elevation of the nodes , the length of each pipe). So that , the pressure in the nodes and velocity in the links will meet the requirements as close as possible. The appropriate diameters for proposed network are found and given in table 4.3 along with the elevation and demand data . the same data are shown in figs. 4.4 and 4.5 .

The calculated velocities , head loss , and pressure are given in tables 4.2. The proposed water distribution network for year 2035 is plotted in figure 4.4 and 4.5.

Tabel 4.1: The calculation for the base demand:

Area	no.House	no.person	in future	water con	Q per h	Q PER sec	Q/NO.NODE
1	23	276	652	65225.56	4076.598	1.13238822	0.161769746
2	2	24	57	5671.788	354.4867	0.09846854	0.024617135
3	41	492	1163	116271.7	7266.978	2.01860509	0.201860509
4	17	204	482	48210.2	3013.137	0.8369826	0.119568943
5	17	204	482	48210.2	3013.137	0.8369826	0.2789942
6	29	290	685	68534.1	4283.382	1.1898282	0.396609401
7	11	110	260	25995.69	1624.731	0.45131415	0.045131415
8	32	320	756	75623.84	4726.49	1.31291388	0.187559126
9	25	250	591	59081.12	3692.57	1.02571397	0.341904656
10	14	140	331	33085.43	2067.839	0.57439982	0.287199911
11	34	340	804	80350.33	5021.896	1.394971	0.199281571
12	21	210	496	49628.14	3101.759	0.86159973	0.287199911
13	230	2300	5435	543546.3	33971.65	9.43656851	0.277546133
14	54	540	1276	127615.2	7975.952	2.21554217	0.553885543
15	37	370	874	87440.06	5465.004	1.51805667	0.138005152
16	72	720	1702	170153.6	10634.6	2.95405623	0.211004016
17	32	320	756	75623.84	4726.49	1.31291388	0.21881898
18	43	430	1016	101619.5	6351.221	1.76422803	0.252032575
19	12	120	284	28358.94	1772.434	0.49234271	0.492342705
20	48	480	1134	113435.8	7089.735	1.96937082	0.281338689
21	250	2500	5908	590811.2	36925.7	10.2571397	0.341904656
22	115	1150	2718	271773.2	16985.82	4.71828426	0.589785532
23	162	1620	3828	382845.7	23927.86	6.64662652	0.474759037
24	43	430	1016	101619.5	6351.221	1.76422803	0.588076009
25	80	800	1891	189059.6	11816.22	3.2822847	0.65645694
26	59	590	1394	139431.5	8714.466	2.42068497	0.22006227
27	152	1520	3592	359213.2	22450.83	6.23634093	0.69292677
28	120	1200	2836	283589.4	17724.34	4.92342705	1.230856763
29	124	1240	2930	293042.4	18315.15	5.08754129	0.363395806
30	101	1010	2387	238687.7	14917.98	4.14388443	0.517985554
31	121	1210	2860	285952.6	17872.04	4.96445561	0.992891122
32	185	1850	4372	437200.3	27325.02	7.59028337	0.506018891
33	84	840	1985	198512.6	12407.04	3.44639894	0.492342705

Column 1 : is the area and its tached in the chart.

Column 2: number of the house in each area.

Column 3: number of person = no. of floor (2) * no. of person each floor *no. of houses on that area.

Column 4 : number of person on the future after 25 years in this formula :

pf=pc(1+3.5%)^n.

where :

pf : no of person on the future.

Pc : no. of current person.

n : no. of years =25 years.

Column 5 : number of future person * 100 l/d.

Column 6 : column 5/16(no. of hours).

Column 8 : Q/ no. of node in each area.

Table 4.2 : input data for the proposed network (X,Y) , (Node) And the pressure at each node for the proposed net work :

junction	X (m)	Y (m)	Elevation (m)	Demand (l/s)	Pressure Head	Hydraulic Grade
					(m)	(m)
3	157,941.07	88,346.47	778	0.59	34.83	812.83
6	158,250.34	87,974.31	778	0.59	34.75	812.75
7	158,421.75	87,839.97	778	0.59	34.72	812.72
8	157,381.41	87,905.92	750	0.59	71.83	821.83
10	157,608.86	87,480.01	751	0.59	70.76	821.76
11	157,711.88	87,260.16	752	0.59	69.71	821.71
12	157,822.19	86,994.32	753	0.59	68.69	821.69
13	158,167.81	87,169.93	754	0.59	67.69	821.69
26	153,457.37	92,252.45	649	0.16	88.65	761.99
27	153,448.88	92,203.24	650	0.16	87.65	761.95
29	153,416.81	92,140.61	652	0.16	77.54	761.89
31	153,355.11	92,048.99	655.89	0.16	85.32	761.8
33	153,217.08	91,901.06	663.9	0.16	88.9	761.64
35	153,182.83	91,837.76	666.57	0.16	87.45	761.59
37	153,173.00	91,779.61	668.08	0.16	83	761.54
39	153,259.36	91,609.21	672	0.02	89.4	761.4
41	153,315.89	91,565.18	675	0.02	86.35	761.35
43	153,499.47	91,509.18	683	0.02	78.2	761.2
45	153,570.52	91,481.30	692.16	0.02	68.98	761.14
47	153,690.46	91,422.81	695	0.12	66.04	761.04
49	153,738.37	91,416.04	699.34	0.12	61.67	761.01
51	153,758.49	91,468.99	703	0.12	57.9	760.9

junction	X (m)	Y (m)	Elevation (m)	Demand (l/s)	Pressure Head	Hydraulic Grade
					(m)	(m)
55	153,811.53	91,514.00	706.96	0.2	53.82	760.78
57	153,830.09	91,541.53	707	0.2	53.73	760.73
59	153,838.47	91,570.05	710.42	0.2	50.28	760.7
61	153,813.36	91,594.58	710.9	0.2	49.77	760.67
63	153,852.42	91,633.43	711.25	0.2	49.39	760.64
65	153,878.79	91,640.98	711.75	0.2	48.88	760.63
67	153,996.70	91,657.87	716	0.2	44.59	760.59
69	154,048.08	91,653.31	723.18	0.2	37.4	760.58
71	154,088.22	91,644.56	723.95	0.2	36.63	760.58
73	154,106.46	91,638.34	724.22	0.2	36.36	760.58
75	153,860.65	91,404.09	695.05	0.12	65.78	760.83
77	153,895.37	91,424.94	691.85	0.12	68.92	760.77
79	153,935.21	91,465.90	688.5	0.12	72.18	760.68
81	153,962.67	91,459.75	688.7	0.28	71.94	760.64
83	153,991.29	91,426.86	688.89	0.28	71.69	760.58
85	154,158.48	91,379.27	695.67	0.28	64.67	760.34
87	154,348.86	91,192.14	683.91	0.4	76.07	759.98
89	154,457.54	91,044.11	674.02	0.4	85.73	759.75
91	154,531.16	90,929.40	670	0.4	89.58	759.58
93	154,582.47	90,837.25	665	0.05	84.45	759.45
95	154,604.16	90,816.03	662	0.05	87.41	759.41
97	154,635.13	90,794.72	661	0.05	88.37	759.37
99	154,658.35	90,769.84	660.86	0.05	88.47	759.33
101	154,691.45	90,656.56	660	0.05	89.19	759.19
103	154,713.13	90,620.32	662	0.05	87.14	759.14
105	154,738.57	90,601.03	662.4	0.05	86.7	759.1
107	154,776.42	90,589.42	662.25	0.05	86.81	759.06
109	154,779.99	90,611.95	664	0.19	84.99	758.99
111	154,770.53	90,632.38	665	0.19	83.94	758.94
113	154,757.92	90,647.47	666	0.19	82.91	758.91
115	154,755.80	90,690.60	668.85	0.19	80.02	758.87
117	154,781.15	90,790.23	676	0.19	82.8	758.8
119	154,771.70	90,888.52	688.5	0.19	70.27	758.77
121	154,787.96	90,991.42	700	0.19	58.77	758.77
123	154,798.15	90,581.34	660	0.05	88.96	758.96
125	154,994.21	90,436.96	641.09	0.29	87.65	758.74
127	155,017.83	90,472.89	644.25	0.2	84.35	758.6
129	155,009.16	90,497.26	644.8	0.2	83.79	758.59
131	155,007.58	90,612.68	654.11	0.2	84.28	758.39
133	155,025.90	90,702.45	657.5	0.2	80.79	758.29
135	155,065.58	90,788.48	657.6	0.2	80.62	758.22

junction	X (m)	Y (m)	Elevation (m)	Demand (l/s)	Pressure Head	Hydraulic Grade
					(m)	(m)
139	155,099.99	90,903.70	659.5	0.2	88.7	758.2
141	154,782.99	90,586.67	662.25	0.05	86.72	758.97
144	154,792.08	90,514.88	660	0.34	88.84	758.84
146	154,781.40	90,420.50	668.07	0.34	80.68	758.75
148	154,758.70	90,329.84	668.18	0.34	80.55	758.73
150	155,140.99	90,326.36	644	0.29	84.6	758.6
152	155,318.88	90,239.63	647.71	0.29	80.75	758.46
154	155,259.34	90,278.53	646.18	0.29	82.33	758.51
157	155,306.30	90,201.76	651.5	0.29	86.79	758.29
159	155,333.20	90,084.42	657	0.28	80.8	757.8
161	155,332.05	90,040.52	660	0.28	87.63	757.63
163	155,325.94	90,010.46	660.32	0.28	87.2	757.52
165	155,345.89	89,945.52	658.74	0.28	88.54	757.28
167	155,378.36	89,917.69	660	0.28	87.15	757.15
169	155,406.51	89,906.75	666.98	0.28	80.07	757.05
171	155,456.86	89,847.63	674.31	0.28	82.52	756.83
173	155,504.88	89,816.95	679.59	0.28	77.09	756.68
175	155,537.94	89,805.56	684	0.28	72.59	756.59
177	155,546.31	89,765.29	687	0.28	69.49	756.49
179	155,542.93	89,727.98	688.85	0.28	67.56	756.41
181	155,546.41	89,709.96	689	0.28	67.37	756.37
183	155,560.35	89,695.48	689.7	0.28	66.64	756.34
185	155,612.74	89,657.73	688.2	0.28	68.03	756.23
187	155,659.19	89,595.04	691.31	0.28	64.79	756.1
189	155,663.44	89,541.67	685.8	0.28	69.84	755.64
191	155,633.10	89,466.75	677	0.28	78.02	755.02
193	155,603.05	89,444.32	675.5	0.28	79.26	754.76
195	155,566.81	89,442.91	676.69	0.28	77.85	754.54
197	155,543.63	89,427.72	680.02	0.28	74.37	754.39
199	155,532.19	89,377.88	684.3	0.28	69.85	754.15
201	155,501.25	89,309.29	686	0.28	67.84	753.84
203	155,458.32	89,238.78	684	0.28	69.56	753.56
205	155,351.76	89,184.23	684.5	0.28	68.71	753.21
207	155,288.10	89,158.43	687.47	0.28	65.58	753.05
209	155,150.56	89,100.31	690.91	0.28	61.86	752.77
211	155,106.82	89,089.91	690	0.28	62.49	752.49
213	155,064.55	89,094.24	688.75	0.28	63.55	752.3
215	155,004.87	89,093.55	692.32	0.28	58.59	750.91
217	154,962.08	89,089.48	691	0.28	59.24	750.24
219	154,845.84	89,068.52	686.2	0.28	62.97	749.17
221	154,783.90	89,058.67	686.65	0.28	62.25	748.9

junction	X (m)	Y (m)	Elevation (m)	Demand (l/s)	Pressure Head	Hydraulic Grade
					(m)	(m)
225	155,593.99	90,040.16	668.3	0.55	90.14	758.44
227	155,904.55	89,941.89	678.37	0.55	80.06	758.43
229	156,061.99	89,878.36	693.35	0.49	65.12	758.47
231	156,200.26	89,903.46	700	0.25	58.56	758.56
233	156,194.84	89,968.97	704.28	0.25	54.03	758.31
235	156,142.99	89,978.16	702.19	0.25	55.97	758.16
237	156,106.12	89,992.57	700	0.25	58.09	758.09
239	156,086.39	90,005.71	698.54	0.25	59.53	758.07
241	156,044.09	90,007.59	693.11	0.25	64.94	758.05
243	155,967.05	90,024.75	687.16	0.25	70.88	758.04
245	155,976.63	89,912.70	684.45	0.55	73.98	758.43
248	155,972.77	89,963.96	684	0.14	74.41	758.41
250	155,964.89	89,995.83	683.55	0.14	74.86	758.41
252	155,964.45	90,034.55	682.75	0.14	75.65	758.4
254	155,965.41	90,091.64	678	0.14	80.39	758.39
256	155,972.34	90,124.81	677	0.14	81.39	758.39
258	155,998.15	90,153.14	672	0.21	86.38	758.38
260	156,030.03	90,216.28	667	0.21	91.37	758.37
262	156,073.39	90,322.52	663.5	0.21	84.87	758.37
264	156,108.14	90,368.16	658.5	0.21	89.86	758.36
266	156,138.52	90,434.26	653	0.21	86.36	758.36
268	156,136.02	90,493.36	653.5	0.21	84.85	758.35
270	156,132.24	90,517.45	655.68	0.21	82.67	758.35
272	156,137.78	90,568.20	660.1	0.21	88.24	758.34
274	156,134.30	90,622.66	662.56	0.21	85.78	758.34
276	156,140.45	90,663.80	661	0.21	87.34	758.34
278	156,146.60	90,709.97	661	0.21	87.33	758.33
280	156,188.61	90,830.57	660.45	0.21	87.88	758.33
282	156,193.47	90,924.25	663.8	0.21	94.53	758.33
284	156,205.12	91,005.88	665.45	0.21	92.88	758.33
286	155,938.96	90,039.62	682.67	0.14	75.69	758.36
288	155,889.85	90,098.64	690.59	0.14	67.71	758.3
290	155,872.39	90,134.51	690	0.14	68.27	758.27
292	155,821.64	90,178.22	697.7	0.14	60.55	758.25
294	155,807.56	90,203.13	695	0.14	63.25	758.25
296	155,679.66	90,292.72	686.7	0.14	71.54	758.24
298	155,994.38	89,905.57	684.45	0.55	73.98	758.43
301	156,007.93	89,797.54	680.94	0.34	77.44	758.38
303	155,990.28	89,746.30	681	0.34	77.37	758.37
305	155,974.00	89,718.62	679.2	0.34	79.16	758.36
307	155,835.24	89,647.39	683.95	0.34	74.36	758.31

junction	X (m)	Y (m)	Elevation (m)	Demand (l/s)	Pressure Head	Hydraulic Grade
					(m)	(m)
311	155,976.43	89,253.13	711.5	0.34	46.69	758.19
313	156,052.56	89,128.09	718.26	0.34	39.89	758.15
315	156,076.35	89,080.77	719.8	0.34	38.34	758.14
317	156,102.37	88,995.13	720.82	0.34	37.3	758.12
319	156,105.11	88,775.19	713.01	0.34	45.07	758.08
321	156,128.67	88,690.90	707.5	0.34	50.57	758.07
323	156,156.59	88,642.85	705	0.34	53.06	758.06
325	156,157.43	88,614.94	705	0.34	53.05	758.05
327	156,082.22	88,491.85	705.2	0.34	52.83	758.03
329	156,073.76	88,458.52	705.25	0.34	51.82	757.07
331	156,071.56	88,418.93	702.5	0.34	53.61	756.11
333	156,072.62	88,360.31	696	0.34	58.91	754.91
335	156,094.30	88,314.63	694.55	0.34	59.49	754.04
337	156,067.57	88,255.00	694.4	0.34	58.71	753.11
339	156,047.71	88,180.39	691.64	0.34	60.59	752.23
341	156,036.54	88,115.76	687.3	0.34	64.34	751.64
343	156,040.16	88,055.53	681.2	0.34	70.04	751.24
345	156,074.60	87,943.28	677.5	0.34	73.18	750.68
347	156,094.69	87,823.59	679	0.34	68.92	747.92
349	156,079.67	87,769.66	680.23	0.34	66.94	747.17
351	156,057.47	87,734.56	681	0.34	65.91	746.91
353	155,988.95	87,501.51	695	0.34	51.48	746.48
355	156,021.52	88,484.33	703	0.34	54.22	757.22
357	155,961.99	88,452.92	705	0.34	51.79	756.79
359	155,913.68	88,393.37	707	0.34	49.66	756.66
361	156,305.26	89,923.08	706.33	0.66	52.31	758.64
363	156,291.48	90,009.19	707.2	0.22	51.18	758.38
365	156,276.61	90,036.61	704.8	0.22	53.52	758.32
367	156,266.57	90,055.56	703.99	0.22	54.3	758.29
369	156,256.81	90,132.74	698	0.22	60.23	758.23
371	156,248.58	90,160.68	695.4	0.22	62.82	758.22
373	156,240.57	90,199.87	688.32	0.22	69.89	758.21
375	156,426.73	89,866.12	710	0.66	48.73	758.73
377	156,473.01	89,860.57	712	0.69	46.73	758.73
379	156,479.24	89,786.26	713	0.69	45.73	758.73
381	156,484.79	89,763.12	718.36	0.69	40.36	758.72
383	156,460.83	89,738.35	719	0.3	39.72	758.72
385	156,465.16	89,703.43	720	0.1	38.72	758.72
387	156,474.64	89,641.72	717.11	0.3	41.61	758.72
389	156,484.92	89,638.06	717.11	0.3	41.61	758.72
391	156,491.42	89,614.78	715.2	0.3	43.52	758.72

junction	X (m)	Y (m)	Elevation (m)	Demand (l/s)	Pressure Head	Hydraulic Grade
					(m)	(m)
395	156,391.22	89,882.77	711.6	0.65	47.13	758.73
398	156,369.82	89,718.49	716.3	0.65	42.75	759.05
400	156,435.91	89,587.59	710	0.59	49.39	759.39
402	156,535.84	89,462.54	710	1	50.1	760.1
404	156,664.75	89,345.81	724.69	1	77.17	801.86
406	156,723.44	89,240.34	729.74	1	72.85	802.59
408	156,832.61	89,083.58	737.51	0.99	72.16	809.67
410	156,963.72	88,927.62	747.68	0.99	63.49	811.17
412	157,049.90	88,743.37	753.1	0.99	59.61	812.71
414	157,063.38	88,710.33	752	0.99	61.04	813.04
416	157,063.65	88,640.02	751	0.99	62.69	813.69
418	157,076.18	88,589.68	751	0.49	64.64	815.64
420	157,126.80	88,513.08	753	0.49	66.13	819.13
422	157,161.58	88,447.03	754	0.49	68.01	822.01
424	157,120.98	88,407.51	755	0.49	66.99	821.99
426	157,081.73	88,362.84	753.2	0.49	68.78	821.98
428	157,023.39	88,297.47	752.09	0.49	69.87	821.96
430	156,986.25	88,158.31	745.29	0.49	76.65	821.94
432	157,189.07	88,629.14	743.57	0.51	70.01	813.58
434	157,265.83	88,720.71	743.8	0.51	69.68	813.48
436	157,321.87	88,782.03	747.8	0.51	65.61	813.41
438	157,368.88	88,854.25	752.54	0.51	60.81	813.35
440	157,540.00	88,675.68	767.57	0.51	45.61	813.18
442	157,661.24	88,542.23	770	0.51	43.08	813.08
444	157,740.26	88,481.66	775	0.51	38.04	813.04
446	157,860.19	88,434.49	778	0.51	35	813
448	157,339.34	88,897.70	747	0.51	66.32	813.32
450	157,280.46	88,963.68	745	0.51	68.28	813.28
452	157,233.60	89,028.81	744	0.51	69.25	813.25
454	157,218.71	89,057.23	748	0.51	65.25	813.25
456	157,136.15	89,108.15	741	0.51	72.23	813.23
458	157,080.66	89,166.35	744	0.51	69.23	813.23
460	157,050.21	89,223.03	733.5	0.51	79.73	813.23
462	156,696.38	89,289.55	729.33	1	72.87	802.2
465	156,648.14	89,257.95	728.71	0.36	73.49	802.2
467	156,648.68	89,231.42	725	0.36	77.2	802.2
469	156,656.80	89,212.20	725.43	0.36	76.76	802.19
471	156,618.77	89,114.62	720	0.36	82.19	802.19
473	156,596.68	89,086.20	720.5	0.36	81.69	802.19
475	156,569.18	89,067.90	729.26	0.36	72.92	802.18
477	156,565.28	89,038.88	730	0.36	72.18	802.18

junction	X (m)	Y (m)	Elevation (m)	Demand (l/s)	Pressure Head	Hydraulic Grade
					(m)	(m)
481	156,527.49	88,968.29	744.17	0.36	58.01	802.18
483	156,565.82	88,943.60	746.28	0.36	55.9	802.18
485	156,605.34	88,890.65	747.12	0.36	55.06	802.18
487	156,615.74	88,867.81	750	0.36	52.18	802.18
489	156,596.79	88,794.94	745	0.36	57.18	802.18
491	156,568.20	88,754.23	740	0.36	62.18	802.18
493	156,455.19	89,563.33	707	0.59	52.47	759.47
496	156,419.24	89,557.25	707	0.59	52.25	759.25
498	156,357.12	89,555.67	708.4	0.59	50.78	759.18
500	156,287.60	89,569.41	708.4	0.59	50.73	759.13
502	156,212.52	89,540.87	702.32	0.59	56.76	759.08
504	156,148.02	89,539.02	693.82	0.59	65.23	759.05
506	156,093.04	89,547.47	683.35	0.59	75.68	759.03
508	156,015.06	89,513.90	687.63	0.59	71.39	759.02
510	155,992.15	89,506.22	690.96	0.59	68.05	759.01
512	155,950.84	89,461.88	695.5	0.59	63.51	759.01
514	156,429.21	89,486.62	705.89	0.47	53.22	759.11
516	156,388.27	89,450.24	705.67	0.47	53.34	759.01
518	156,316.70	89,389.85	701.8	0.47	57.07	758.87
520	156,317.21	89,360.24	701.1	0.47	57.73	758.83
522	156,334.47	89,325.39	701	0.47	57.79	758.79
524	156,304.63	89,253.59	702.52	0.47	56.2	758.72
526	156,274.31	89,184.97	702.8	0.47	55.87	758.67
528	156,261.32	89,165.35	702.73	0.47	55.92	758.65
530	156,237.22	89,161.69	702.93	0.47	55.71	758.64
532	156,188.77	89,167.65	706.5	0.47	52.13	758.63
534	156,175.91	89,133.00	707	0.47	51.62	758.62
536	156,175.78	89,085.22	708.5	0.47	50.12	758.62
538	156,171.32	89,017.70	713	0.47	45.61	758.61
540	156,119.76	88,931.15	719.73	0.47	38.88	758.61
542	156,375.11	90,009.87	697.06	0.22	61.63	758.69
544	156,353.17	90,074.63	694.05	0.22	64.63	758.68
546	156,335.98	90,162.39	682.8	0.22	75.86	758.66
548	156,339.42	90,190.94	677	0.22	81.65	758.65
550	156,406.03	90,178.78	670	0.22	88.64	758.64
552	156,461.22	90,165.41	667.34	0.22	91.3	758.64
554	156,486.99	90,170.82	667.34	0.22	81.29	758.63
556	156,647.70	90,495.58	659	0.22	89.62	758.62
558	156,796.66	90,738.54	660.35	0.22	88.26	758.61
560	156,764.07	90,773.62	660.95	0.22	87.66	758.61
562	156,751.19	90,789.32	660.96	0.22	87.65	758.61

junction	X (m)	Y (m)	Elevation (m)	Demand (l/s)	Pressure Head	Hydraulic Grade
					(m)	(m)
567	156,347.06	89,711.90	716.4	0.28	42.48	758.88
569	156,344.13	89,743.30	715	0.28	43.73	758.73
571	156,259.14	89,756.94	705	0.28	53.44	758.44
573	156,169.05	89,763.11	696	0.28	62.25	758.25
575	156,141.44	89,783.47	691.8	0.28	66.4	758.2
577	156,071.82	89,773.51	687.47	0.28	70.69	758.16
579	156,000.14	89,748.28	682	0.28	76.15	758.15
581	155,712.21	89,629.82	693.8	0.28	62.03	755.83
583	155,651.99	89,789.46	694.68	0.28	60.95	755.63
585	156,961.77	88,705.33	755	0.52	57.71	812.71
587	156,959.45	88,672.34	755.91	0.52	56.79	812.7
589	156,940.24	88,645.53	753.47	0.52	59.23	812.7
591	156,827.61	88,565.03	743.47	0.52	69.23	812.7
593	156,810.69	88,546.63	743	0.52	69.7	812.7
595	156,776.64	88,403.46	736	0.52	76.7	812.7
597	156,703.90	88,292.86	729.11	0.52	83.59	812.7
599	156,661.18	88,226.04	728	0.52	84.7	812.7

Table 4.3 : input data for the proposed network and the value of velocity and head loss (Pipe):

Pipe	Length (m)	Diameter	Material	Headloss	Velocity
		(mm)		Gradient (m/km)	(m/s)
P-16a	19	300	Steel	0.73	0.36
P-16b	19	300	Steel	0.73	0.36
P-17a	80	250	Steel	6.1	1.06
P-17b	80	250	Steel	6.1	1.06
P-28	49.93	300	Steel	0.81	0.36
P-30	70.37	300	Steel	0.8	0.35
P-32	110.46	300	Steel	0.79	0.35
P-34	202.32	300	Steel	0.78	0.35
P-36	71.98	300	Steel	0.77	0.35
P-38	58.98	300	Steel	0.77	0.34
P-40	191.03	300	Steel	0.76	0.34
P-42	71.65	300	Steel	0.75	0.34
P-44	191.93	300	Steel	0.75	0.34
P-46	76.32	300	Steel	0.75	0.34
P-48	133.44	300	Steel	0.75	0.34
P-50	48.39	300	Steel	0.74	0.34
P-52	56.64	100	Steel	1.97	0.29
P-54	35.43	100	Steel	1.78	0.27
P-56	34.56	100	Steel	1.6	0.26
P-58	33.2	100	Steel	1.32	0.23
P-60	29.72	100	Steel	1.06	0.21
P-62	35.1	100	Steel	0.83	0.18
P-64	55.09	100	Steel	0.62	0.15
P-66	27.43	100	Steel	0.44	0.2
P-68	119.11	100	Steel	0.29	0.22
P-70	51.58	100	Steel	0.17	0.24
P-72	41.08	100	Steel	0.08	0.27
P-74	19.27	100	Steel	0.02	0.28
P-76	122.87	250	Steel	1.49	0.44
P-78	40.5	250	Steel	1.47	0.44
P-80	57.13	250	Steel	1.46	0.44
P-82	28.14	250	Steel	1.44	0.43
P-84	43.6	250	Steel	1.41	0.43
P-86	173.83	250	Steel	1.37	0.42
P-88	266.95	250	Steel	1.34	0.42

Pipe	Length (m)	Diameter	Material	Headloss	Velocity
		(mm)		Gradient (m/km)	(m/s)
P-92	136.31	250	Steel	1.25	0.4
P-94	105.47	250	Steel	1.2	0.39
P-96	30.35	250	Steel	1.19	0.39
P-98	37.59	250	Steel	1.19	0.39
P-100	34.03	250	Steel	1.18	0.39
P-102	118.02	250	Steel	1.18	0.39
P-104	42.23	250	Steel	1.17	0.39
P-106	31.93	250	Steel	1.17	0.39
P-108	39.59	250	Steel	1.16	0.39
P-110	22.81	75	Steel	2.93	0.3
P-112	22.52	75	Steel	2.2	0.25
P-114	19.67	75	Steel	1.57	0.21
P-116	43.18	75	Steel	1.04	0.17
P-118	102.81	75	Steel	0.61	0.19
P-120	98.74	75	Steel	0.29	0.2
P-122	104.17	75	Steel	0.08	0.2
P-126	243.48	250	Steel	0.9	0.33
P-128	43	75	Steel	3.28	0.32
P-130	25.86	150	Steel	0.09	0.2
P-132	115.44	75	Steel	1.76	0.23
P-134	91.62	75	Steel	1.16	0.18
P-136	94.74	75	Steel	0.68	0.19
P-138	58.14	75	Steel	0.32	0.2
P-140	68.34	75	Steel	0.09	0.26
P-142	7.12	150	Steel	12.2	0.99
P-143	16.07	250	Steel	0.9	0.34
P-145	72.36	75	Steel	1.85	0.23
P-147	94.98	75	Steel	0.88	0.15
P-149	93.46	75	Steel	0.24	0.22
P-151	183.79	250	Steel	0.73	0.3
P-155	127.65	250	Steel	0.71	0.29
P-156	71.11	250	Steel	0.68	0.29
P-158	39.9	150	Steel	4.31	0.57
P-160	120.39	150	Steel	4.08	0.55
P-162	43.92	150	Steel	3.86	0.53
P-164	30.67	150	Steel	3.66	0.52
P-166	67.94	150	Steel	3.45	0.5
P-168	42.77	150	Steel	3.26	0.49
P-170	30.2	150	Steel	3.07	0.47
P-172	77.65	150	Steel	2.88	0.46

Pipe	Length (m)	Diameter	Material	Headloss	Velocity
		(mm)		Gradient (m/km)	(m/s)
P-176	34.97	150	Steel	2.52	0.42
P-178	41.13	150	Steel	2.35	0.41
P-180	37.47	150	Steel	2.19	0.39
P-182	18.35	150	Steel	2.03	0.38
P-`184	20.1	152.4	Steel	1.73	0.35
P-186	64.57	150	Steel	1.73	0.35
P-188	78.02	150	Steel	1.58	0.33
P-190	53.55	100	Steel	8.58	0.64
P-192	80.82	100	Steel	7.71	0.6
P-194	37.51	100	Steel	6.9	0.57
P-196	36.27	100	Steel	6.12	0.53
P-198	27.72	100	Steel	5.38	0.49
P-200	51.14	100	Steel	4.69	0.46
P-202	75.25	100	Steel	4.05	0.42
P-204	82.54	100	Steel	3.44	0.39
P-206	119.72	100	Steel	2.89	0.35
P-208	68.68	100	Steel	2.37	0.32
P-210	149.32	100	Steel	1.91	0.28
P-212	44.96	75	Steel	6.05	0.44
P-214	42.49	75	Steel	4.55	0.38
P-216	59.69	50	Steel	23.38	0.71
P-218	42.98	50	Steel	15.46	0.57
P-220	118.11	50	Steel	9.08	0.42
P-222	62.72	50	Steel	4.28	0.28
P-224	57.96	50	Steel	1.19	0.23
P-226	339.82	250	Steel	0.06	0.19
P-228	325.74	250	Steel	0.05	0.2
P-232	140.54	250	Steel	0.63	0.28
P-234	65.74	75	Steel	3.8	0.34
P-236	52.66	75	Steel	2.71	0.29
P-238	39.58	75	Steel	1.8	0.23
P-240	23.71	75	Steel	1.05	0.17
P-242	42.34	75	Steel	0.5	0.29
P-244	78.93	75	Steel	0.14	0.26
P-246	77.76	250	Steel	0.03	0.26
P-249	51.4	200	Steel	0.24	0.2
P-251	32.84	200	Steel	0.23	0.24
P-253	38.72	200	Steel	0.21	0.23
P-255	57.09	200	Steel	0.13	0.19
P-257	33.89	200	Steel	0.12	0.21

Pipe	Length (m)	Diameter	Material	Headloss	Velocity
		(mm)		Gradient (m/km)	(m/s)
P-261	70.74	200	Steel	0.1	0.21
P-263	114.75	200	Steel	0.08	0.29
P-265	57.37	200	Steel	0.07	0.27
P-267	72.75	200	Steel	0.06	0.27
P-269	59.14	200	Steel	0.05	0.26
P-271	24.39	150	Steel	0.16	0.19
P-273	51.06	150	Steel	0.13	0.38
P-275	54.57	150	Steel	0.09	0.57
P-277	41.6	150	Steel	0.07	0.26
P-279	46.58	150	Steel	0.04	0.35
P-281	127.71	150	Steel	0.03	0.54
P-283	93.81	150	Steel	0.01	0.52
P-285	82.46	150	Steel	0	0.21
P-287	25.99	75	Steel	1.25	0.29
P-289	76.78	75	Steel	0.89	0.26
P-291	39.89	75	Steel	0.59	0.22
P-293	66.99	75	Steel	0.35	0.39
P-295	28.61	75	Steel	0.16	0.36
P-297	156.16	75	Steel	0.05	0.33
P-299	19.14	250	Steel	0.02	0.35
P-300	72.87	250	Steel	0.59	0.27
P-302	108.87	250	Steel	0.37	0.21
P-304	54.19	250	Steel	0.35	0.2
P-306	32.12	250	Steel	0.33	0.2
P-308	155.97	250	Steel	0.31	0.19
P-310	216.63	250	Steel	0.29	0.18
P-312	204.17	250	Steel	0.27	0.17
P-314	146.39	250	Steel	0.25	0.17
P-316	52.96	250	Steel	0.23	0.16
P-318	89.51	250	Steel	0.21	0.35
P-320	219.95	250	Steel	0.19	0.25
P-322	87.52	250	Steel	0.18	0.24
P-324	55.57	250	Steel	0.16	0.23
P-326	27.93	250	Steel	0.14	0.2
P-328	144.25	250	Steel	0.13	0.32
P-330	34.39	75	Steel	28.02	1.01
P-332	39.65	75	Steel	24.16	0.93
P-334	58.63	75	Steel	20.56	0.85
P-336	50.57	75	Steel	17.23	0.77
P-338	65.35	75	Steel	14.18	0.7

Pipe	Length (m)	Diameter	Material	Headloss	Velocity
		(mm)		Gradient (m/km)	(m/s)
P-342	65.58	75	Steel	8.9	0.54
P-344	60.34	75	Steel	6.69	0.46
P-346	117.41	75	Steel	4.77	0.39
P-348	121.37	50	Steel	22.76	0.7
P-350	55.98	50	Steel	13.36	0.52
P-352	41.54	50	Steel	6.3	0.35
P-354	242.91	50	Steel	1.75	0.17
P-356	61.16	50	Steel	13.36	0.52
P-358	67.31	50	Steel	6.3	0.35
P-360	76.69	50	Steel	1.75	0.17
P-362	106.81	250	Steel	0.79	0.31
P-364	87.2	75	Steel	2.93	0.3
P-366	31.2	75	Steel	2.09	0.25
P-368	21.44	75	Steel	1.38	0.2
P-370	77.8	75	Steel	0.81	0.15
P-372	29.12	75	Steel	0.38	0.1
P-374	40.01	75	Steel	0.11	0.35
P-378	46.62	250	Steel	0.06	0.37
P-380	74.56	250	Steel	0.04	0.26
P-382	23.8	250	Steel	0.03	0.25
P-384	34.46	250	Steel	0.01	0.23
P-386	35.19	250	Steel	0.01	0.23
P-388	62.44	250	Steel	0.01	0.22
P-390	10.92	250	Steel	0.01	0.22
P-392	24.17	250	Steel	0	0.21
P-394	36.95	250	Steel	0	0.2
P-396	94.94	250	Steel	0.98	0.35
P-397	39.22	250	Steel	0.08	0.39
P-399	165.66	250	Steel	1.9	0.5
P-411	203.75	250	Steel	7.34	1.04
P-413	203.4	250	Steel	7.61	1.06
P-415	35.69	250	Steel	9.05	1.17
P-417	70.32	250	Steel	9.35	1.19
P-419	51.87	200	Steel	37.52	2.19
P-421	91.82	200	Steel	38.02	2.2
P-423	74.65	200	Steel	38.52	2.22
P-425	56.66	200	Steel	0.28	0.16
P-427	59.46	200	Steel	0.23	0.24
P-429	87.61	200	Steel	0.19	0.23
P-431	144.03	200	Steel	0.15	0.3

Pipe	Length (m)	Diameter	Material	Headloss	Velocity
		(mm)		Gradient (m/km)	(m/s)
P-435	119.49	200	Steel	0.85	0.28
P-437	83.08	200	Steel	0.76	0.27
P-439	86.16	200	Steel	0.67	0.25
P-441	247.32	150	Steel	0.71	0.21
P-443	180.3	150	Steel	0.55	0.19
P-445	99.57	150	Steel	0.4	0.16
P-447	128.88	150	Steel	0.28	0.13
P-449	52.54	150	Steel	0.63	0.2
P-451	88.43	150	Steel	0.47	0.17
P-453	80.24	150	Steel	0.34	0.14
P-455	32.09	150	Steel	0.22	0.11
P-457	97	150	Steel	0.13	0.2
P-459	80.41	150	Steel	0.06	0.06
P-461	64.34	150	Steel	0.02	0.23
P-463	64.54	250	Steel	5.34	0.88
P-464	56.16	250	Steel	6.82	1
P-466	57.67	250	Steel	0.1	0.19
P-468	26.53	250	Steel	0.09	0.19
P-470	20.86	250	Steel	0.07	0.29
P-472	104.73	250	Steel	0.07	0.28
P-474	36	250	Steel	0.06	0.27
P-476	33.03	250	Steel	0.05	0.27
P-478	29.28	250	Steel	0.04	0.26
P-480	44.65	250	Steel	0.03	0.35
P-482	35.71	250	Steel	0.02	0.34
P-484	45.59	250	Steel	0.01	0.34
P-486	66.07	250	Steel	0.01	0. 33
P-488	25.1	250	Steel	0.01	0.22
P-490	75.29	250	Steel	.12	0.21
P-492	49.74	250	Steel	.01	0.21
P-494	30.98	250	Steel	2.49	0.58
P-495	129.09	250	Steel	4.89	0.84
P-497	36.46	150	Steel	5.98	0.68
P-499	62.14	150	Steel	1.07	0.27
P-501	70.87	150	Steel	0.84	0.23
P-503	80.32	150	Steel	0.63	0.2
P-505	64.53	150	Steel	0.45	0.17
P-507	55.63	150	Steel	0.3	0.13
P-509	84.9	150	Steel	0.17	0.19
P-511	24.17	150	Steel	0.08	0.27

Pipe	Length (m)	Diameter	Material	Headloss	Velocity
		(mm)		Gradient (m/km)	(m/s)
P-515	71.34	150	Steel	2.02	0.38
P-517	54.77	150	Steel	1.76	0.35
P-519	93.64	150	Steel	1.52	0.32
P-521	29.61	150	Steel	1.29	0.3
P-523	38.89	150	Steel	1.08	0.27
P-525	77.76	150	Steel	0.89	0.24
P-527	75.02	150	Steel	0.72	0.21
P-529	23.54	150	Steel	0.56	0.19
P-531	24.37	150	Steel	0.42	0.16
P-533	48.82	150	Steel	0.3	0.13
P-535	36.96	150	Steel	0.2	0.19
P-537	47.78	150	Steel	0.12	0.28
P-539	67.67	150	Steel	0.05	0.25
P-541	100.74	150	Steel	0.02	0.23
P-543	128.12	150	Steel	0.31	0.14
P-545	68.38	150	Steel	0.26	0.18
P-547	89.43	150	Steel	0.21	0.19
P-549	28.76	150	Steel	0.17	0.19
P-551	67.72	150	Steel	0.13	0.19
P-553	56.78	150	Steel	0.1	0.27
P-555	26.33	150	Steel	0.07	0.26
P-557	362.35	150	Steel	0.05	0.25
P-559	284.99	150	Steel	0.03	0.24
P-561	47.88	150	Steel	0.01	0.22
P-563	20.31	150	Steel	0.01	0.21
P-565	20.8	250	Steel	2	0.52
P-566	125.84	250	Steel	2.4	0.57
P-568	34.26	75	Steel	6.2	0.45
P-570	31.54	75	Steel	4.66	0.38
P-572	86.08	75	Steel	3.33	0.32
P-574	90.3	75	Steel	2.2	0.25
P-576	34.3	75	Steel	1.29	0.19
P-578	70.33	75	Steel	0.61	0.13
P-580	75.99	75	Steel	0.17	0.26
P-582	63.41	50	Steel	4.28	0.28
P-584	170.62	50	Steel	1.19	0.14
P-586	95.99	250	Steel	0.07	0.28
P-588	33.07	250	Steel	0.06	0.27
P-590	32.99	250	Steel	0.04	0.26
P-592	138.44	250	Steel	0.03	0.25

Pipe	Length (m)	Diameter	Material	Headloss	Velocity
		(mm)		Gradient (m/km)	(m/s)
P-596	147.16	250	Steel	0.01	0.23
P-598	132.38	250	Steel	0.01	0.22
P-600	79.31	250	Steel	0.01	0.21

Table 4.4 : The data for pumps , reservoir , and pressure reduce valve :

Pump	Elevation (m)	Discharge (l/s)	Pump Head (m)	Discharge Pump	Water Power
				Grade (m)	(kW)
PMP-16	647	25.35	116.99	761.99	29.03
PMP-17	759.5	75.05	57.01	822.01	41.88

Reservoir	Elevation (m)	Inflow (l/s)	Hydraulic Grade (m)
1	645	-25.35	645
2	765	-75.05	765

PRV	Elevation (m)	Diameter (mm)	Discharge (l/s)	Headloss (m)
PRV-6	710	250	42.1	41.76

4.6 SUMMARY

In this chapter , the proposed water distribution network for Alsamou' town has been studied and evaluated . the result of calculation necessary for the network design have been given and discussed.

CHAPTER FIVE

BILL OF QUANTITIES

CHAPTER FIVE

BILL OF QUANTITY

FOR THE PROPOSED WATER NETWORK COLLECTION SYSTEM

No.	EXCAVATION	UNIT	QTY	UNIT PRICE		TOTAL PRICE	
				$	C	$	C
A1	Excavation of pipes trench in all kind of soil for one pipe diameter 12 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	1315				
A2	Excavation of pipes trench in all kind of soil for one pipe diameter 10 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	8803				
A3	Excavation of pipes trench in all kind of soil for one pipe diameter 6 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	8554				

A4	Excavation of pipes trench in all kind of soil for one pipe diameter 4 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	1320				
A5	Excavation of pipes trench in all kind of soil for one pipe diameter 3 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	2293				
A6	Excavation of pipes trench in all kind of soil for one pipe diameter 2 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	1175				
			Sub-Total	**23460 M**			
B	**PIPE WORK**						
B1	Supplying, storing and installing of steel	LM	23640				
B2	Fire hydrants with 2” quick connection coupling	NR	0				
B3	Welding and installation of gate valve with dresser coupling for all pipe	NR	22				
B3	Welding and installation of washout dresser coupling for all pipe	NR	6				

B3	Welding and installation of Air release valve with dresser coupling for all pipe	NR	21				
B3	Welding and installation of pressure reduce valve with dresser coupling for all pipe	NR	1				
				Sub-Total			
C	***PIPE BEDDING AND BACKFILLING*** **Dimension and material**						
C1	Supplying and embedment of sand for one pipe diameter 12 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	1315				
C2	Supplying and embedment of sand for one pipe diameter 10 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	8803				
C3	Supplying and embedment of sand for one pipe diameter 6 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	8554				

C4	Supplying and embedment of sand for one pipe diameter 4 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	1320				
C5	Supplying and embedment of sand for one pipe diameter 3 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	2293				
C6	Supplying and embedment of sand for one pipe diameter 2 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	1175				
Sub-Total 23460 M							
D	**MANHOLES, Details according to the drawing**						

D1	Supplying and installing of precasted manhole including excavation pipe connection, epoxytar coating, 25-ton cast iron cover and backfill, size 1200mm, depth up to 1.00m.	NR	2				
				Sub-Total			
E	**Concrete Surround**						
E1	Suppying and installing of reinforced concrete (B 200) protection concrete encasement for pipes.	LM	23640				
				Sub-Total			
F	**Air And Water Leakage Test**						
F1	Air leakage test for all pipe lines according to specifications, including for all temporary works.	LM	23640				
F2	Water leakage tests for manholes, depth up to 1.00 meter according to specifications.	NR	2				

Sub-Total							
G	**Survey work**						
G1	Topographical survey required for shop drawings and as built DWGS using absoluet Elev. And coordinate system	LM	23640				

CHAPTER

6 *CONCLUSIONS*

CHAPTER SIX
CONCLUSIONS

In this project, the proposed water distribution network in Alsamou' town has been studied and evaluated. The trial is also made to design the town network for year 2035. It is also brought out many important conclusions. The main conclusions drawn from the present study are summarized below:

1. 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 and due to this condition the average consumption of water in the town in general is very low and does not represent the present actual demand of water.

2. The present population of Alsamou' town is around 21750 person. Prediction of the future population of Alsamou' town is very difficult due the political uncertainties. The rate of population growth is taken as 3.5%.

3. The socio-economic survey shows that the total water demand for domestic use in the town for year 2010 is around 555713 cubic meter per year, and 1876100 cubic meter per year for year 2035, which means that water demand will be around four times the present quantity in year 2035 which is possible to arrange from our natural resources.

4. Water source is available from the Palestinian Water Authority.

5.The length of the proposed network is 23460m, diameter of pipes in this network are divided from 2" to 12".

6.in year 2035, Al-Samou' town is in direct need of larger quantities of water and more adequate supply scheme. In redesign the distribution network , the results show that a new network are to be constructed.

7.In the future creation of an section within the waters of the town council to oversee the implementation of the water system and provide engineers, technicians and workers and equipment to maintain the sustainability of the network.

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