GAZİANTEP UNIVERSITY GRADUATE SCHOOL OF NATURAL & APPLIED SCIENCES

APPRAISAL OF WATER SUPPLY SYSTEM IN DİYARBAKIR

M. Sc. THESIS
IN
CIVIL ENGINEERING

By

Befrin Neval BİNGÖL

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Befrin Neval BİNGÖL

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APPRAISAL OF
WATER SUPPLY SYSTEM
IN DİYARBAKIR

M.Sc. Thesis
in
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Supervisor
Asst. Prof. Dr. Mazen KAVVAS

by

Befrin Neval BİNGÖL

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Gaziantep Üniversitesi

İnşaat Mühendisliği

Yüksek Lisans Tezi

Danışman
Yr. Doç. Dr. Mazen KAVVAS

Befrin Neval BİNGÖL

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Name of the thesis: 'Appraisel of Water Supply System in Diyarbakır'
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Approval of the Graduate School of Natural and Applied Sciences

Prof. Dr. Ramazan KOÇ
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science/~~Doctor of Philosophy.~~

Assc. Prof. Dr. Mustafa GÜNAL
Civil Engineering Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science/Doctor of Philosophy.

Asst. Prof Dr. Mazen KAVVAS
Supervisor

Examining Committee Members Title and Name-surname	signature
Assc. Prof. Dr. Mustafa GÜNAL	
Asst. Prof Dr. Mazen KAVVAS	
Asst. Prof Dr. Abdülkadir ÇEVİK	
Asst. Prof Dr. Bülent BELİBAĞLI	
Asst. Prof Dr. Faruk GEYİK	

ABSTRACT

APPRAISAL OF
WATER SUPPLYSYSTEM
IN DİYARBAKIR

BİNGÖL, Befrin Neval
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In this research, water supply system of Diyarbakır city is investigated in all aspects. This study is divided into two main sections. In the first section, the history and present of the water supply system in the city is investigated. Also, the characteristics of Diyarbakır water supply current system are examined in terms of raw water pipeline, treatment plant, distribution reservoirs, and pipeline network. Then, the weaknesses and difficulties that are currently encountered in the management of the system are investigated and presented.

In the second section, the new techniques applied on some parts of the system are investigated regarding the degree of improvement on the system. In order to enable for comparison between the cases where new technology is used and otherwise, it was necessary to select a suitable region of the city of the city; where it would be possible to observe the effect and efficiency of the implementation of new technology on the existing water supply system within. The new technology applied is SCADA and GIS-MIS, which enable to storing and retrieving data of all kinds and levels required for the perfect management of the region. This investigation enabled for good and reliable comparison between the regions of the city where SCADA and GIS-MIS systems are implemented and the other regions with no such facilities. This comparison leads to believe that the use of SCADA and GIS-MIS in water supply systems would enable to full control of the system, and also, to the detection of the causatives of water loss in the system. Consequently, this would eventually enable to decrease water loss to the internationally acceptable level. The results of this investigation in the second section lead to interesting results where the use of new technology in water supply systems would be extremely recommended.

KEYWORDS: water supply system; water loss; water consumption, pipe nets; SCADA; GIS; MIS

ÖZET

DİYARBAKIR SU SİSTEMİNİN DEĞERLENDİRİLMESİ

BİNGÖL, Befrin Neval
Yüksek Lisans Tezi, İnş Müh. Bölümü
Tez Yöneticisi: Yr. Doç. Dr. Mazen KAVVAS
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'Diyarbakır İçmesuyu Sisteminin' bütün yönleriyle araştırılmıştır. Bu çalışma iki ana bölüme ayrılır. Bu çalışmanın birinci bölümünde, şehrin içme suyu sisteminin geçmişi ve şimdiki durumu ele alınmıştır. Ayrıca, Diyarbakır İçmesuyu Sisteminin karakteristik yapısı ham su hattı, arıtma tesisi, dağıtım depoları ve boru şebekeleriyle birlikte incelenmiştir. Daha sonra, şu anki durumuyla su sisteminin yönetimdeki güçsüzlükler ve zorluklar araştırılıp belirtilmiştir.

İkinci bölümde ise, bazı bölgelerde yeni kullanılmaya başlanan tekniklerin de yardımıyla su sistemimdeki iyileşmeler araştırılmıştır. Bu yeni tekniklerin kullanıldığı ve kullanılmadığı bölgelerin mukayesesi amacıyla, şehrin uygun bir bölgesi seçilip, mevcut olan su sisteminde yeni uygulan tekniklerin etkisi ve verimliliği ortaya konulmuştur. Bu uygulanan yeni teknolojiler SCADA ve GIS-MIS olup, bunlar her çeşit bilgi saklamasında, gerektiğinde tekrarlanmasında ve sistemin iyi bir şekilde yönetilmesine olanak sağlar. Bu çalışmada, şehirde bu teknolojik programların kullanıldığı ve kullanılmadığı yerler incelenerek iyi ve güvenilir bir karşılaştırma yapılmıştır. Bu karşılaştırma sonucunda SCADA ve GIS-MIS kullanımının, tüm sistemin kontrolünü sağladığı ve su sistemindeki su kaçaklarının sebeplerini ortaya koyduğu gözlenmiştir. Sonuç olarak, bu da su kayıplarının azaltılarak uluslararası kabul edilen seviyelere çekilebilinmesine olanak sağlar. Bu çalışmanın ikinci kısmında yer alan ilginç sonuçları, bu yeni sistemlerin su temin sistemlerinde kullanılması gerekliliğini kanıtlar nitelikte olup, kullanılması önemle tavsiye edilir.

Ana Kelimeler: içme suyu sistemi; su kaybı; su tüketimi; boru hatları;
SCADA; GIS; MIS

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LIST OF SYMBOLS

A	Resistance Coefficient
B	Flow Exponent
C	Hazen-Williams roughness coefficient
d	Pipe diameter
DİE	Devlet İstatistik Enstitüsü
DİSKİ	Diyarbakır İçmesuyu ve Kanalizasyon İdaresi
DSİ	Devlet Su İşleri
ε	Darcy-Weisbach roughness coefficient
f	Friction factor
Fr.F	French Frank
GIS	Geographical Information System
h_L	Head loss
K_a	Arithmetic constant
L	Pipe length
m	Increment constant of İller Bank
MIS	Management Information System
n	Manning roughness coefficient
P	Increment constant
P_C	Commercial population of Muradiye
P_e	Population in some earlier year
P_f	Future population
P_i	Initial population
P_M	Population of Muradiye
P_R	Residential population of Muradiye
q	Flow rate

$Q_{Administrative\ Loss}$	Administrative Loss water of Muradiye
$Q_{Annually}$	Annually flow of Muradiye
Q_{Daily}	Daily flow of Muradiye
Q_{GIS}	GIS flow data of Muradiye
$Q_{Monthly}$	Monthly flow of Muradiye
$Q_{Physical\ Loss}$	Phsical Loss water of Muradiye
Q_{SCADA}	SCADA flow data of Muradiye
$Q_{Subscriber}$	Subscriber flow data of Muradiye
SCADA	Supervisory Control and Data Acquisition
t_e	Earlier year
t_f	Future year
t_i	Initial year
Ø	Diameter of pipe

CHAPTER–1: INTRODUCTION

1.1. IMPORTANCE OF WATER NOWADAYS

Water is the common name applied to the liquid form (state) of the hydrogen and oxygen compound H_2O. Pure water is an odourless, tasteless, clear liquid. Water is one of nature's most important gifts to mankind. With two thirds of the earth's surface covered by water and the human body consisting of 75 percent of it, it is evidently clear that water is one of the prime elements responsible for life on earth. Water circulates through the land just as it does through the human body, transporting, dissolving, and replenishing nutrients and organic matter, while carrying away waste material.

Water has been used since antiquity as a symbol by which to express devotion and purity. Some cultures, like the ancient Greeks, went as far as to worship gods who were thought to live in and command the waters. Whole cities have been built by considering the location and availability of pure drinking water. The place of gathering was around the wells, which is perhaps the following trend in building fountains in the middle of piazzas.

For thousands of years, humanity has been aware of the importance of water. In Rome, a couple of thousand years ago, it was considered to be one of the biggest crimes to pollute the water.

Today in our advanced and modern society believe that human have to sacrifice everything including the water of this planet human inhabit. People are rapidly destroying water's life-giving capacities. Increased population, industrial wastes and agricultural chemicals are contaminating our water sources. In our civilization, people as individuals use water as if they had limitless amounts of it. Unfortunately, water is limited and ‘Water can be without the company of human being but humans can only be without water for a few days.’

Water is a key component in determining the quality of our lives. Today, people are concerned about the quality of the water they drink but quantity must also be concerned. Although water covers more than 75% of the Earth, only 1% of the Earth's water is available as a source of drinking. In densely populated areas, drinking water has become a scarcity for which people pay it. Currently, human continue to contaminate potable water sources. Before using water, it is needed to be treated. Many public water systems treat water with chlorine to destroy disease-producing contaminants that may be present in the water. Today, drinking water treatment gets become a necessity. Furthermore, distribution of water is the other problem of proper water usage.

Usable water source has restricted as 1% in concern but it is not meaning that human have inadequate water. The main problem is distribution way of water. People have to take precautions before ‘Water Wars’ started between countries.

The subject of this thesis is ‘Appraisal of Water Supply System in Diyarbakır’. Firstly, the existing water supply system is explained with details of Diyarbakır. Then, the water supply system is assessed in all aspects. The new systems used in Diyarbakır supply system will be introduced and used for calculating water loss from network. In that concern, the pilot region of Muradiye is researched and appraised with the water loss amounts. Finally, the hydraulic model Muradiye Quarter is analyzed in EPANET programme.

The aim of this thesis is to display importance of water supply systems for a city and the general problems that encountered with the design stage to entire life of distribution system. The betterment is suggested about supply system of selected region to extend the pipe’s life and avoid water losses in that concern.

1.2. OPTIMAL DESIGN CRITERIAS FOR WATER DISTRIBUTION SYSTEMS

The main design criteria for appropriate water supply system is to obtain water from source, treat the water to acceptable quality standards and deliver desired quantity of water to all planned regions of city at the desired time.

1.2.1. Usage of Sources

The source of water supply is to be formed surface water (such as rivers or lakes) and groundwater. Municipal supply systems consist of one or more sources it especially depends on demand of consumers and reliability of source.

Worldwide, the demand for water is growing rapidly, and in many countries the cost of developing new supplies is becoming prohibitive. Simultaneously, increased water pollution is worsening the imbalance between water supply and demand. Proper water sources management planning is playing the most important role in supplying system.

The designer should be considered the expected age of system with the reliability of source. The demand of water supply is calculated that will require for whole life of project and also considered emergency situations.

1.2.2. Importance of Pipeline Systems

The appropriate municipal water supply system must have feasible pipeline network. Interconnected pipes are used for transport water to consumers. The pipes are main part of system and designed with some considerations: demand of consumers, service pressure, fire demand, and alignment of system, subsurface conditions, and rights of ways and piping materials.

The demand is used to obtain sizes, alignment and future growth of pipes. The service pressure must be in balance that is for consumers neither too low nor too high for proper pipeline system. Low pressures cause flow reductions; high pressures cause faucets to leak, valve seats to wear out quickly, and water being wasted in system leaks. Typical service pressure criteria's must be overlap with selection of furnished pipes.

Fire demand depends on the land use and varies by community. The rate of flow is calculated with local fire department statistics.

A proper pipeline alignment is an evaluation of subsurface conditions. It helps to designer to identify the type, size and accurate location of all other underground utilities along the proposed pipeline alignment. The pipeline alignment is selected to avoid disturb conflicts.

The city's rights of ways are other limiting factors for both construction and future access. The locations of pipes should be designed take care of appropriate rights of way.

Pipe material selection is other factor that effects the proper water distribution net. Distribution must resist to internal pressure, external loads, differential settlement of soils, corrosive action of soils and water in pipes. The selection is made with considering service conditions (pressure, soil loads, corrosion potential of soil, and potential corrosive nature of water); availability (local availability, sizes and thickness, compatibility with available fittings); properties of pipe (strength, ductility, corrosion resistance, fluid friction resistance); economics (cost, required life, cost of maintenance and repairs).

The design and construction of pipeline have lots of local and national criteria's in general concern. The proper system must be operated with these criteria's; to avoiding pressure regulations, leakage of water, differential settlement of pipes, disturbs rights and energy losses of system [1]. Most municipal water systems are designed especially for their budget. The cost overrun of water supply system is not acceptable approach because of limited of funds. The existing distribution systems have so many problems in that time. The rehabilitation of existing systems is become more expensive than the construction of new lines. Economy must have affects on the system of course, but it should assess with serviceability and operating supply net.

Consequently, water is a source of nature and valuable for human being. The usage and distribution of water is related with quality of life. To rise the standards of life, the necessary importance have to be given for usage of water before being late.

1.3. WATER SYSTEM PROJECTION OF TURKEY

When the situation of Turkey is considered, it can be asserted that water has significant importance nowadays. The biggest cities of Turkey suffer from inadequate water sources and authorities continue warning people to be more conscious in using water. The individual water consumption for a day is 111 litres for Turkey. The following Table 1.1 illustrates the water demand in some major cities. These values were taken from State Planning Organization [2].

Table 1.1 Water Consumption at Major Cites in Turkey [2]

Metropolitan Municipalities	**Water Demand (l/c/d)**
Adana	160
Ankara	141
Antalya	105
Bursa	113
Diyarbakır	**128**
Erzurum	167
Eskişehir	78
Gaziantep	84
İçel	101
İstanbul	125
İzmir	99
Kayseri	380
İzmit	204
Konya	121
Samsun	108
Average for Municipalities	**129**
Average for Turkey	**111**

Water is the most essential element in the world for human beings to survive. The inadequate amount of clean water and unfair dispersion of drinkable water is threatening the public life in most part of the world including Turkey. Therefore, accurate water usage has significant effects to prolong limited water sources. We need some urgent changes in our existing water policy, that is; a new policy giving more importance on the efficient supply and distribution systems which target minimum water losses for the consumers must be developed in the near future.

In that concern, Turkey has limited water sources, contrary to generally supposed view which supports Turkey's being a water rich country, and thus authorities have to take precautions before facing the deprivation of water. The following Table 1.2 shows the annual clean water consumption per person in some countries. As seen from the table Turkey is below the average consumption amount [3].

Table 1.2 Amount of Annually Consumed Clean Water for a Person in World [3]

Country-Continent Mean Average	**Annual Clean water Consumption Per Capita m^3**
Syrian	1,200 m^3
Iraq	1,300 m^3
Lebanon	2,020 m^3
Asia	3,000 m^3
West European	5,000 m^3
Africa	7,000 m^3
South America	23,000m^3
Turkey	**1,430 m^3**
Average Of World	7,600 m^3

For DSİ (Devlet Su İşleri) data's, in 2030 Turkey is going to use water sources with 100% maximum production. The future population will be increased to 80 million in 2030 and annual consumption of water per person will have to decrease from 1,430 m^3 to 1,100 m^3, hence Turkey will start to suffer from water deprivation. In the light of these predictions, it is possible to conclude that Turkey will come to face serious water source problems between 2050 and 2100. Therefore, Turkey must take immediate precautions to prevent needless losses and improper water usage.

In Turkey, most of water supply projects were designed by related government entities. The system of water distribution line is calculated and designed with high water leakage from pipelines at the beginning of design stage in Turkey. These approach show how emphasize given to proper water source usage and observe acceptable construction standards in Turkey. Therefore, these approaches are shortened water sources usage period, caused to high treated water losses from network pipeline, increased water production cost, and made damages on pipeline systems. The main design criteria for appropriate water supply system must be like as: obtain water from source, treat the water to acceptable quality standards and deliver desired quantity of water to all planned regions of city at the desired time with minimum water losses.

In conclusion, the water losses must be stopped immediately to prolong clean water sources and produce water with low cost to public.

CHAPTER–2: WATER SUPPLY SYSTEM OF DİYARBAKIR

2.1. HISTORIY OF WATER DISTRIBUTION

The known oldest drinking water pipeline of Diyarbakır was established in 1535 by Kanuni Sultan Süleyman (Sultan of the Ottoman Empire) but the year wasn't definite. The source was 14 km far from the city centre and today the village known as Serapgüzeli at Gözeli location. This source has important place in Diyarbakır and famous with name of 'Hamravat Suyu'.

The brought date of 'Hamravat Suyu' wasn't so clear concerned sources. Evliya Çelebi (famous excursionist of Ottoman) gave date of brought of water for Müslim calendar as a year of 941 (for Gregorian calendar as 1535).

In the travel book of Evliya Çelebi's (Zahuri Danışman Yayını, c.6, s.127, 1970); Çelebi was told for Hamravat water: 'Old scholars put cotton into the Hamravat water and balanced , in Istanbul at the door of the old palace there was unique fountain and wetted cotton with this water; the cottons were balanced together. The wetted cotton of Hamravat water was lighter than the other. This means the water is very light and beneficial. The Hamravat water has curious effect on mucus, ballast and soda. In the long period of time, some of emperors had given special importance to Hamravat water.' [4]

Kanuni Sultan Süleyman gave to concern for famous Hamravat water. Kanuni charged Kastamonulu Kasım Çelebi, to disturb water to city of Diyarbakır, who was the foreman of Mimar Sinan (famous architect of Ottoman). The source was 14 km away from city, still the science experts shock that the calculation of the supply system, the height of source, passing with tunnels to avoid losses and at the city centre Bağlar location the water rise to 31 m from the building of administration for supplying water to high buildings top floors [5].

The first pipeline of Diyarbakır was built in 1935. The pipeline was made from Vakıflar İdaresi, the line was cast iron and the losses were high. To supply of increase in consumption, first planned and healthful workings were started in 1972. The line was furnished 11 km long with diameter of 1000 mm of precast concrete pipes. The 9000 m^3 reservoir was built at the end of line.

In 1990's, the migration was increased rapidly and existing amount of water wasn't serviced consumption. The additional wells were opened in Gözeli Location and the replacement of 1km of line was started up but unfinished.

In the year of 1995, the infrastructure of city was fully out of whack, the new project was designed for city to solve the problems untill 2030. The new alternative for water supply is surface water. Dam of Devegeçidi was considered first but the contamination of water was averted. The authorized selected Dicle Dam for supplying water.

The increase in migration in recent years, high water losses in existing system and high population of city caused the shortage of water. The water supply project of Diyarbakır provides domestic and industrial water until 2025. The project consists of two parts. The first part is operating now. If the city has water shortage, the second part will start up.

Before recent years, the necessary amount of water wasn't serviced. The treatment plant was put into service in 2001, built by DSİ and operating by DİSKİ, the water become adequate. The quality of water is in the same standards of European Union and TSE 266.

2.2. POPULATION OF DİYARBAKIR

The population of Diyarbakır is analyzed in this part. The statistics give the growth of population and help to predict future population at the end of water project.

2.2.1. Statistics of Population

The below tables (Table 2.1, Table 2.2) illustrate the population of Diyarbakır in 1990, 1997 and 2000. The population of centre and whole city is shown [6].

Table 2.1 Population of Diyarbakır City

Year	**City**	**Country Borough**	**Villages**	**City Center**	**Central Country**
1935	214,142	50,316	163,826	34,642	
1940	257,321	66,103	191,218	42,555	66,429
1945	249,949	63,377	186,572	41,087	64,703
1950	293,738	72,267	221,471	45,053	74,790
1955	343,903	98,798	245,105	61,224	94,665
1960	401,884	124,718	277,166	79,888	132,520
1965	475,919	162,467	313,419	102,653	163,691
1970	581,208	238,504	342,704	149,566	216,963
1975	651,233	281,960	369,273	169,535	244,686
1980	778,150	374,264	403,886	235,617	323,448
1985	934,505	472,055	462,450	305,940	409,127
1990	1,096,447	594,852	501,595	373,810	468,830
1997	1,282,678	832,605	450,073	511,640	
2000	1,362,708	817,708	545,016	545,983	
2007	1,460,714	634,300	605,325	826,414	

Table 2.2 Population Speed Rate of Diyarbakır

Population of Diyarbakır	Year of Accounting			Annually Increased Speed rate (%)	
	1990	**1997**	**2000**	**1990-1997**	**1990-2000**
City	**1,096,447**	**1,282,678**	**1,362,708**	**22.07**	**21.73**
Centre of City	**373,810**	**511,640**	**545,983**	**44.15**	**37.87**

2.2.2. Estimated Future Population of Diyarbakır

The calculation of future population will be made by using different methods such as Graphical, Arithmetical, Geometrical or Comparative Methods. Firstly, Arithmetical Method is used to estimate future population. The below equations (Eq.2.1, 2.2) are used to for calculations:

$$P_f = P_i + K_a\left(t_f - t_i\right) \qquad (2.1)$$

$$K_a = \frac{P_f - P_i}{t_f - t_i} = \frac{P_i - P_e}{t_i - t_e} \qquad (2.2)$$

Where;

P_f : future population,

P_i : initial population,

K_a : arithmetic constant,

t_f : future year,

t_i : initial year,

P_e : population in some earlier year

t_e : earlier year.

Especially, calculations are related in whole city's population. The water served from treatment plant is serviced to city centre. My calculations are also made to predict future population at the end of project life, 2025.

For 2025 and 2007 with K_{avr},

$$K_{avr} = \frac{P_i - P_e}{t_i - t_e} = 17410.21$$

$$P_f = P_i + K_a (t_f - t_i)$$

$$P_{2025} = 1{,}460{,}714 + 17410.21 \times (2025 - 2007) = 1{,}774{,}098$$

Table 2.3 Arithmetic Method for Prediction of Future Population in Diyarbakır

Year	**Initial Population**	**Earlier Population**	**Initial Time**	**Earlier Time**	**K**
1935	214,142				
1940	257,321	214,142	1940	1935	8635.80
1945	249,949	257,321	1945	1940	-1474.40
1950	293,738	249,949	1950	1945	8757.80
1955	343,903	293,738	1955	1950	10033.00
1960	401,884	343,903	1960	1955	11596.20
1965	475,919	401,884	1965	1960	14807.00
1970	581,208	475,919	1970	1965	21057.80
1975	651,233	581,208	1975	1970	14005.00
1980	778,150	651,233	1980	1975	25383.40
1985	934,505	778,150	1985	1980	31271.00
1990	1,096,447	934,505	1990	1985	32388.40
1997	1,282,678	1,096,447	1997	1990	26604.43
2000	1,362,708	1,282,678	2000	1997	26676.67
2007	1,460,714	1,362,708	2007	2000	14000.86
K_{avr}	**17410.21**				

Secondly, logarithmic method is used for forecasting future population. In this method, following equations steps are used.

$$P = 100 \times \frac{\log(P_e) - \log(P_i)}{t_e - t_i} \quad \text{.....} \quad (2.3)$$

$$Log(P_f) = Log(Pe) + (t_f - t_i) \times Log(1 + \frac{P}{100}) \quad \text{.....} \quad (2.4)$$

P_f : future population,

P_i : initial population,

P : increment constant,

t_f : future year,

t_i : initial year,

P_e : population in some earlier year

t_e : earlier year.

For 2025 and 2007 with P_{avr} ,

$$P = 100 \times \frac{\log(P_e) - \log(P_i)}{t_e - t_i} = 1{,}18$$

$$Log(P_f) = Log(Pe) + (t_f - t_i) \times Log(1 + \frac{P}{100})$$

$$= Log(1460714) + (2025 - 2007) \times Log(1 + \frac{1{,}18}{100})$$

$$= 1{,}804{,}136$$

Table 2.4 Logarithmic Method for Prediction of Future Population in Diyarbakır

Year	Initial Population	Earlier Population	Initial Time	Earlier Time	P
1935	214,142				
1940	257,321	214,142	1940	1935	1.60
1945	249,949	257,321	1945	1940	-0.25
1950	293,738	249,949	1950	1945	1.40
1955	343,903	293,738	1955	1950	1.37
1960	401,884	343,903	1960	1955	1.35
1965	475,919	401,884	1965	1960	1.47
1970	581,208	475,919	1970	1965	1.74
1975	651,233	581,208	1975	1970	0.99
1980	778,150	651,233	1980	1975	1.55
1985	934,505	778,150	1985	1980	1.59
1990	1,096,447	934,505	1990	1985	1.39
1997	1,282,678	1,096,447	1997	1990	0.97
2000	1,362,708	1,282,678	2000	1997	0.88
2007	1,460,714	1,362,708	2007	2000	0.43
P_{avr}	**1.18**				

Finally, method of İller Bank is used for forecasting population. According to this method, increment percentage is calculated from following formula [7].

$$P = \left(\sqrt[(t_e - t_i)]{\frac{P_e}{P_i}} - 1 \right) \times 100 \qquad \text{(2.5)}$$

$$P_f = P_e \times \left(1 + \frac{P}{100}\right)^{(t_f - t_e)} \qquad \text{(2.6)}$$

P_f : future population,

P_i : initial population,

P : increment constant,

t_f : future year,

t_i : initial year,

P_e : population in some earlier year

t_e : earlier year.

For 2025 and 2007 with P_{avr} ,

$$P = \left(\sqrt[(t_e - t_i)]{\frac{P_e}{P_i}} - 1 \right) \times 100 = 2.34$$

$$P_f = P_e \times \left(1 + \frac{P}{100}\right)^{(t_f - t_e)} = 1{,}460{,}714 \times \left(1 + \frac{2.34}{100}\right)^{(2025 - 2007)} = 2{,}215{,}045$$

Table 2.5 İller Bank Method for Prediction of Future Population in Diyarbakır

Year	Initial Population	Last Population	Initial Time	Earlier Time	P
1935	214,142	1,460,714	2007	1935	2.7
1940	257,321	1,460,714	2007	1940	2.63
1945	249,949	1,460,714	2007	1945	2.89
1950	293738	1,460,714	2007	1950	2.85
1955	343,903	1,460,714	2007	1955	2.82
1960	401,884	1,460,714	2007	1960	2.78
1965	475,919	1,460,714	2007	1965	2.71
1970	581,208	1,460,714	2007	1970	2.52
1975	651,233	1,460,714	2007	1975	2.55
1980	778,150	1,460,714	2007	1980	2.36
1985	934,505	1,460,714	2007	1985	2.04
1990	1,096,447	1,460,714	2007	1990	1.69
1997	1,282,678	1,460,714	2007	1997	1.32
2000	1,362,708	1,460,714	2007	2000	0.97
2007	1,460,714				
P_{avr}	**2.34**				

Table 2.6 Future Population Estimation of Diyarbakır

	Arithmetic Method	Logarithmic Method	Method of İller Bank
Future Population of Diyarbakır in 2025	1,774,098	1,804,136	2,215,045

Before the project, the 1990 accountings were based in future population calculations. The Table 2.7 shows the estimation of population propped up 1990 accountings [7].

Table 2.7 Estimation of Diyarbakır City Population [7]

YEARS	ARITHMETIC METHOD	LOGARITHMIC METHOD	LITTLE SQUARE METHOD	DSİ CALCULATION METHOD	İLLER BANK CALCULATION METHOD		
					$m=m_{average}$ m=4.81	$m=m_{average}$ m=3.00	$m=m_{average}$ N_{1990}=435,495
1990							435,495
1995	800,000	800,000	800,000	902,000	800,000	800,000	550,766
2000	866,715	884,423	1,002,305	1,045,000	1,011,821	927,419	696,643
2005	935,430	977,440	1,255,740	1,211,000	1,279,727	1,075,133	881,098
2010	1,003,145	1,080,413	1,573,258	1,405,000	1,618,567	1,246,374	1,114,391
2015	1,070,860	1,194,236	1,971,060	1,629,000	2,047,125	1,444,889	1,409,455
2020	1,138,575	1,320049	2,469,448	1,888,000	2,589,155	1,675,022	1,782,645
2025	1,206,290	1,459,117	3,093,855	2,188,000	3,274,701	1,941,810	2,254,646
2030	1,274,005	1,612,835	3,876,145		4,141,763	2,251,090	2,851,622

2.3. SOURCES OF WATER SUPPLY

There are two water sources for Diyarbakır drinking-water net: Dicle Dam and Gözeli Wells.

2.3.1. Dicle Dam

Dicle dam is built at a distance of 50 kilo metres to Diyarbakır city centre. More specifically, the Dam and the HPP (high pressure pumps) are located at a distance of 800 metres from the point of junction of the streams of Maden and Dibni to form the Tigris, and 22 kilometres downstream of the Kralkızı Dam. Construction works were started in 1986.

The project is for energy production and irrigation. On the right bank plains of the Tigris, 130.159 hectares of land will be irrigated, 54.279 by gravity and 75.880 by pumping. The HPP has a capacity of 2x55=110 MW and will generate 298 million kWh of energy annually [8].

As a part of the Kralkızı-Dicle Integrated Project, the Dicle Dam and HPP project reached a physical realization of 93.2%. Its budget allowance for 1997 is 1 trillion 601 billion. With the completion of the project, the HPP will contribute 2 trillion 980 billion TL to the national economy in energy production, and 9 trillion 800 billion TL in irrigation. Thus the total contribution of the facilities will amount to 12 trillion 780 billion TL at 1997 prices. Impounding started on 25 October 1997 and construction work was planned for completion by 30 December 1997. The total cost of the project is about 22 trillion TL at 1997 prices. Table 2.8 shows some characteristic of dam [8]:

Table 2.8 Characteristics of Dicle Dam [8]

Location	DİYARBAKIR
River	DİCLE
Purpose	IRRIGATION , ENERGY
Construction (Starting And Completion) Year	1986-1997
Type	ROCFILL , EARTHFILL
Dam Volume	2 180 000 M^3
Heigth From River Bed	640,00 M
Crest Level	718,00 M
Death Volume	340,00 HM^3/YEAR
Reservoir Volume At Normal Water Surface Elevation	595,00 HM^3/YEAR
Active Volume	255,00 HM^3/YEAR
Annual Output	1085,75 HM^3/YEAR (with Kralkızı Dam)
Irrigation Area	126 080 HA
Annual Generation	298 GWh

2.3.2. Gözeli Wells

The water is taken to distribution reservoir by gravitational energy. This source is consisting of 22 deeper wells. The water has high quality; rich about minerals and water is passed only final chlorination before distribution reservoir. The discharge of water is 360 l/s. Gözeli is supplied %20 of water for daily consumption.

Diyarbakır city centre is nearly 7500 years old. The known oldest water distribution net was built in 1535 by Kasım Çelebi who is master-builder of Mimar Sinan's. The source was 14 kilometres away from city centre and called 'Hamravat Suyu'. Today, people are also amazing the way getting water to city that for prevent water level and water losses by using tunnels , also the water was conveyed 31 m height in city centre. Although 'Hamravat Suyu' is special water and thinking that it's curative for long years. Hamravarat source is still used, it is in Gözeli place.

This water has basalt formation and come out from cracks. On the other hand, Diyarbakır has another historical source 'Anzele' but it wasn't used for drinking water any more. Anzele is at the city centre and the unrestrained water passing underground is too much, so this water is needed some special process before using like super chlorination techniques which is very expensive. Because of all, this water is used for irrigation facilities.

2.4. PIPELINE SYSTEM and PUMP STATION of SOURCE

2.4.1. Structural Characteristics of Pipeline and Pump Station

Dicle Dam is 35 kilometres far away from Treatment Plant. Diyarbakır Drinking Water Project was given out by contract into three parts: Raw Water Pipeline, Pump Station and Treatment Plant.

Raw water is taken with Ø 1,600 steel pipe from Dicle Dam and HES to treatment plant. First, water is taken with Ø 2,200 steel pipe by T1 sluiceway tunnel to pump station, it is pumped to 3,000 l/s raw water derivation tunnel by two gentle and one standby pump. From derivation tunnel water is gone to treatment plant by gravity.

In pump station, there are two 4,000 kW, 11 kV and 1500 period/ min. electrical motor found. The 4000 kW group of pump motors with 3.3 kV frequency converter were firstly used to give way system in Turkey. The variation periodic pump motor is feed by one 34.5/3.3 kV 5 MVA transformer [9].

The pumps are horizontal axle and double aspirated engine; output is 1.5m^3/s, Hm 195 m. Also, the second part's pump platform, entrance-exit structures, and ram vane rooms were built.

The Ø 1,600 steel pipes were used for pipelines and they are nearly 31 km long. The muffle steel pipes were manufactured in two stages; inside was concrete and outside was polyethylene. The wall thickness was 14 mm.

The size of units within the context of project as follows:

The name of unit	Size
Water Intake Tower	13 m
T1 Tunnel Ø 2,200 S.P.	430 m
Collector Line	1+042 km
Elevated Line	6+425 km
Derivation Tunnel	1+245 km
Pipeline	24+191 km

2.4.2. Construction and Activation Date

The construction of pipeline and pump station was started in 1997 and finished in 2001. The following table (Table 2.9) is a brief of construction facility [9].

Table 2.9 Construction and Activation Date of Pipeline and Pump Station [9]

Contractor	MAPA İnş. ve Tic. A. Ş.
Time of Adjudication	08.02.1997
Starting in Business	25.09.1997
1st Estimation	415 billion TL
Rate of Discount	% 10,15
2nd Estimation	985 billion TL
Rate of Increment	% 137
Date of Finish	31.05.2001

2.4.3. Conveyance Line of Source

The raw water is taken from Dicle Dam with Ø2,200 steel pipe at a height of 45m.This line is designed for 6m/s. The water is entered to pump station, one variable and two stable pumps are working in there. The variable pump is served water at 0.7-1.5 m^3/s; the stable is served at $1.5m^3/s$. The water is pumped with Ø1,600 steel pipes to the conduit and there is flow-meter on that line. The conduit is 176 m high from pump station. There are two balanced tunnel on the line between pump and conduit; first one is 123m and second is 48 m high from pump station. This line is delivered 3m/s and the first part of project. The balanced tunnels provide decreasing the speed of turned water. They like as refreshing pools and protect the system from damages. The tunnel's volumes are 135 and 270 m^3. The ram vanes are also used to regulate remained water pressure by run out water from system. There are nearly 40 vanes on the whole pipeline.

The following figures are the illustration of raw water pipeline between source and treatment plant. (Figure 2.1; 2.2)

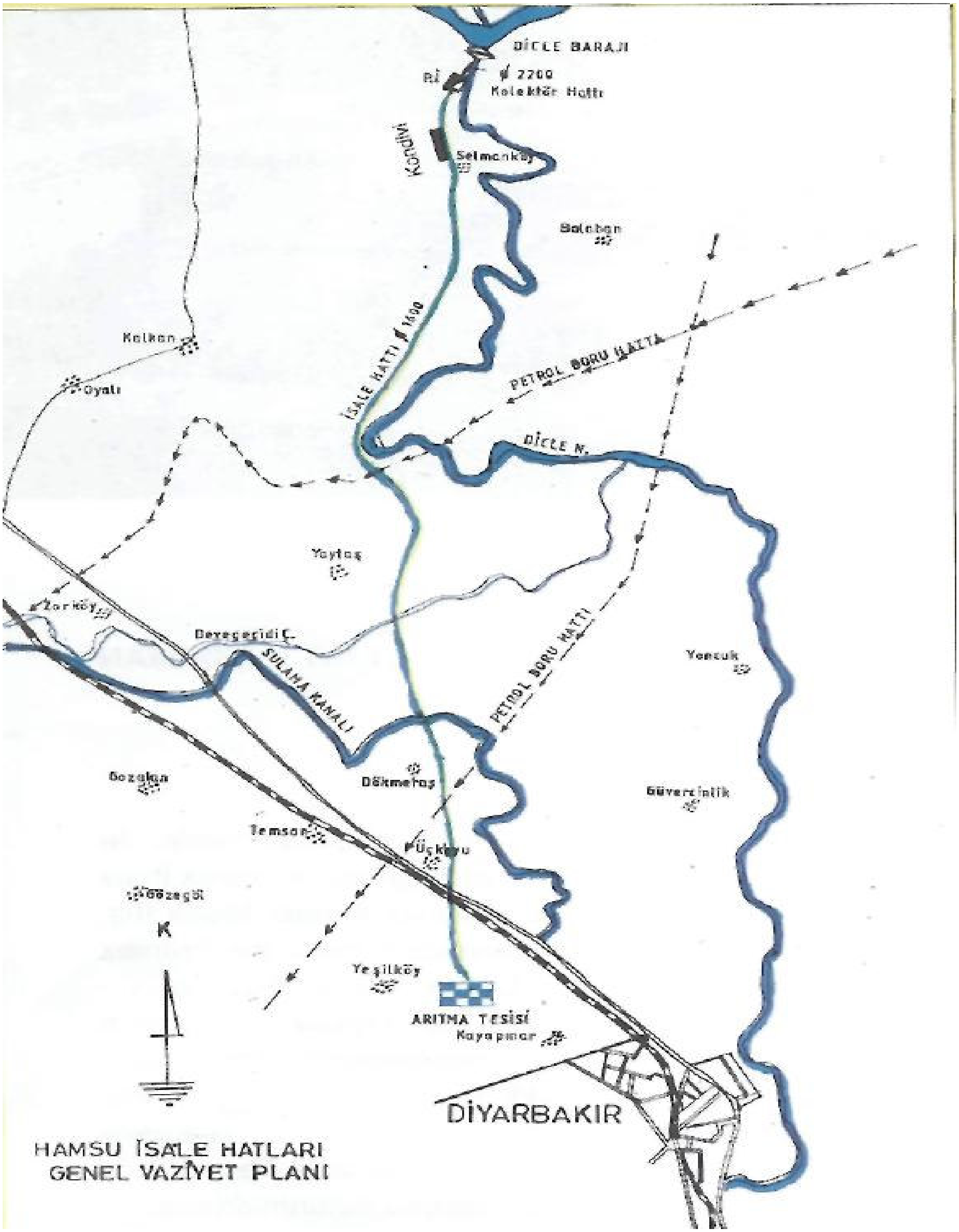

Figure 2.1 The Route of Raw Water Pipeline.

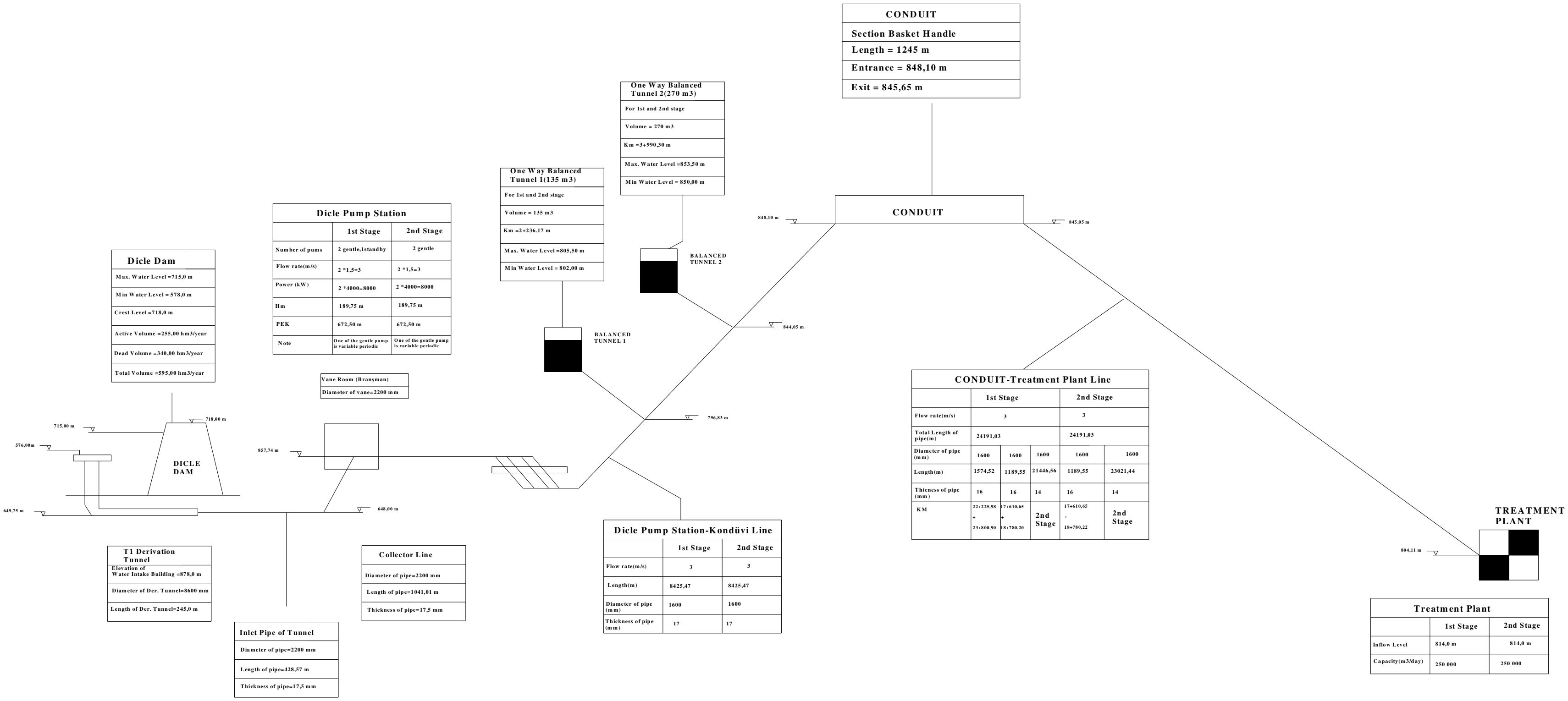

Figure 2.2 The Pipeline of Raw Water

2.5. TREATMENT PLANT

2.5.1. Capacity and Location

Capacity: The raw water is came from Dicle Dam and pumped to the treatment plant. Treatment plant has been designed to contribute to the drinking water supply of Diyarbakır city. The plant inlet is 255,000 m^3/day (or 3.0 m^3/s) when the flow is nominal. In the plant, there is 10,000 m^3 treated water reservoir. The standard daily consumption of water for individual is 200l, this plant is serviced for 1,280,000 people. Treatment plant has been designed in two stages and in the future the inlet discharge will increased to 6.0 m^3/s.

Location: Treatment plant was built on the Diyarbakır-Elazığ highway, opposing to Üçkuyular Village, at Mastaras Hill and away from 11 kilometres city centre. Treatment plant is far away from Dicle Dam about 35 kilometres.

2.5.2. Construction and Activation Date

Treatment Plant Construction Agreement Information is shown below [9]:

Table 2.10 Construction and Activation Date of Treatment Plant in Diyarbakır [9]

Contractor	MAPA İnş. ve Tic. A. Ş.
Time of Adjudication	12.12.1997
Starting in Business	19.03.1998
1st Estimation	1,800 trillion TL
Rate of Discount	% 13,80
Duration of Agreement	1035 days
2nd Estimation	3,702 trillion TL
Rate of Increment	% 105
3rd Estimation	4,350 trillion TL
Rate of Increment	% 36
Date of Finish	31.05.2001

As follows Treatment Plant Assemblage Agreement Information [10]:

Table 2.11 Construction and Activation Date of Treatment Plant in Diyarbakır [10]

Contractor	Degrèmont S. A.
Time of Adjudication	15.04.1996
1st Estimation	60,000,000 Fr. F
Rate of Discount	% 9,96
Budget of Agreement	54,200,000 Fr. F
Duration of Agreement	1295 days

2.5.3. General Principles of Water Treatment Plant

The raw water originates from groundwater which feeds river of Tigris (Dicle). The chemical composition of surface water depends on the type of terrain the water has passed through before flowing into the drainage area. Along its course, water dissolves various components of soil. The exchange between water and air at the surface causes gasses (oxygen, nitrogen, carbon dioxide) to dissolve in the water. The raw water contains dissolved gasses, suspended solids, presence of natural organic matter and plankton which were dangerous for human health. Water made available to consumers for all uses.

Water coming out of the consumer's faucet must be 'potable', that is, it must conform to standards in force regardless of how the consumer chooses to use it.

A number of factors determines which water should be treated before it's distributed. For each source, human must assess;

The quantity: 'source' must be able to furnish the required quantity of water at all times.
The quality: the quality of available raw water must meet current legal standards.

The cost: For each available source the capital and operating costs must be compared so as to assure both quality and quantity of water for distribution.

Diyarbakır treatment plant was designed becoming raw water to drinking water. The raw water characteristics are given in Table 2.12 [10]:

Table 2.12 Design Criteria for the Quality of the Raw Water Used at Diyarbakır Plant [10]

PARAMETER	**UNIT**	**VALUE**
Temperature	°C	17.7-20.8
Turbidity	NTU	2.15-4.53
Suspended solids	mg/l	2
Color (total)	PtCo	6-37
Permanganate value	mg/l O_2	2.7-3.2
Mn (total)	mg/l	0.01
Fe total)	mg/l	0.07
pH		7.65-7.73
Hardness	mg/l $CaCO_3$	204
Alkalinity	mg/l $CaCO_3$	152
Amonia N-NH_4	mg/l	0.01
Nitrite N-NO_2	mg/l	0.028
Nitrate N-NO_3	mg/l	0.7
Phosphate(PO_4)	mg/l	0.9

Plant inlet is 255,000 m^3 per day – i.e. 3,0 m^3/s. The treated water must have limited standards, Table 2.13 shows Turkish Standards for Drinking Water [10].

Table 2.13 Turkish Standards for Drinking Water Diyarbakır Plant [10]

Parameters	**Turkish Maximum Acceptable Value**
Turbidity NTU	0.4
Ph	7< pH< 8.5
Color	Not exceeding 5 Pt-Co
Aluminum mg/l Al	Not exceeding 0.5 mg
Iron	Not exceeding 0.10
Manganese	Not exceeding 0.05

Treatment Principle

Figure 2.3 illustrates the flow chart of water in treatment plant [11].

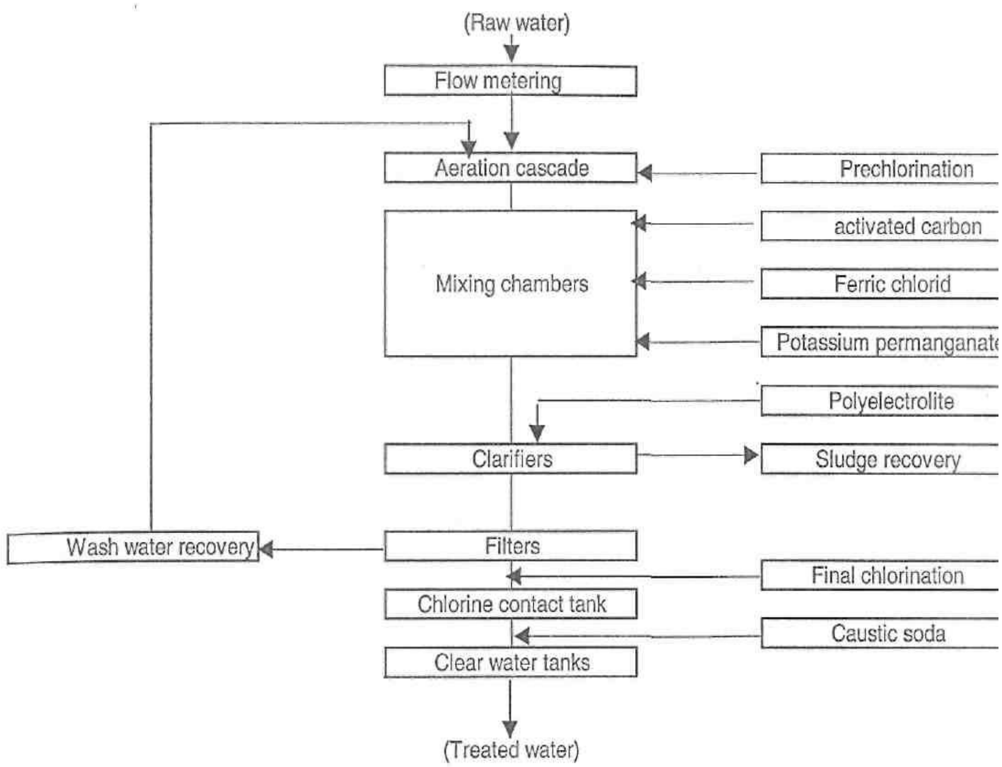

Figure 2.3 The Flow Chart of Treatment Plant

The raw water goes through the following treatment steps:

2.5.3.1. Aeration

The aeration step is required for oxygenation of the raw water. Through a 4 steps aeration cascade, the atmospheric oxygen will be dissolved into the raw water. The cascade is designed in order to raise the oxygen content up to 60% of saturation of raw water totally free of dissolved oxygen, at a maximum temperature of 30°C.

The first phase compartment of the aeration cascade will be provided with two isolating penstocks and with two by-pass penstocks.

2.5.3.2. Pre-chlorination

Pre-chlorination ensures better filterability by enhancing coagulation and thus permits a better water quality to be treated

Pre-chlorination is intended to:

- destroy the existing micro-organisms likely to grow in the structures and the sludge blanket. It thus keeps the clarifiers and filters clean and prevents sludge rising within these clarifiers
- finalise oxidation of ammonia ;
- decrease taste threshold and, in most cases, reduce water discoloration.

Furthermore pre-chlorination inhibits the growth of algae. For a good efficiency of pre-chlorination, raw water must contain free chlorine in small quantity. The quantity of chlorine to be injected is given by the "breakpoint test" and the "demand of chlorine". In this plant, the chlorine is injected as chlorinated water.

2.5.3.3. Coagulation – flocculation

Water contains very fine, colloidal or pseudo colloidal suspended solids which must be gathered into a bulky and heavy floe to allow settling and help retention in the filters. The interfaces of colloids are electrically charged, which prevents nearby particles from coming close together.

The action takes place in two steps:

- Coagulation, which destabilizes the colloids to give rise to a precipitate,

- Flocculation, which is intended to increase the volume and cohesion of the flow formed by coagulation.

Coagulation; Usage of this is made of metal salt such as ferric chloride. The amount to be used depends on the nature of the water to be treated:

- it is determined at plant start-up after Jar tests have been conducted ,

- the greater the water's colloid content, particularly matter of vegetable origin, the higher the amount of reagent required for clarification,

- the nature of organic matter has an influence on coagulation, the coagulation with ferric chloride admit a large range of pH. So it is unnecessary to adjust this pH with caustic soda.

Flocculation; Flocculation is promoted by placing the water into contact with the maximum amount of floe already formed by the prior treatment. This is the technique applied in sludge blanket apparatus.

Flocculation can be further improved by the addition of a chemical used as a flocculants aid, such as polyelectrolyte.

Settling: Settling is designed to allow the particles in suspension in the water to settle, under the effect of gravity, to improve water quality.

To ensure that settling takes place, the settling rate of the particles must be higher than the water's rising velocity. These particles exist in the raw water and are precipitated into larger (and thus heavier) floccules by adding chemical agents during flocculation.

In Diyarbakir Water Treatment Plant Lamellar Pulsator type clarifiers are used in order to save land acquisition and reduce the overall cost of the plant.

2.5.3.4. Settling: Sand filtration

Filtration is designed to remove particles suspended in water, whether these particles exist in the raw water or result from a previous coagulation process.

The trapped suspended solids gradually block the interstices between the constituent elements of the filtering media. This phenomenon is known as "filter clogging".

As clogging increases, the head losses affecting the flow of water passing through the filter also increase. Therefore, the water level above the sand increases. When head loss increases up to 1.2 m, the filter must be washed.

The rate of clogging depends on:

- the characteristics of the water: the more turbid the water is, the faster the filter becomes clogged.

- the quality of coagulation, flocculation and settling: the worse the quality of this treatment, the faster the filter becomes clogged,

- the flow per unit of filtering area or filtration rate: the head loss increases with the rate,

- the flow per unit of filtering area or filtration rate: the head loss increases with the rate,

- the grain size of the filtering media: the finer the particle size of the filtering material, the more quickly it becomes clogged.

2.5.3.5. Disinfection

To given amount of calcium and magnesium bicarbonates, it correspond concentration of free carbon dioxide which is the amount of carbon dioxide required to prevent breakdown of the bicarbonates and precipitation of the corresponding carbonates. This amount is known as the "equilibrium carbon dioxide".

If the water contains an amount of carbon dioxide higher than the equilibrium value, the excess amount is known as the "aggressive carbon dioxide". The amount of half-bound $C0_2$ (HCO_3 of the bicarbonates) is equal to the amount of bound $C0_2$. The water containing aggressive CO_2 dissolve the carbonates in to form of bicarbonates; therefore, they are incapable of causing the formation of a protective carbonate film on the surfaces in contact with them.

In contrast, the waters which contain less free CO_2 than the theoretical amount of equilibrium $C0_2$ precipitate $CaC0_3$. They are scale-forming.

Consequently, "saturation pH" corresponds to each value of the alkalinity. When the pH of water is below the saturation pH, this water is considered aggressive. Neutralisation can be performed by several methods, and in particular for this plant by caustic soda if necessary, to obtain the equilibrium pH as given by the marble test.

2.5.3.6. Stability at the Saturation pH

Whether or not they have undergone prior treatment, and although they may appear perfectly clear, most waters are often contaminated by microbes dangerous to health. Due to its high efficiency even when employed in minute amounts and to its ease of application, chlorine is the most commonly used reagent for water disinfection purposes. Chlorine's germicidal action even in small dosages is explained by the destruction of the enzymes required for the existence of the microbial germs. Chlorine also has considerable oxidising properties which favour organic matter destruction. The amount of chlorine used for disinfection is slightly higher than the chlorine demand if the temperature is below 10°C, and slightly less than the chlorine demand if the temperature is above 15°C. In this plant, chlorine is injected as chlorinated water.

2.5.4. Process of Treated Water

The raw water comes through a 1,600 mm pipeline into a balancing tank having net volume of 750 m^3. The raw water pipe is equipped with an electromagnetic flow meter diameter 1,200 mm, an inlet control valve diameter 1,200 mm and inlet-isolating valve diameter 1,600 mm.

Figure 2.4.A Pump Station.

Figure 2.4.B Pump Station.

Figure 2.5 Derivation Tunnel.

2.5.4.1. Aeration Structure

The first step of treatment process is aeration by means of a multi-stepped cascade to increase the oxygen content of the raw water. Aeration tank is used to decrease water pressure and increase oxygen.

- Number of aeration structure 2
- Total nominal flow rate .... 259,200 m^3/day
- Total fall .... 2.0 m
- Number of steps.................................... ….. 4
- Total length of weirs for each fall .... 27.2 m
- Increase of oxygen content .... 60 % of the deficiency in dissolved oxygen

By-pass of the aeration cascade was be effected by a 1100 x 1100 manually operated penstock. Plant by-pass penstock size is 1,600 x 1,600 mm.

Figure 2.6 Aeration Structure.

Figure 2.7 Aeration Tank.

Pre-chlorination is prevented bacteria creation and coagulation-flocculation. Also activated carbon and potassium permanganate is added to avoid taste and odour defects of water. Ferric chloride is used for breaking the bonds of electrons of suspended particles.

2.5.4.2. Mixing Chambers

From the aerator, raw water flows to the two mixing tanks. The mixed water is distributed between the 6 clarifiers installed in either streams by means of distribution chambers each provided with sharp crested weirs. Isolating penstocks is enable upstream isolation of the weirs. Individual metering of the flow conveyed to the clarifiers is achieved on the distribution weirs. When closing all the penstocks upstream the clarifiers, the water is overflow to the clarified water channels, thus by-passing the clarifiers.

Figure 2.8 Mixing Chambers.

2.5.4.3. Clarifiers

Polyelectrolyte is mixed to water for preventing flocculation. Water is absorbed with vacuum fan to take out the air from water and dropped out suddenly to avoid settled down of suspended particles. Water smash from pipe bunches and rises again. Pulsators prevent increase of mud level and also take out mud when it reaches flood level.

Figure 2.9 Clarifiers.

2.5.4.4. Filters

The water is already cleaned at %60-%70 when came to filters. Special sand is used in filters pools for settling remained particles from water.

Figure 2.10 Filters.

2.5.4.5. Chlorine Contact Tanks and Clear Water Tanks

From the outlet of the filter plant, the water flow to the chlorine contact tank 3,550 m^3. The connecting pipe between the filter plant and the chlorine contact tank are provided with a filtered water flow meter. The proposed arrangement provides the straight length necessary for a proper measurement.

The outlet of the tank is consisting of a weir, to maintain full the chlorine contact tank. The connecting pipe will be provided with one valve outlet to the wash water holding tank.

After the contact tanks water is come to clear water tanks. The clear water reservoir capacity is 10,000 m^3. At contact chamber outlet, PH is adjusted by costic soda injection.

Furthermore the costic soda, potassium permanganate, active carbon is not used at treatment plant because of the high quality of raw water.

Figure 2.11 10,000 M^3 Reservoir.

The outlet of the plant will consist of a 1,600 mm pipe up to the limit of the site. This pipe is equipped with a flow meter ND 1,200 mm and with an electrically operated valve ND 1,600 mm. A branch with an electrically operated isolation valve for connection to the second phase is provided at this stage.

The accumulated sludge is transferred to the thickener for coagulation and with overspill water, sludge is settled to bottom. The sludge is sucked by pump from mixing rooms to filter press.

The lime is added to sludge for prevent sticking to filter press. With pressure 380 bars, the sludge is pressed. The remained water is given to sewerage and plaques are left to the nature.

Figure 2.12 Sludge Filter Rooms.

Figure 2.13 Liming Unit.

Figure 2.14 Filter Press.

Figure 2.15 Sludge Digesters.

The plant operation system is recoverable; the water is not wasted in the units. Untreated water turns back to entrance of plant to contribute treatment system. Only the water outcome from filter press is not used.

In the administration building, there are SCADA room and chemical laboratory. The main purpose of this project is to install a SCADA system which is established as a computer-based centralized management system to monitor and control of potable water production and purification. Two computers is used one of them is for daily and other is for monthly data's. The daily tests are conducted in laboratory, samples are taken from five parts of plant: Raw water, Mixing Chambers, Clarifiers, Filters and 10,000 m^3 reservoir.

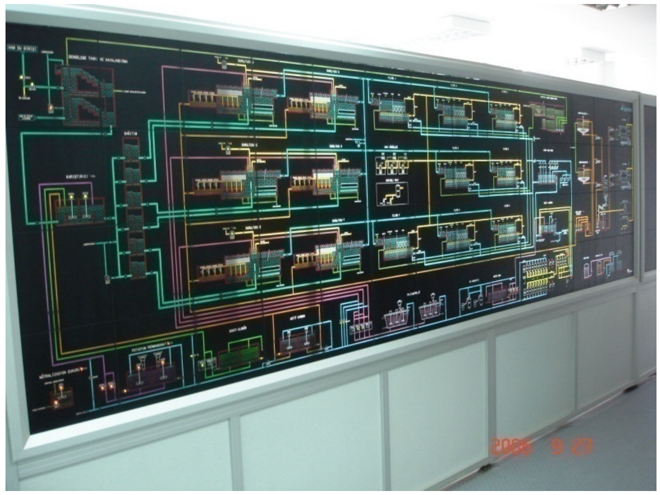

Figure 2.16 SCADA Control Room.

Figure 2.17 Chemical Laboratory.

Figure 2.18 Chlorination Rooms.

Figure 2.19 Diyarbakır Drinking Water Treatment Plant.

2.5.5. Efficiency for Current Population and Future Capacity

Capacity of treatment plant is 255,000 m^3/day. This means water is served 1,280 000 person for daily consumption standards. According to formal last population counting, city's population is 641,616. Today population of city is nearly 800,000 then source and plant meet the demand of city.

The expected age of plant will planned as year of 2025. Also, the second stage of plant and raw water pipeline construction both will be planned for 2025.

On the other hand, authorized expect increase of population, suggested that to put into service the second part in year of 2015.

2.5.6. The History of Variation of Inflow and Priority

The data show the difference between inflow and outflow values. This loss is resulted from maintenance of plant, irrigation of open space area, personal usage and discharge with sludge.

Table 2.14 Annually Water Inflow and Outflow of Diyarbakır Water Treatment Plant

Year	**Inflow from Dam (m^3)**	**Outflow to Reservoir (m^3)**
2001	20,504,476	17,197,000
2002	37,776,706	34,239,826
2003	51,476,000	45,307,000
2004	51,964,000	50,194,000
2005	51,933,000	50,471,000
2006	54,849,000	53,373,000
TOTAL	**268,503,182**	**250,781,826**

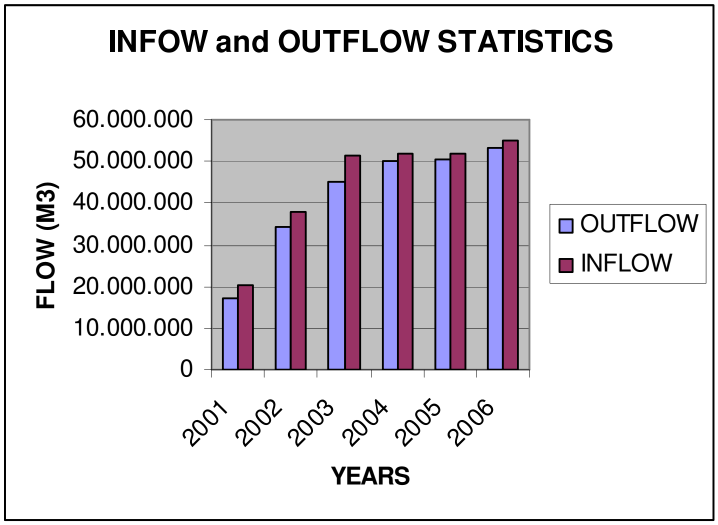

Figure 2.20 The Bar Chart of Inflow and Outflow.

2.5.7. Sufficiency and Efficiency of Available Staff

Plant is conducted with forty staff: 1 mechanical engineer, 2 chemical engineer, 1 chemist, 1 biologist, 16 technician and workers.

In developed countries, the same plant is conducted with 100 staffs. Formally, staffs who are working for plant is selected from authorized of municipality. Consequently they must be sufficient to work at plant. In Turkey number of treatment plant is limited so finding professional staff is another handicap.

2.6. WATER DISTRIBUTION NETWORK OF DİYARBAKIR

The city of Diyarbakır is located on the Dicle (Tigris) River. The historical and present growth of the city is on a large basaltic plain sloping gently eastward in elevation from 770 to 550 meters above sea level. The old city abuts the edge of the Dicle River bank. Today the city expands to north, west and south from the old city like fan shape.

Rapidly increased population make the ninth largest city of Turkey according to 2000 accountings. The existing infrastructure wasn't sufficient to current population. The part of distribution supply net project had been started up in 1995 by leading of İller Banks.

The old network had four primary sources. Their supplied volumes were: Gözeli -47 %, Hamidiye-15 %, Yeniköy- 15.7 %, Anzele-9.4 %. Together these four sources contributed 88 % of the total water supply to the city. The 88 % percent thought that there was no need to new system maybe. However, the hydraulic complexity, existing water shortages, the sources only supplied to their individual production capacity and high water losses of oldest pipeline had been caused to construct and rehabilitate the new pipeline.

The alternative water source was chosen as Dicle Dam, other existing source Gözeli is still used in new system. The 80 % of delivered water is supplied from Dicle Dam, remained (20 %) from Gözeli Wells for daily consumption.

2.6. 1. Existing Pipe Network

Diyarbakır has a wide western part, which is relatively flat, loosely settled and populated, having new development areas. This area is surrounded by three densely settled and populated areas. In south-west there are new development areas.

In relations with these geographic and topographic conditions, the existing distribution system of Diyarbakır is divided into main supply zones and main supply zones are also divided into many sub-zones at 40-70 m elevation interval.

The existing distribution network starts at the treatment plant located at the west part of the city. The raw water to treatment plant is supplied from the Tigris (Dicle) River. The main water supply to the city is made with 2,200 mm steel pipe, which is connected to the clean water tanks at the treatment plant.

The main pipeline transports the clean water by gravity to the water reservoirs and main pumping station, and from this pumping station to the supply zones at upper elevations. Six supply zones are supplied from 16 reservoirs, which are connected to the 2,200 mm steel main pipeline [11]. (Table 2.15)

Table 2.15 The Sixth Supply Pressure Zones of Diyarbakır Supply Net [11]

NAME of RESERVOIRS	**SUPPLYING ZONES**
Water reservoir **DY 1**	Pressure zone **1**
Water reservoir **DY 2.1**	Pressure zone **2.1**
Water reservoir **DY 2.2**	Pressure zone **2.2**
Water reservoir **DY 2.3**	Pressure zone **2.3**
Water reservoir **DY 3.1**	Pressure zone **3.1**
Water reservoir **DY 3.2**	Pressure zone **3.2**
Water reservoir **DY 3.3**	Pressure zone **3.3**
Water reservoirs **DY 4.1-1** and **DY 4.1-2** (to be constructed in 2020)	Pressure zone **4.1**
Water reservoir **DY 4.2**	Pressure zone **4.2**
Water reservoir **DY 5.1-2**	Pressure zone **5.1** (to be implemented in 2020)
Water reservoirs **DY 5.2-1** and **DY 5.2-2**	Pressure zone **5.2** (to be implemented in 2020)
Water reservoir **DY 6-2**	Pressure zone **6** (to be implemented in 2020)
Water reservoir **DM1**	Kayapınar area
Water reservoir **TDY1**	Water reservoir **DY2.2**

There are various inter-zonal connections between pressure zones having the same or different pressure levels. These connections are being controlled by the valves.

2.6. 1.1. Construction and Activation Date

The construction activity had started up in 1995 and completed in 2004. The new pipeline construction bid was given out to contractor by İller Banks. The following table is the brief of construction activity. (Table 2.16)

Table 2.16 Construction Activity of Network Pipeline in Diyarbakır

Name of Business	DİYARBAKIR DRINKING WATER LINE
Contractor	SER-HAT TAAH. İNŞ. SAN. TUR. VE TİC. LTD. ŞTİ.
1st Estimation	585.000.000.000 TL. (1994 Unit Price)
Rate of Discount	18,10 %
Starting in Business	1995
Date of Finish	2004

The below figure illustrates the laying lengths of pipes according to each year. (Figure 2.21)

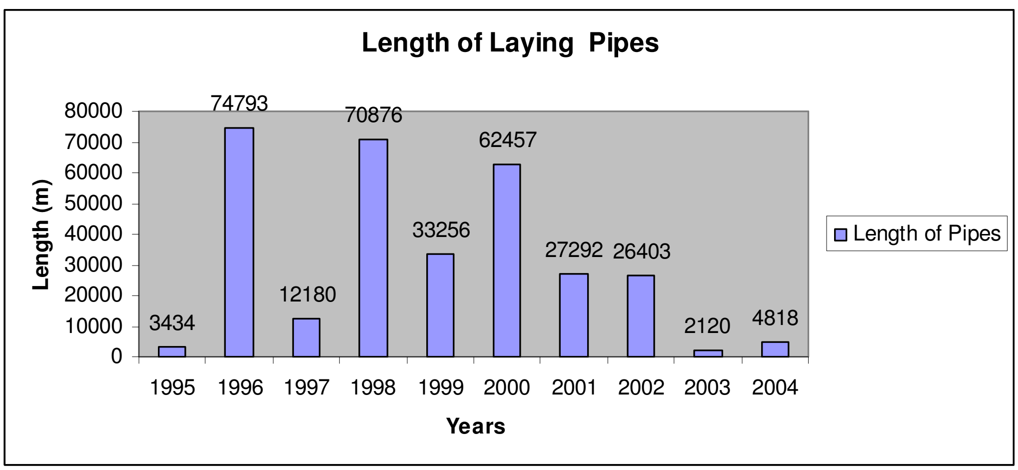

Figure 2.21 Length of Laying Pipes.

2.6.1.2. Type of Distribution Network

The existing pipe network is grid type. In this system, all reservoirs are connected with pipes and those connections provide water in emergency situation, it means you can take water from nearby reservoir for damaged reservoirs supply zone.

The pipeline of loop system has advantage in same concern. The loop system give chance to supply water from close pipe to system and consumers get water without water cut.

The grid type is checkable easier than branched system. You can observe flow of water gradually in this system.

2.6.1.3. Characteristics of Pipes

The pipeline network is started from reservoirs for delivering water to their supply zones. Now, only two reservoirs are activated and supply water to the city. The treated water is taken from storage reservoir (10,000 m^3) to the main distribution reservoir (DY 3.1) with Ø1,400 steel pipe. The other reservoir (DY 2.2) is taken water from Gözeli wells and DY 3.1 with two pipeline Ø800 and Ø1000 pipes.

The distribution of water is provided by gravity to reservoirs and network of the city. The length of network is about 450 km. The types of pipe material used in network are PVC (polyvinylchloride), steel, Pe (Polyethylene), ACP (Asbestos-cement) pipes.

PVC (polyvinylchloride) Pipe: This type of pipe both used in water and wastewater. It is the most commonly used plastic pipe for municipal water distribution systems because of its resistance to corrosion, its high strength to weight, its light weight and its ease installation.

Steep Pipe: It is available in all any sizes for use in water distribution systems. The main advantages of steel pipe include high strength, the ability to deflect without breaking, the ease of installation, shock resistance, the ease of fabrication of large pipe, the availability of special configurations by welding and ease of the field modification.

Pe (Polyethylene) Pipe: It is started using widely in transmission and distribution system applications because of its resistance to corrosion, its light weight, insight strength to weight, its resistance to cracking, its smoother interior wall surface and its demonstrated resistance to damage during seismic events.

ACP (Asbestos-cement) Pipe: It is made by mixing Portland cement and asbestos fibber under pressure and heating to produce a hard strong product. The ACP is rarely used nowadays. Asbestos has some hazardous effect on human health and after the starting production of PVC, its usage is decreased.

The following table consist of used pipe materials their diameters and lengths which were laying down in network of Diyarbakır [11]. (Table 2.17 The aspect of network).

Table 2.17 The Aspect of Diyarbakır Network [11]

DIAMETER and TYPE of PIPE	UNIT	LINKS BETWEEN RESERVOIRS (km)	NETWORK (km)
Ø 125 Pe	Pipeline		70.363
Ø100 PVC	Pipeline		193.485
Ø 125 PVC	Pipeline		21.488
Ø 150 ACP	Pipeline		25.448
Ø 200 ACP	Pipeline		17.616
Ø 250 ACP	Pipeline		8.714
Ø 300 ACP	Pipeline		9.289
	Discharge line	2.246	
Ø 350 ACP	Pipeline		5.092
Ø 400 ACP	Pipeline		4.354
	Reservoir Link	3.388	
Ø 600 ACP	Discharge line	4.272	
Ø 500 St	Pipeline		6.431
	Reservoir Link	2.340	
Ø 600 St	Pipeline		8.055
	Reservoir Link	5.562	
Ø 700 St	Pipeline		5.309
	Reservoir Link	132	
Ø 800 St	Pipeline		5.041
	Reservoir Link	4.556	
Ø 1000 St	Pipeline		8.662
	Reservoir Link	13.002	
Ø 1200 St	Pipeline		6.884
	Reservoir Link	665	
Ø 1400 St	Pipeline		10.630
	Reservoir Link	3.719	
Ø 1800 St	Reservoir Link	4394	
TOTAL		**44.286**	**406.861**
GENERAL TOTAL		**451.147**	

2.6.2. Main Distribution Reservoirs

Water project is composed of sixteen main distribution reservoirs. The reservoirs are placed according to deliver water in most effective way to their pressure supply zone. The water is distributed from reservoirs to supply zones by gravity. The reservoirs are connected with pipeline and checked with vanes.

The only working reservoirs are DY 3.1 and DY 2.2 now, other's construction facilities haven't being completed yet.

DY 3.1 is the main distribution reservoir that takes water from treatment storage reservoir with Ø1,400 steel pipe. DY 3.1 serves water to five pressure zone. Although, the Ø800 steel pipe is transferred water from DY 3.1 to DY 2.2 .

DY 2.2 is placed after the Gözeli Collector Chamber. The water taken from chamber is pre-chlorine before entering DY 2.2; three pipes are conveyed from chamber to reservoir line. The connection of water, which come from DY 3.1 and Gözeli chamber, is with Ø1,400 steel pipe just before DY 2.2. The DY 2.2 reservoir delivers water for only one pressure zone.

2.6.2.1. Construction and Activation Dates

From the sixteen reservoirs, only two of them is activated and their construction was completed. The following table show the physical realization of reservoirs [11]. (Table 2.18.)

Table 2.18 The Physical Realization of Distribution Reservoirs in Diyarbakır [11]

NAME of UNIT	Physical Realization (%)	Construction Date	Activation Date
DY 1.1 15,000 M^3 D. Reservoir (450 Evler)	55	1995	–
DY 4.1 15,000 M^3 D. Reservoir (Arıtma)	24	1995	–
DY 3.2 15,000 M^3 D. Reservoir (Karakuyu)	83	1995	–
DY 5.2 15,000 M^3 D. Reservoir (Talaytepe)	78	1995	–
DY 2.3 2,000 M^3 D. Reservoir (Silvan Yolu)	9	1995	–
DY 3.3 7,500 M^3 D. Reservoir (Silvan Yolu)	60	1995	–
DY 4.2 15.000 M^3 D. Reservoir (Silvan Yolu)	60	1995	–
DY 2.2 15,000 M^3 D. Reservoir (Bağlarbaşı)	92	1995	2001
DY 2.2 15,000 M^3 D. Reservoir (Kayapınar)	99	1995	2001

2.6.2.2. Size and Structure of Main Distribution Reservoirs

Main distribution reservoirs capacity and location was designed according to their topographic location, demand of water, supply energy for their own pressure zone and efficient entire life of project. All reservoirs are prismatic, reinforcement, and burial type; total volume capacity of reservoirs is 197,500 m^3. Numbers of reservoirs are sixteen but only two of them are used. The reservoirs are built in buried ground type. They are also two partitioned to avoid damages from water stress and fluctuations inside the reservoir.

As mentioned before the construction states of reservoirs, the following table is shown the size, base level, entering pipe level and death level of distribution reservoirs (Table 2.19).

Table 2.19 The Construction Structure Properties of Distribution Reservoirs in Diyarbakır [7]

RESERVOIRS	**VOLUME (M^3)**	**BASE LEVEL (M)**	**ENTERING PIPE LEVEL (M)**	**DEATH LEVEL (M)**
DY 4.1-1	15,000	759.80	763.25	758.00
DY 3.1	30,000	730.01	731.50	726.00
DY 5.2-1	15,000	793.05	795.25	790.00
DM- 1	5,000	766.72	769.50	765.00
DY 4.2	15,000	759.70	763.25	758.00
DY 2.2	30,000	685.75	688.35	683.35
DY 1	15,000	658.70	661.25	656.00
DY 2.3	2,000	687.59	690.00	686.00
DY 3.3	7,500	716.13	719.00	714.00

CHAPTER–3: APPRAISAL OF DİYARBAKIR WATER SUPPLY SYSTEM

Water has attractive effect on people’s life in other words, water increased quality of life. Most of the world suffers from inadequate water source and contamination of natural sources of water. The dispersion of drinking water is also unfair in that concern. Because of the water’s importance on life, people should use water with the most appropriate way.

The water supply system have significant place on the control of water usage. Water supply systems provide the collection, transmission, treatment, storage, and distribution of water for homes, commercial establishments, industry, and irrigation, as well as for such public needs as fire fighting.

Most part of the world, governments finance public water supply systems for public health. The government give work to municipality to establish and control water supply systems for residential areas. Water supply system project planning is depending on initially parting budget. In other words, water supply project must have economic feasibility to apply.

A completely satisfactory water distribution system should fulfil its basic requirements such as providing the expected quality and quantity of water during its entire lifetime for the expected loading conditions with the desired residual pressures. In that concern, the source and its reliability, quality of water, maintenance and operation costs of system have important roles when designing project of supply system. In appropriate systems, water must be delivered to supply zones without any shortage.

3.1. DESCRIPTION OF REGION

3.1.1. General

Diyarbakır is located in the area of Southeast and lay on 15.354 km^2. Centre of city is placed at 37° 55' north latitude and 40° 15' east longitude. Diyarbakır neighbouring cities are Batman and Muş at east; Şanlıurfa, Adıyaman and Malatya at east; Bingöl and Elazığ at north; Mardin at south [7].

3.1.2. History

The first civil community, 'Hurriler' scattered between Van Lake and North of Syrian at B.C. 3500. After this culture, Sumer-Akkadian Empire (coming from south) dominated at B.C. 2750. The area is the centre of Middle East therefore it was controlled by different societies. In order of history, this area was dominated by Urartian at B.C. 775; Assyrian between B.C. 736 to 754 and Persian Empire later on. After that, this area was fallen into Byzantine Empire power. In Caliph Ömer time, city was captured by army of Islam in 639. In 1042, the city was dominated by Malik Shah1 and connected to Seljuk Empire. Between 1097 and 1183 İnaloğulları controlled city. T hen Artuqid dynasty captured the city in 1183 then, White Sheep's Turkomans was taken it in 1394. In 1507, Safavid dynasty dominated city and the city had been controlled by Ottoman Empire at Çaldıran War, in 1515.

3.1.3. Geographical and Topographical Properties

Diyarbakır is flatness straight place, 650 m height from sea level, and at the east of Tigris River. City was established centre of the bowl area which turned round with high rise mountains and hills. This region is bordered at north with Southeast Taurus Mountains; at northwest with Maden Mountain (2230 m) which is the extension of one sequence of the Malatya Mountains; and at the northeast with long sequence İnceburun and Muşgüneyi Mountains. From the little south of this sequence, Uzuncaeski Mountain (1576 m) is continued by the intrusion to inside sections. The sequence of the Southeast Taurus Mountains is decreased towards to east, and increased with extinct volcano Karacadağ Mountain at the border of

Diyarbakır-Şanlıurfa. The highest point of Karacadağ is the Kolluba Hill (1957 m). The south of city is lower than 1000 m and like gentle floating area. General height is decreased to 500 m at the Tigris Valley base.

Tigris River and its branches is the important stream which passes from city borders. Tigris passes nearly all sides of the border of city at the northwest-southeast direction. At north Ambar and Pamuk creek; south Ballıkaya, Olucak brook with Göksu and Savur creek contribute to Tigris. Kulp and Aydınlık creeks are born from northeast mountains which joined and formed Batman creek. This creek contributes to Tigris at Hasankeyf.

The one-third occupied area of the city extends to Tigris and branches by the sequence. The largest one forms Diyarbakır plain. The main plains of those regions are Ergani plain at the right part of Tigris River in south part of Ergani; Diyarbakır, Göksu-Çınar, Şeyhhan Plain at the both sides of Ergani-Diyarbakır-Çınar Highway; and Batman-Silvan Plain at the left part of Tigris.

3.1.4. Climate

In this area, continental climate is dominated; summers are hot and dry, winters are cold, snowy and rainy. Fallings are seen especially in winters and spring terms. The longest season is autumn and shortest is spring. The heat difference between day and night is high in winter and summer term. In Diyarbakır, the muggy heats are experienced for four months because of the interruption of north winds by Southeast Taurus Mountains. The observations show that the hottest city is Diyarbakır at July and August in Turkey. Also, the low snow falling is seen in Diyarbakır. The average of snowy days is 7 in a year and snow falls between November and March.

The climatology station is being worked since 1929 and observed climate properties. Annually average temperature is 15,9 °C, known highest temperature was 46,2 °C(21.07.1937), known lowest temperature was -24,2 °C (11.01.1933) [7].

3.1.5. Geology

The Southeast Turkey (Anatolian) Basin is the most active and oil prone basin in Turkey and it is located on the northern extension of the famous oil prone of the Arabian Plate, where the geology is very similar to Northern Iraq and Syria. However, in the Diyarbakır city basin, the major reservoir and sources rocks are not as many as in the Arabian Plate. In Diyarbakır , the major source rocks are Dadas Shale and Late Cretaceous Carbonates and the main reservoir rocks are Late Paleocene and Late Cretaceous Mardin Carbonates and the Paleozoic sandstone of Bedinan and Hazro.

3.1.6. Earthquake State

For the data's of 'Turkey's Earthquake Regions Map', this was published by Ministry of Construction and Housing Earthquake Research Institute, project area and city centre of Diyarbakır including south part were in the fourth degree earthquake region. North part was in the third degree region.

In the last century, instrumental measuring data's showed four nearest major destroying earthquakes. The nearest of this was at the 73 km away from centre of Diyarbakır.

3.1.7. Underground Water

Underground water is deeper in general of Diyarbakır. Static water level is fluctuated between 15m – 40m in shallow areas at the deep boring logs. In the most part of city, underground water is much deeper. However along the Tigris valley, the underground water level is much higher.

3.1.8. Social and Economical State of the City

Diyarbakır region wasn't well educated generally. There is a university in the centre of city. Including Faculty of Medical and State Hospital, all healthy society exists.

Diyarbakır is one of the developed cities about economy in the Southeast Region. From ancient times, city was the important commercial centre but in 19 th century it was came to a stop.

Agriculture is the foundation of economical facilities. Field agriculture is dominant in this region and mostly grain production is made.

Nowadays city is backward than other cities about industrial activities. Petroleum is important underground richness. Petroleum, iron, lead, zinc, copper, phosphate, stone coal, and lignite beds are found in this region. Copper and chromium mines are operating.

Commerce of city is depending on amount of agricultural materials production and activity of market. Main trade materials are grains, animal and animal productions, almond and textile.

Important historical places found in borders of city. Diyarbakır Walls are the second longest walls of the world. Lots of civilizations were placed in Diyarbakır during the ancient time.

3.2. WATER SUPPLY SYSTEM OF CITY

3.2.1. Background of Water Supply System

The main water source was naturally formed as side spring called Gözeli. Water was collected from four galleries to unique centre and distributed. Not so long, the spring tapping structure is built. Once whole city demand was supplied by Gözeli and its flow was 350 l/s .

Because of the increased in population, Gözeli started to become inadequate and some deep wells were added to same area. Presently, twenty-one wells were opened and total production was 300 l/s. But near the well's area, uncontrolled and unplanned industrialization development with texture and texture paint, oil fabrics were established; these fabrics also discharged their wastewater without control. The wastewater passed nearby some wells and was caused to decrease in quality of drinking water. As the decrease in quality, the wells which were at the route industrial wastewater, were closed by DİSKİ General Management in August 2002 . Because of the out of serviced wells, the flow of source is increased to 400 l/s.

The old distribution network systems were built and separated to two zones. The first zone was restricted with level of 650 meters and fed from three sectioned reservoir by Ø 800 mm pipeline. From the same reservoir, water is transferred to elevated reservoir with two Ø 500 mm ACP (Asbestos Cement Pipes) and second zone was fed from this 1160 meter pipeline. Elevated reservoir's capacity was 500 m^3 and crest level was 713 m. The inner city network construction was started in 1972 and serviced sooner.

Existing network lines was finished in 1935 and consist of font type of pipes. Unfortunately, the top of those pipes were leaking water and they were unrecovered. In several times, additive networks constructed but their operation plans weren't exist and these pipes were also leaking and useless. Because of the old formation, water losses assumed more than % 50 in that time.

In that time, demand of water was supplied from Gözeli source about 250 l/s , from Serapgüzeli wells about 500 l/s and collected into the DM2 reservoir. Also 250 l/s was provided from other sources in the city (Alipınar, Anzele and İçkale) and transferred to network. The other wells, which are owned by official institution and personal, supplied 150 l/s. The total amount was 1150 l/s. After the maintenance of leakage at the pipeline of Gözeli source, added wells that opened from DSİ and the twelve wells which were opened at the east of Tigris River; the amount of water was increased to 1,700 l/s. The Figure 3.1 shows the schematic layout of previous water supply net [12].

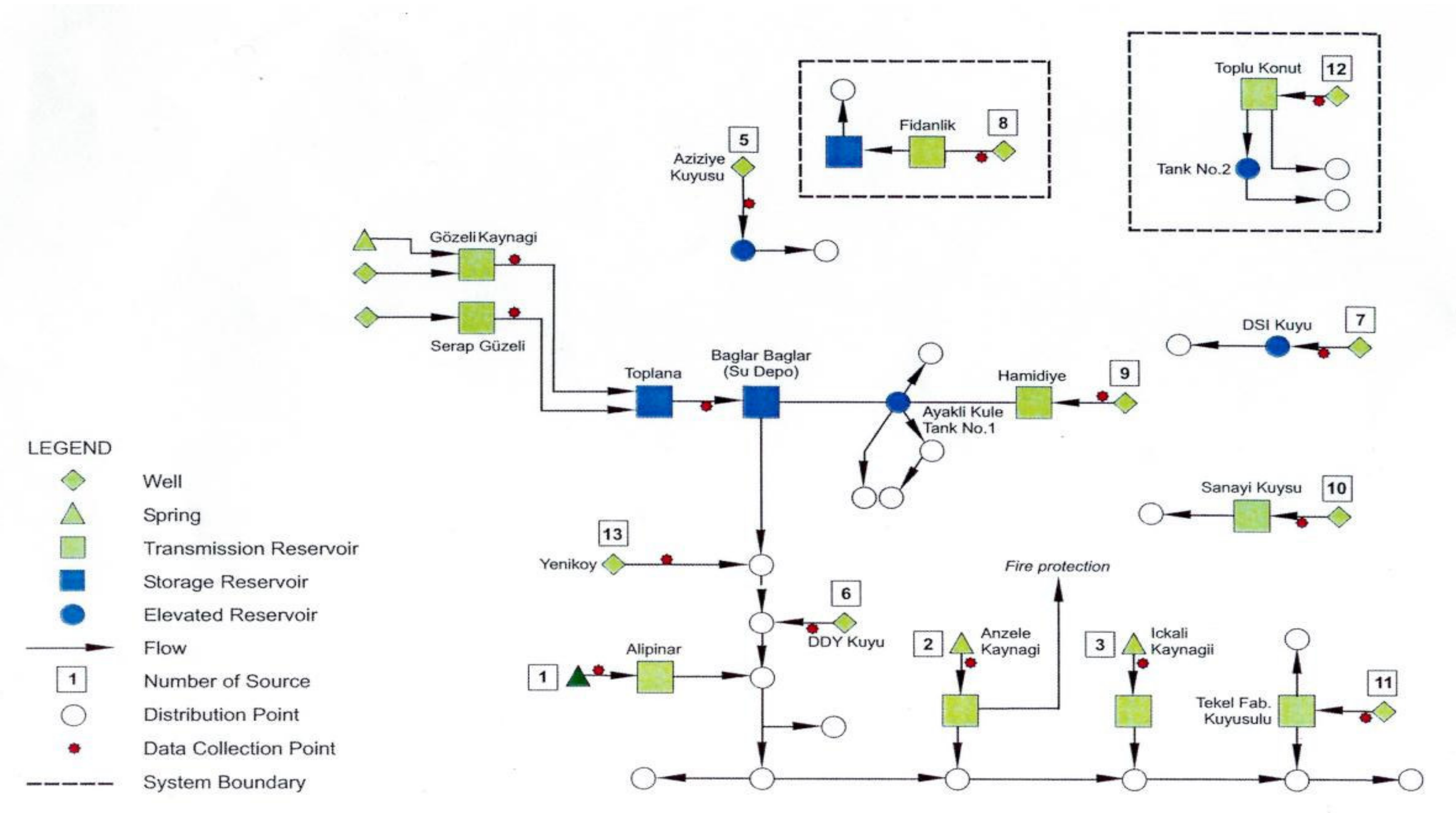

Figure 3.1 Schematic Layout of Previous DISKI Water Sources.

3.2.2. Present of Water Supply System

Diyarbakır Water Supply System Project was designed in two stages. First part is activated in 2001; project is met consumer's demand today. Second part will be come into service in the year of 2025. This new system supply purified water in limited drinking standards (TSE-266). The treated water standard is below the limited standards, so the quality of drinking water is very high.

The daily consumed water for each person projection that was taken into consideration with domestic, public, commercial usages and network losses; was thought gross and showed below Table 3.1 [7].

Table 3.1 Planned Water Demand Projection for Diyarbakır [7]

Year	**Population of Project (person)**	**Gross Consumed Water (l/p/day)**	**Total Demand for Project (m^3/s)**	**Total Demand for DSİ (m^3/s)**
1995	800.000	250	2,31	2,65
2000	930.000	270	2,91	3,04
2005	1,080.000	300	3,75	3,63
2010	1,250.000	300	4,34	4,58
2015	1,450.000	300	5,03	5,73
2020	1,680.000	330	6,42	7,11
2025	1,950.000	330	7,45	8,51
2030	2,250.000	330	8,59	9,86

Water Supply Project was designed to service for five municipalities which are in the borders of metropolitan municipality: Sur, Yenişehir, Bağlar, Kayapınar and Bağıvar. The following figures illustrate the regions of these municipalities and the structure of residential area of whole city. (Figure 3.2, and Figure 3.3.) Some 61% of the developed land within the Diyarbakır City limits is residential. Twenty seven percent (27%) is classified as government use. Six percent (6%) of the available land is dedicated to commercial use and five percent (5%) for industrial purposes [12].

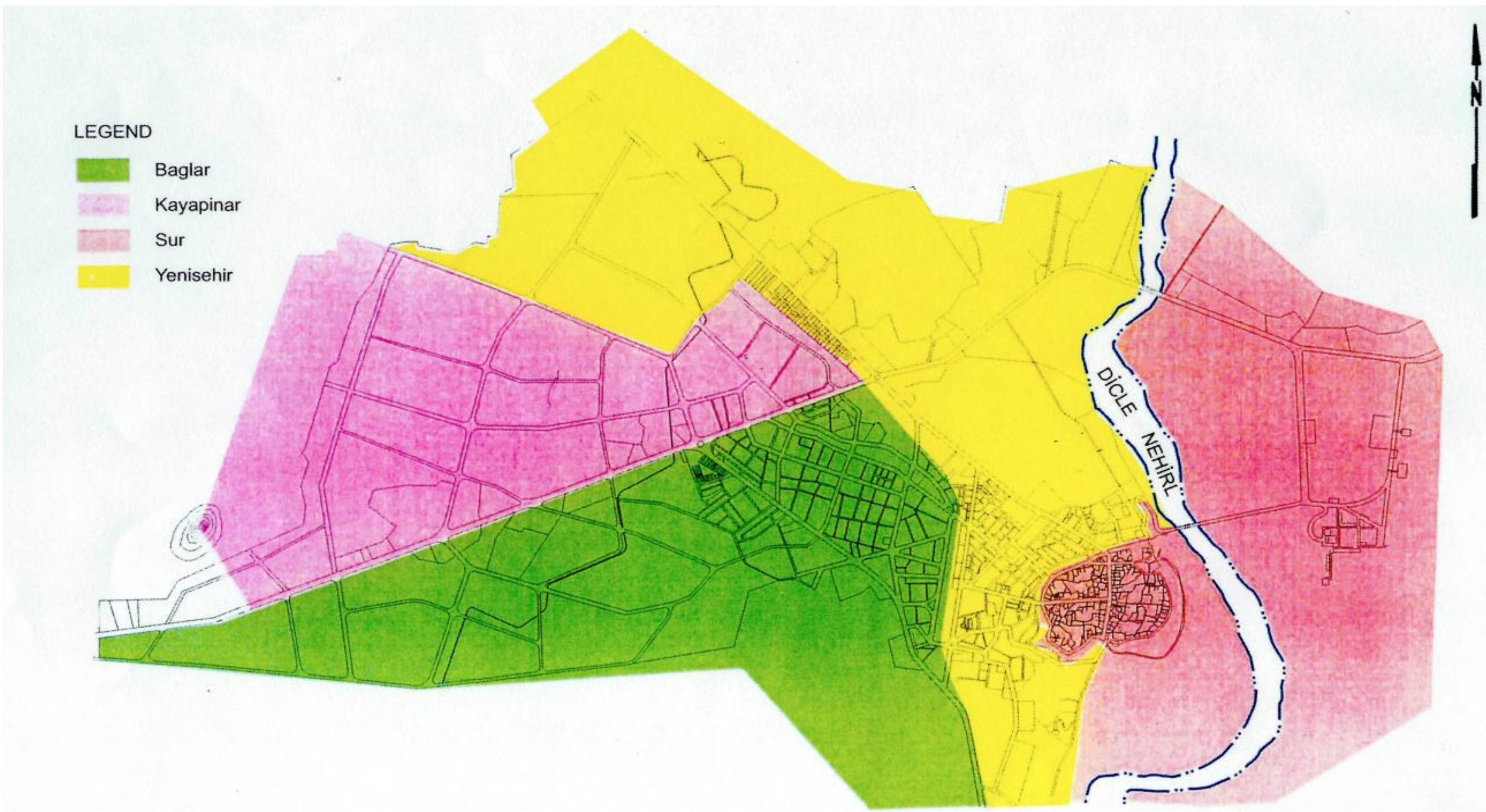

Figure 3.2 Municipal Boundaries.

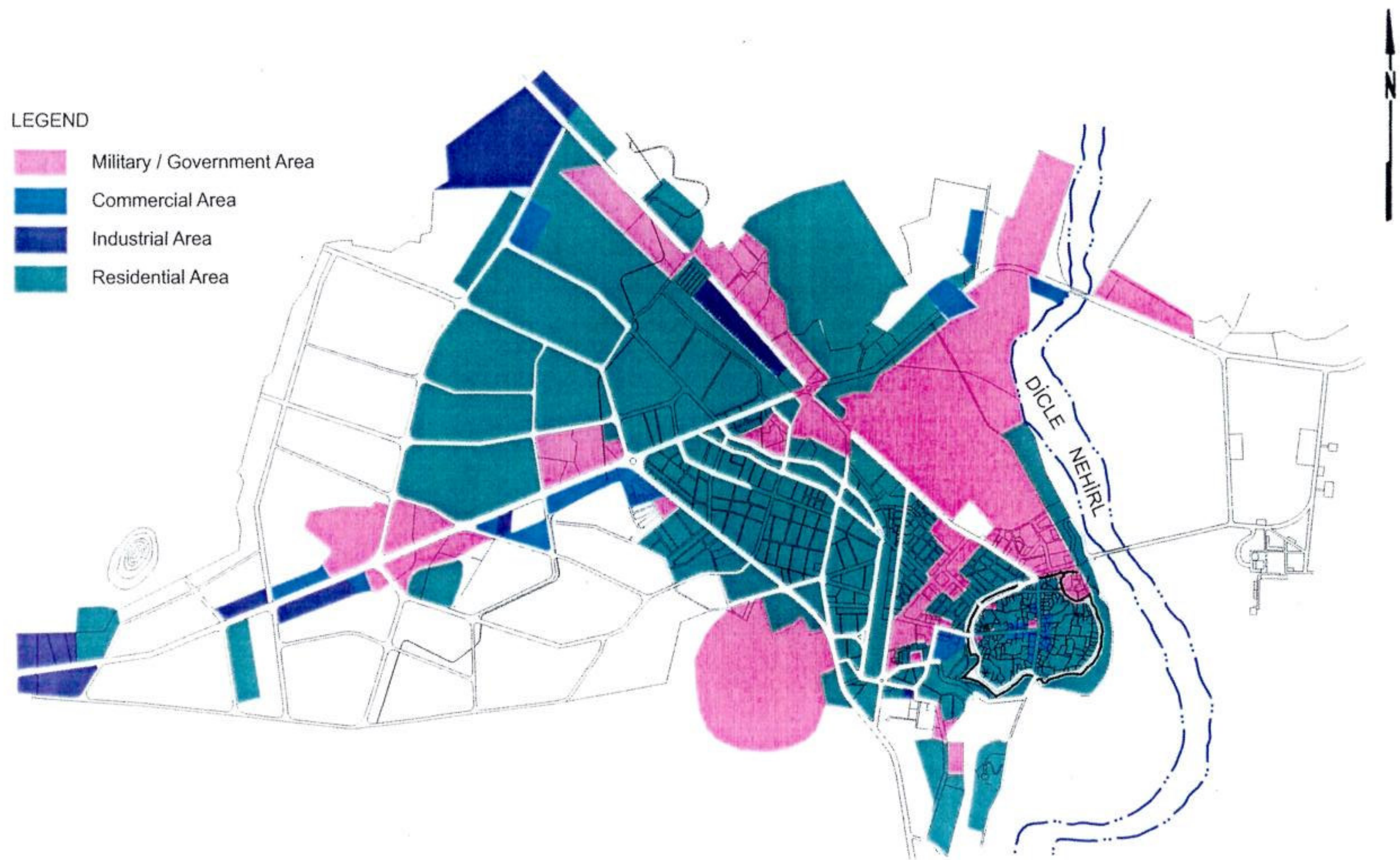

Figure 3.3 General Land Use.

The water supply project was designed in two stages. The design criteria's were based on İLLER BANK. The following Table 3.2 shows typical design criteria of İller Bank. The daily amount of consumed water for each person, including commercial and residential plants, was calculated 300 l/s/day for both 2010 and 2020; 330 l/s/day for both 2030. This amount was accepted same for all mounts. The hourly maximum consumption for network calculations was 1,5 times averages of flows. The fire flow was 20.00 l/s at main pipes, 10.00 l/s at base pipes and 5.00 l/s at secondary pipes. The network calculations were made by using dead point method. The pressure difference at the accepted dead points wasn't bigger from 2.0 m. The minimum operation pressure was 30.00 m and maximum static pressure was 80.00 m . Also usage of vanes and placement of fire hydrants were designed for İller Bank criteria's. Underground fire hydrants were placed with 150 m spacing on the network. Fire hydrants were found above the ground at the streets where important structures were in. The summary of project calculations is shown in the Table 3.3 [12, 7].

Table 3.2 İller Bank Sizing Criteria for Potable Water Systems [12]

Network Characteristics	**Fire Flows**			**Fire Quantity and Duration**			**Pressures**			**Zones**	
Future Population : N (35 years later)	Flow in Transmission Pipeline (l/s)	Flow in Main Pipeline (l/s)	Flow in Secondary Pipeline (l/s)	Fire Quantities at Same Time	Fire Duration (hours)	Fire Volume at Reservoir (m^3)	Minimum Operation Pressure (meters)	Maximum Operation Pressure (meters)	Minimum Pressure Difference at Dead Points (meters)	Size of Zones (hectares)	Minimum Diameters for Main and Secondary Pipelines in a Network (mm)
N=<10.000	5.00	5.00	2.50	1	2	36	20	80	1	20-30	Secondary Pipes 65-70 Main Pipes 80
10.001=N=<50.000	10.00	5.00	2.50	2	2	72	20	80	1	20-30	Secondary Pipes 80 Main Pipes 100
50.001=<N=<100.000	20.00	10.00	2.50	2	5	360	30	80	2	20-30	Secondary Pipes100 Main Pipes 125
N=>100.001	20.00	10.00	5.00	2	5	360	30	80	2	20-30	Secondary Pipes 100 Main Pipes150

Table 3.3 The Projection of Population and Water Demand for Diyarbakır [7]

		TOTAL NET WATER DEMAND									TOTAL AVERAGE WATER DEMAND		
YEARS	POPULATION	HOUSES		GOVERNMENT	INDUSTRY	TOTAL			LOSSE S			
	x1000 person	l/p/d	hm^3/a	hm^3/a	hm^3/a	l/p/d	hm^3/a	l/s	%	l/p/d	hm^3/a	l/s
1985	306	85	9494	2.100	1.250	115	12.844	407	50	230	25.688	814
1990	390	95	13.523	3.416	1.735	131	18.674	592	50	262	37.348	1,184
1995	902	105	34.569	7.901	7.572	152	50.043	1,587	40	253	83.405	2,645
2000	1,045	117	44.626	11.061	11.442	176	67.131	2,129	30	251	95.901	3,041
2005	1,211	130	57.562	12.818	15.470	194	85.751	2,719	25	259	114.335	3,626
2010	1,405	146	74.872	14.872	18.461	211	108.206	3,431	25	281	144.275	4,575
2015	1,629	160	95.133	19.027	21.405	228	135.565	4,299	25	304	180.754	5,732
2020	1,888	173	119.217	24.119	24.808	244	168.145	5,332	25	325	224.194	7,109
2025	2,188	180	143.751	28.750	28.750	252	201.252	6,382	25	338	268.336	8,509
2030	2,536					252	233.261	7,397	25	338	311.015	9,862

1-In the table above the population of year 2030 is estimated by DSİ estimation method; l/p/d =litre / person / day; hm3/a=$10^6 m^3$/year

After the second stage of project activated; the demand of 6,000 l/s is supplied from Dicle Dam with Ø1,600 mm pipeline. Then, raw water is treated at treatment plant and sent to DY3.1 reservoir. Water Treatment Plant's production planned capacity was 225,000 m^3/day at first stage of project and 510,000 m^3/day at second stage. The total discharge of water is 7,700 l/s which is supplied from both Dicle Dam and Gözeli Source.

The distribution system is divided into seven pressure zones and these zones are also divided sub-zones in their self because of topography of city. Consequently , network is divided seven main zones and ten sub-zones ; totally thirteen pressure zones which are 1, 2.1 , 2.2 , 2.3 , 3.1 , 3.2 , 3.3 , 4.1 ,4.2 , 5.1 , 5.2 , 6.2 and Kayapınar [7]. (Table 3.4)

Table 3.4 Characteristic of Network Zones in Diyarbakır Pipe Network [7]

Network Zone	**Area (ha)**	**Density (person/ha)**	**Maximum Level (m)**	**Minimum Level (m)**
1	522	155	621.00	567.00
2.1	164	250	650.00	612.60
2.2	881	300	652.00	605.00
2.2(withPRV)	10	300	616.00	552.30
2.3(withPRV)	250	62	660.00	568.00
3.1	733	238	695.80	642.30
3.2	528	225	695.00	651.00
3.3	60	200	685.30	655.00
4.1	665	210	724.00	688.00
4.2	679	140	724.00	693.50
5.1	428	200	765.00	720.00
5.2	898	205	760.00	721.00
6	160	200	795.20	755.50

The laying pipes of network are 372,517 meters at first stage and 562,864 meters at second. Table 3.5 shows the diameter and length of laying pipes [7].

Table 3.5 Laying Pipes in Diyarbakır Network [7]

Diameter of Pipe (mm)	**First Stage (m)**	**Second Stage (m)**	**Total (m)**
100	204,937	372,463	577,400
125	34,331	65,870	100,201
150	30,246	52,651	82,897
200	20,180	25,044	45,224
250	12,336	11,772	24,138
300	9,719	11,477	21,196
350	8,379	4,057	12,436
400	6,882	8,097	14,979
500	4,056	4,363	8,419
600	5,018	2,004	7,022
700	7,641	1,263	8,904
800	4,921	685	5,606
1000	5,302	3,118	8,420
1200	7,008		7,008
1400	11,531		11,531
TOTAL	**372,517**	**562,864**	**935,381**

In the project, there were 16 reservoirs that planned to construct; 12 of them was in first stage and remaining 4 was in second stage. The north of city is in the third level earthquake region and south part is in the forth region. The reservoirs except TDY1 were constructed for D3 region (Earthquake Region 3), TDY1 was constructed for D4 region. All reservoirs are prismatic, reinforcement, and burial type; total volume capacity of reservoirs is 197,500 m^3. The Table 3.6 shows the technical details of reservoirs [7].

Table 3.6 Technical Details of Distribution Reservoirs in Diyarbakır [7]

Resevoir	**Pressure Zone**	**Construction Stage**	**Volume (m^3)**	**Base Level (m)**	**Entering Pipe Level (m)**	**Crest Level (m)**
DY1	1	I	15,000	658.70	661.25	656.00
DY2.2	2.1	I	30,000	685.75	688.35	682.85
DY2.3	2.3	I	2000	687.69	690.00	686.00
DY3.1	3.1	I	30,000	729.00	730.50	725.00
DY3.2	3.2	I	15,000	730.68	731.50	726.25
DY3.3	3.3	I	7,500	715.13	719.00	714.00
DY4.1-1	4.1	I	15,000	759.80	763.25	758.00
DY4.1-2	4.1	II (2020)	10,000	760.00	763.00	758.25
DY4.2	4.2	I	15,000	759.70	763.25	758.00
DY5.1-2	5.1	II (2020)	20,000	793.00	795.25	790.00
DY5.2-1	5.2	I	15,000	793.05	795.25	790.00
DY5.2-2	5.2	II (2020)	15,000	793.00	795.25	790.00
DY6-2	6	II (2020)	3,000	815.00	816.50	812.00
DM1	Kayapınar	I	5,000	766.72	769.50	765.00
TOTAL VOLUME (m^3)			**197,500**			

Today only two reservoirs are used for supplying. The inner structures of these reservoirs (DY3.1 and DY2.2) are illustrated in Figure 3.4 and Figure 3.5.

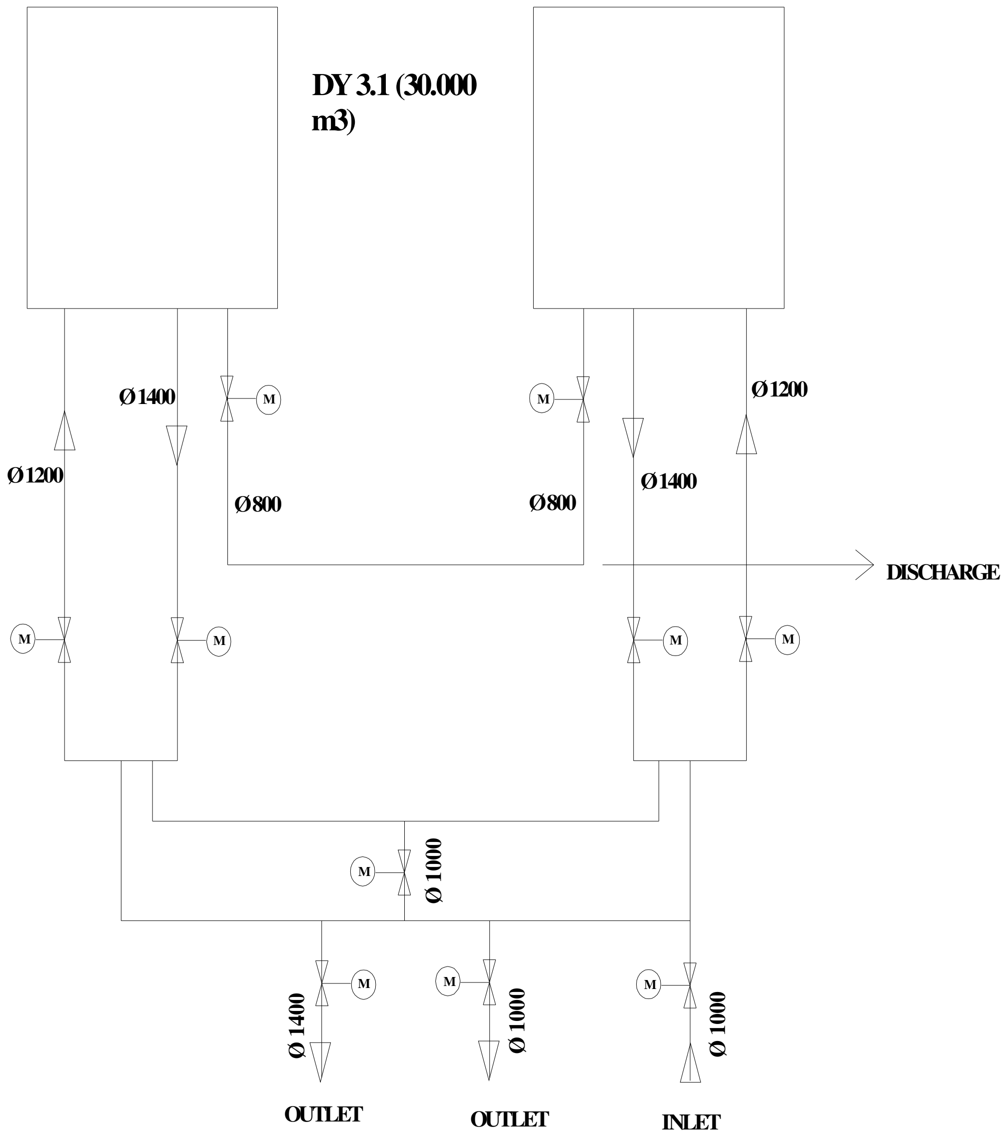

Figure 3.4 Inner Structure of DY3.1 Reservoir.

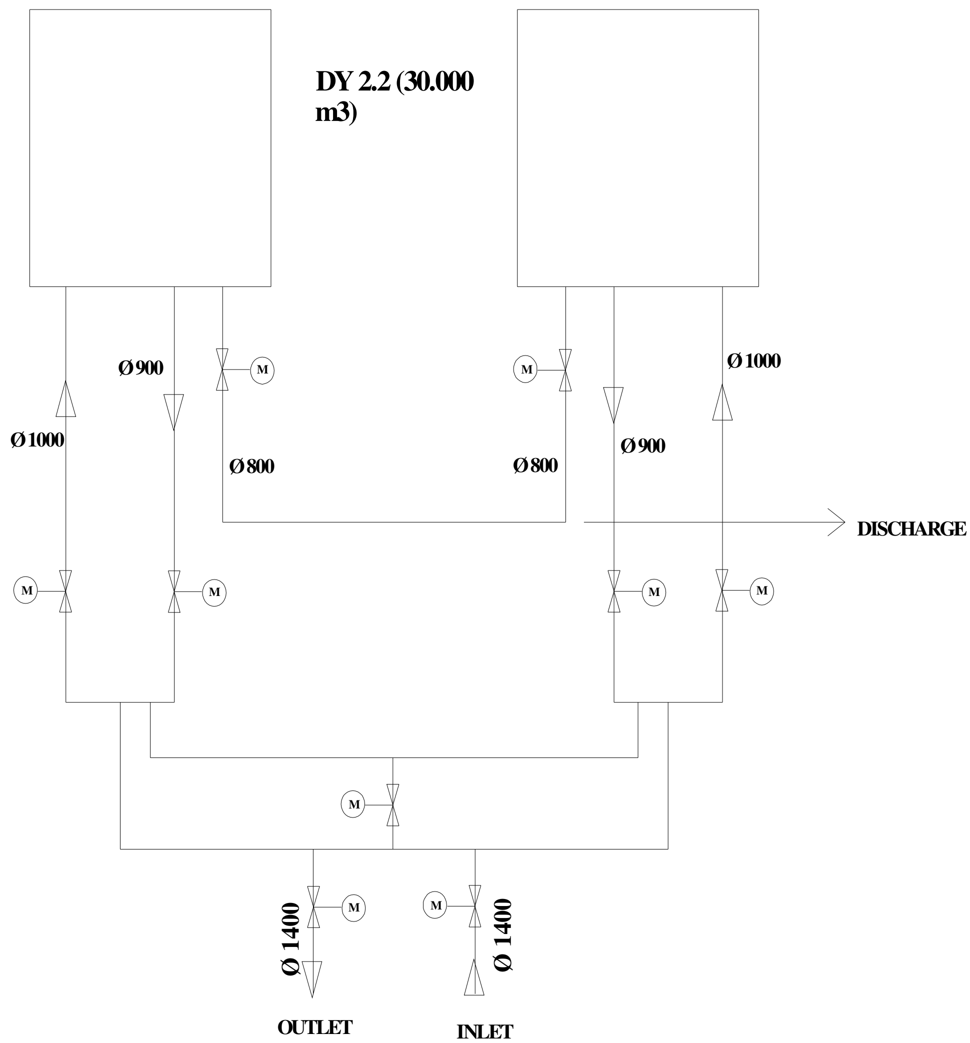

Figure 3.5 Inner Structure of DY2.2 Reservoir.

At supply net, there is 940 vanes in total; 85% of them is diameter of Ø 100 mm and rest of them are change between diameter of Ø 150 mm to Ø 1000 mm.

CHAPTER–4: ADMINISTRATION AND CONTROL OF DİYARBAKIR WATER SUPPLY SYSTEM

In this part of thesis, the administration of Diyarbakır water supply system is being inspected. Historically water and sewerage services in Diyarbakır have been managed internally by the Greater Municipality. In 1995 the Diyarbakır Büyükşehir Belediyesi Su ve Kanalizasyon İdaresi (DİSKİ) was formed as a private semi-autonomous utility. DİSKİ is responsible for providing water and wastewater services for Greater Municipality. DİSKİ service areas are composed of Bağlar, Yenişehir, Sur and Kayapınar regions. The objectives of DİSKİ's for clean water were construction of a new supply; water treatment plant; and new water distribution facilities: replace the older existing system, improve system pressure, and expand the system to newly developed areas.

The proper systems needed effective control mechanisms for delivering water to consumers without any shortage. In addition, these mechanisms also give chance to prevent water losses from supply systems. The recent works in the supply net displays that the programs, which are operating with geographical information systems, have advantages about managing and controlling network. In a city, the water must be supplied for different kinds of uses such as commercial, industrial, domestic, and public. The water distribution system should provide also a stable hydraulic grade to provide enough pressure and water to serve for emergency conditions. Therefore, both operating and administration of system must work efficiently.

In Diyarbakır, GIS (Geographical Information System), MIS (Management Information System), MAPINFO, SCADA (Supervisory Control and Data Acquisition) and Oracle Database programmes are used by DİSKİ (Diyarbakır İçme Suyu ve Kanalizasyon İdaresi). Firstly, DİSKİ established SCADA in Water Treatment Plant in 2001 for monitoring amount of raw water inflow to plant and treated water outflow from plant. After that, MapInfo and GIS were started to set on the boundaries' of DİSKİ's network system. The completion of GIS is provided using MIS with GIS database. Finally SCADA installed for water distribution network at pilot region and still continue to install other parts.

This chapter present general operation system of these programmes in Diyarbakır Supply Net:

4.1. GIS (Geographical Information System) and MIS (Management Information System)

GIS is any system for capturing, storing, analyzing and managing data and helping collection and monitoring of spatial data's. GIS is a tool that allows users to create interactive queries (user created searches), analyze the spatial information, edit data, maps, and present the results of all these operations. GIS helps to manage the flow of water and wastewater to service residential and commercial areas. GIS technology is used to track the location and condition of water mains, valves, hydrants, meters, storage facilities, sewer mains, and manholes. A majority of water/wastewater utilities use GIS technology to integrate all kinds of information and applications with a geographic component into one, manageable system. GIS allows you to organize, manage, and distribute geographic information culled from various databases while maintaining data integrity and focusing on project direction.

GIS can be used to closely model utility networks and integrate other related types of data and CAD drawings. GIS spatial selection and display tools allow users to visualize scheduled work, ongoing activities, recurring maintenance problems, and historical information. The topological characteristics of a GIS database can support network tracing and can be used to analyze specific properties or services that may be impacted by such events as stoppages, main breaks, drainage defects, and so on. Dynamic segmentation can also be used to derive a generalized network to make pressure and flow analysis algorithms run more efficiently [13].

The general definition of MIS which is a planned system of collecting, storing and disseminating data in the form of information needed to carry out the functions of management. In water networks, MIS is especially used with GIS database and contains settling map which is obtained from satellite. This map involves coordination's, height of constructions, number of story, population of living people in the building, subscriber's number of drinking water, position and connections of waste water net, phone and electricity connections, maintenance-age- type of used materials at water and waste water system and so forth. Consequently, MIS is a developed database program that registers all kind of information's and achieves interrogation.

The loss reduction is another usage causality of MIS, because you can get every detail of pressure zones which you are interested in from this database. For example : population ; demand of water ; operating pressure ; amount of chlorination ; number of buildings and subscribers ; number of public departments , parks-gardens, school, hospital, alms house, business firms information's could be gathered from MIS. All these information's give chance for planning sufficient quantity of water to pressure zone ; prolonging the operating system with taking details of every single parts of supply system ; and planning maintenance activities. GIS-MIS system capable to set when and what type of maintenance activity of equipment is made and when it should change while supply system is operating.

DİSKİ manage GIS-MIS database in effective way and the following figures (Figure 4.1 ; 4.2 ; 4.3) were taken from these databases.

Figure 4.1 is the settling map of Muradiye Region which is taken from GIS database. The small table shows some information's about this region.

Figure 4.2 is related to MIS database and shows the building information's of selected building with number 2.

Figure 4.3 is also taken from MIS database and illustrates the subscriber's information's of selected building with number 15.

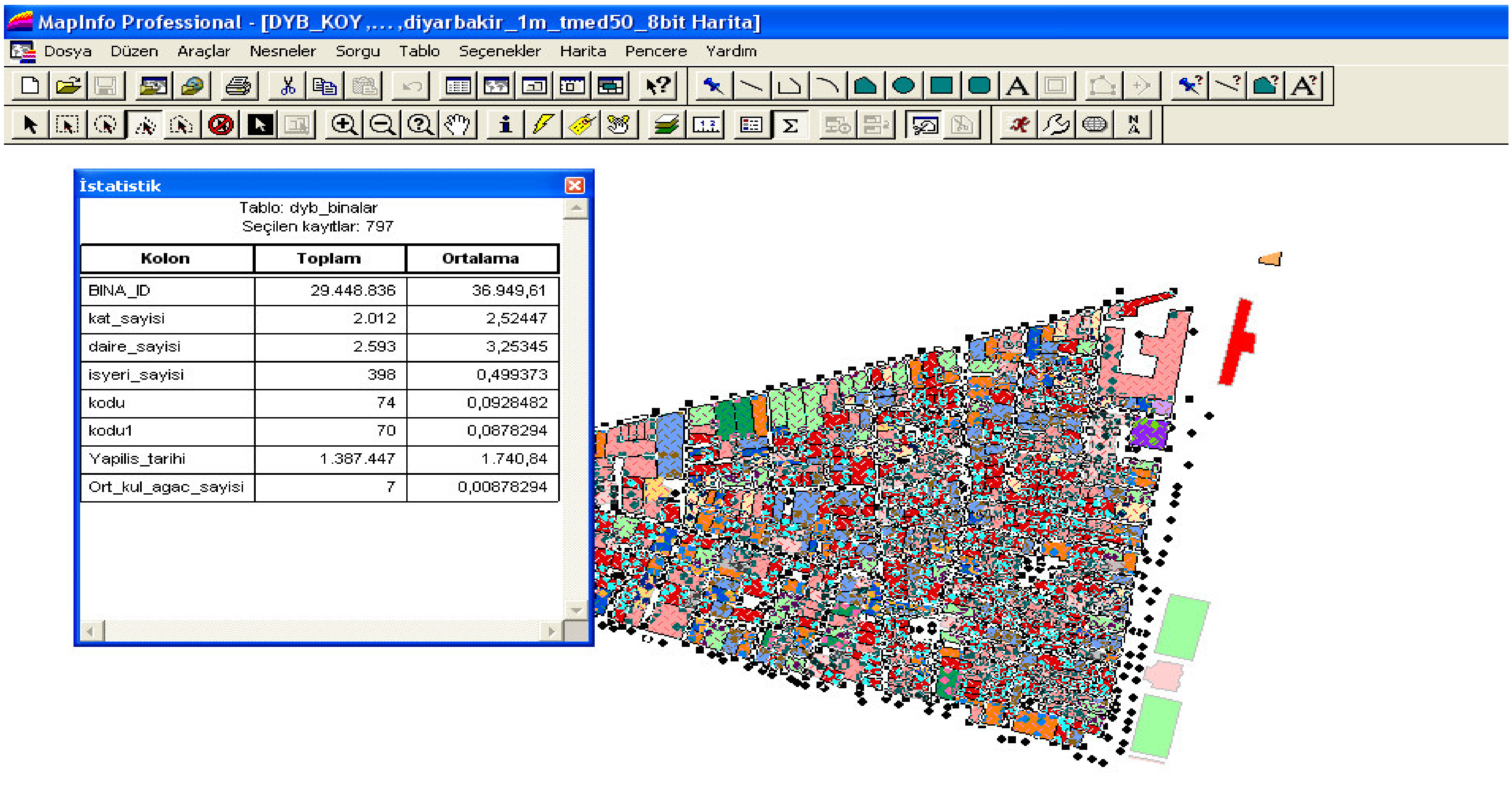

Figure 4.1 Settling Map of Muradiye Region.

Figure 4.2 Building Information's.

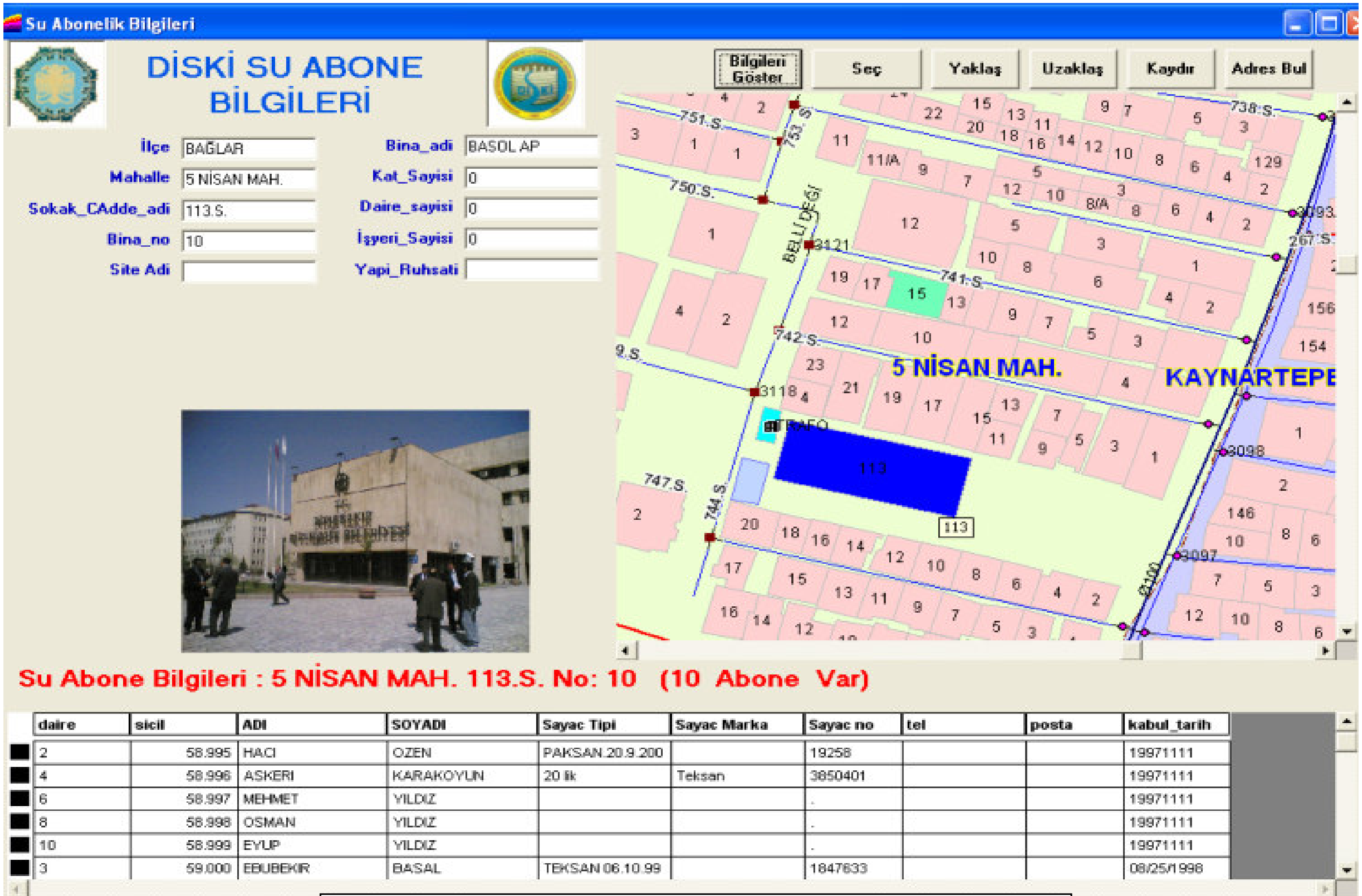

Figure 4.3 Information's of DİSKİ's Subscribers.

4.2. SCADA (Supervisory Control and Data Acquisition)

SCADA is a computer based system for monitoring, visualisation and telemetry control of water and sewage networks, waterworks, clean and waste water treatment plants. Working principle of SCADA is that collecting the information's from remote control units, transferring it back to the central site, carrying out any necessary analysis and displaying that information's on a number of operator screen or displays. The required control actions are then conveyed back to process. The components of the SCADA system communicate via LAN/WAN networks, radio data network, phone or GSM modems. Typically, there are three major elements that make up a SCADA system:

1. The master terminal unit (MTU)
2. The remote terminal unit (RTU)
3. The communications equipment

Remote Terminal Units (RTU): It is used for data collection and administration, visualisation, process control and plant management. Remote terminal units gather information from their remote site from various input devices, like valves, pumps, alarms, meters, etc. Many remote terminal units hold the information gathered in their memory and wait for a request from the MTU to transmit the data [13-17].

Master Terminal Unit (MTU): The heart of the system is the master terminal unit (MTU). The master terminal unit initiates all communication, gathers data, stores information, sends information to other systems, and interfaces with operators. The major difference between the MTU and RTU is that the MTU initiates virtually all communications between the two. The MTU also communicates with other peripheral devices in the facility like monitors, printers, and other information systems [14-17].

Communications Equipment: Communication equipment is required for bi-directional communications between an RTU and the MTU. This can be done through public transmission media or atmospheric means. SCADA systems are capable of communicating using a wide variety of media such as fibber optics, dial-up, or dedicated voice grade telephone lines, or radio [14-17].

SCADA system for water supply net and treatment plant was started to use since 2001 in Diyarbakır. The size and complexity of the network, as well as high level of water leakage, necessitates the operation of the network by the aid of advanced technologies. Implementation of a supervisory control and data acquisition (SCADA) system is intended to improve the efficiency and utility of the operation, maintenance, and management of the water distribution system.

The main purpose of DİSKİ is to install a SCADA system which will be established as a computer-based centralized management system to monitor and control of potable water production, purification, distribution stations which are located within a geographically wide area, within the borders of the city of Diyarbakır, where the Administration is responsible for operation and maintenance. SCADA for distribution network was started to establish in 2006 and workings still keep going on [18].

The purposes of establishing SCADA are:

1. Realization of a real time coordination among the stations based upon the concept of supervisory monitoring and control.
2. The operational ease and reliability which comes with the supervisory monitoring and control.
3. Savings in time, fuel, and manpower, by minimizing the daily duties of the personnel responsible for the maintenance and control of the stations.
4. Avoiding the delay in the response from failures by immediately being notified of such failures, thus minimizing the water supply interruption or water loss.
5. Control of the reservoir levels and alleviation of flooding.
6. Savings in time and equipment by minimizing the failures resulting from negligence.
7. Automatic implementation of essential precautions by sensing the potential failures ahead of time.

8. The ease of adding new stations to the SCADA system.
9. Structured and reliable storage of statistical information about the stations.
10. Provide continuous and adequate water distribution to the existing consumers at high with quality standards.
11. Realization of more reliable, practical, and economical operational management.

The headquarter system is established to DY3.1 Water Reservoirs Operation Building and central computers are also installed in this department which are used for monitoring, control and communication. The data's of SCADA are taken from flow-pressure-chlorine meters that are installed at measuring chambers on the main supply pipes for distribution. The data's are read momentary from flow-pressure-chlorine meters and transferred to RTU by a basic cable ; again with a cable from RTU it is transferred to hand radio ; then from radio signals, the data's are reached to main central radio. This time beginning the adverse, from the radio to main computer the codes are solved and data's are received as measurements of flow-pressure-chlorine.

Diyarbakır's supply zones are divided into 13 sub-zones; also these sub-zones are divided in their selves to sub-zones. Bağlar Region is the biggest and distorted settling area of Diyarbakır. Nearly, 500,000 people lived in that region and it consist of both slum area and new zoned area. The old part of Bağlar is much distorted and the amount of water loss was incredibly higher than other regions. So, SCADA was firstly started to use in Bağlar Region. Bağlar is composed of 23 sub-zones and 15 of theme's installation were completed. The second installation part of city is Yenişehir and workings are going on.

The following figures were taken from Unit of SCADA. Figure 4.4 is the photo from satellite which shows the whole water system of Diyarbakır. Figure 4.5 is the schematic layout of SCADA stations in Diyarbakır. Figure 4.6 shows the RTU connections of SCADA. Figure 4.7 illustrates DY3.1 reservoir and connections of reservoir and water level is seen in this photo. Figure 4.8 is one the station of SCADA which is called Seyrantepe Station.

Figure 4.4 Satellite Map of Diyarbakır.

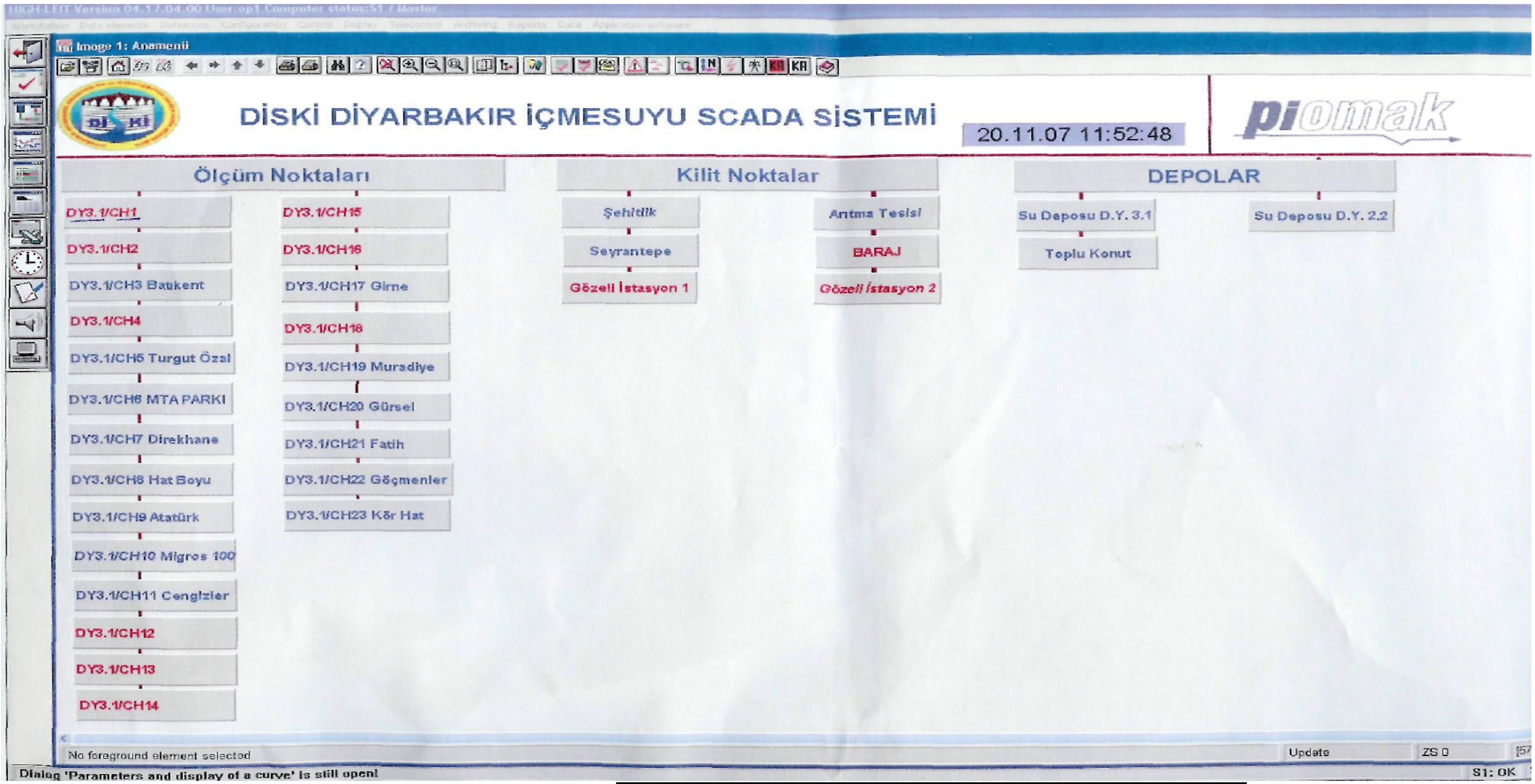

Figure 4.5 Schematic Layout of SCADA Screen.

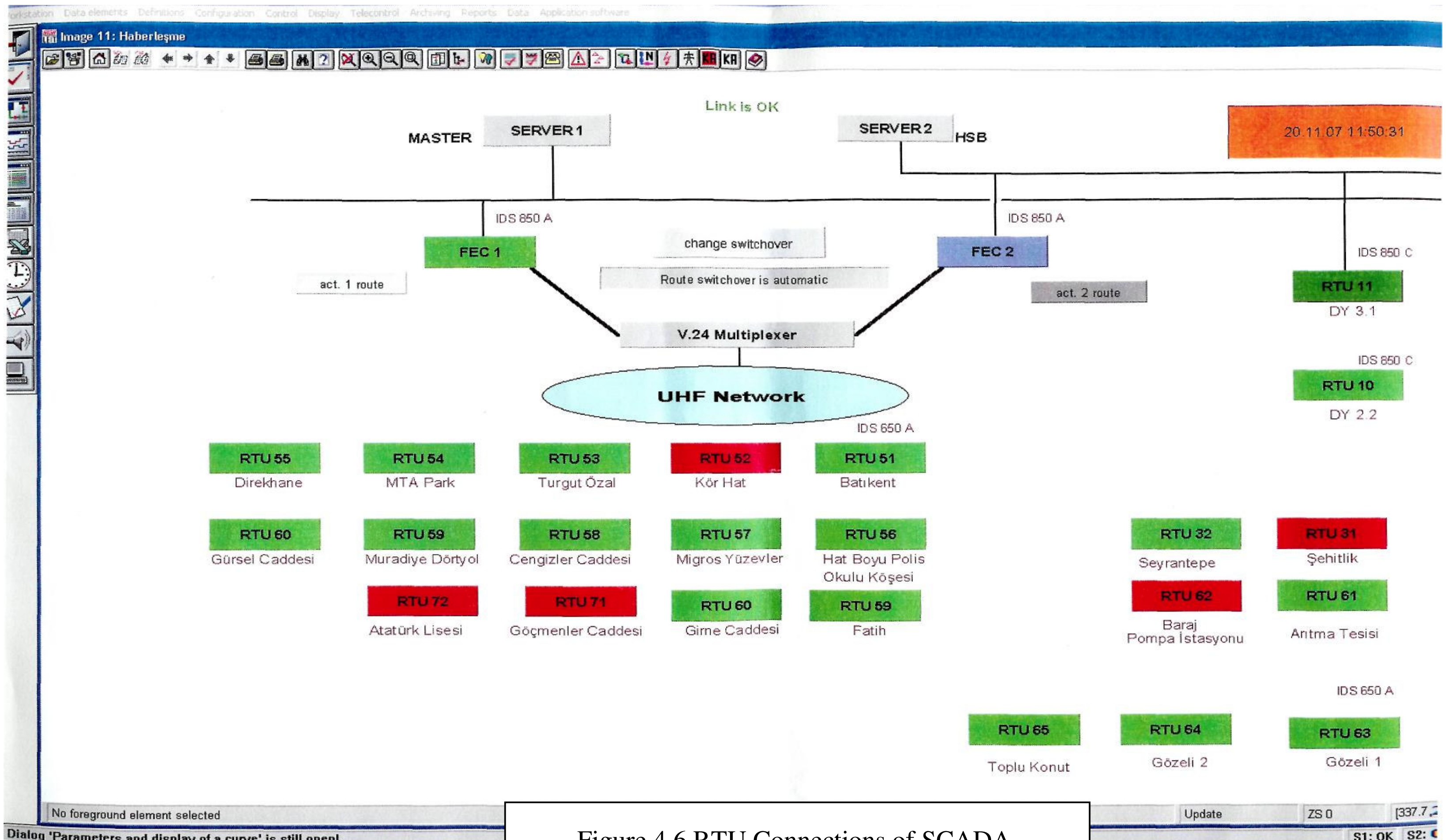

Figure 4.6 RTU Connections of SCADA.

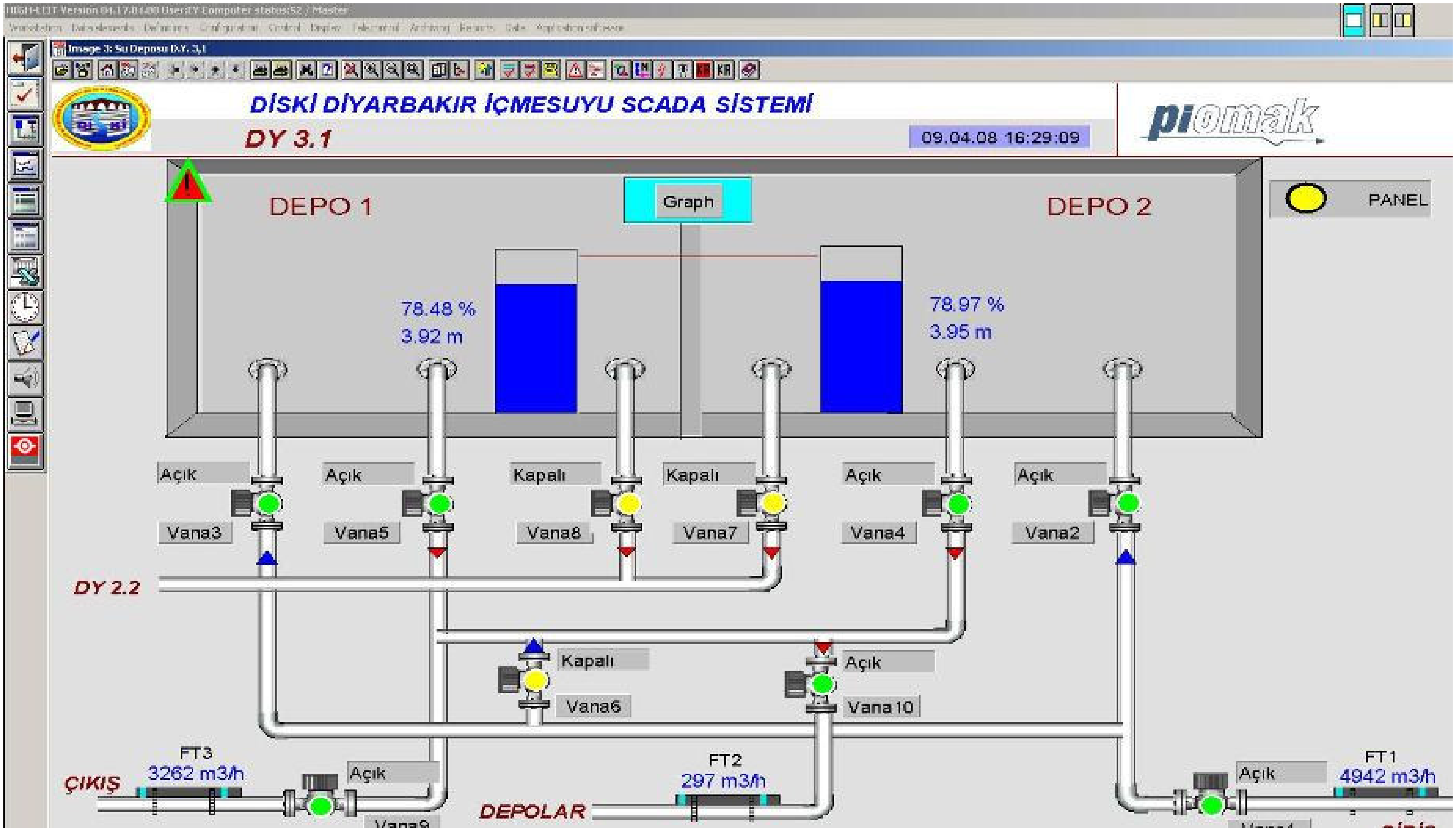

Figure 4.7 DY3.1 Reservoir (30,000 m^3).

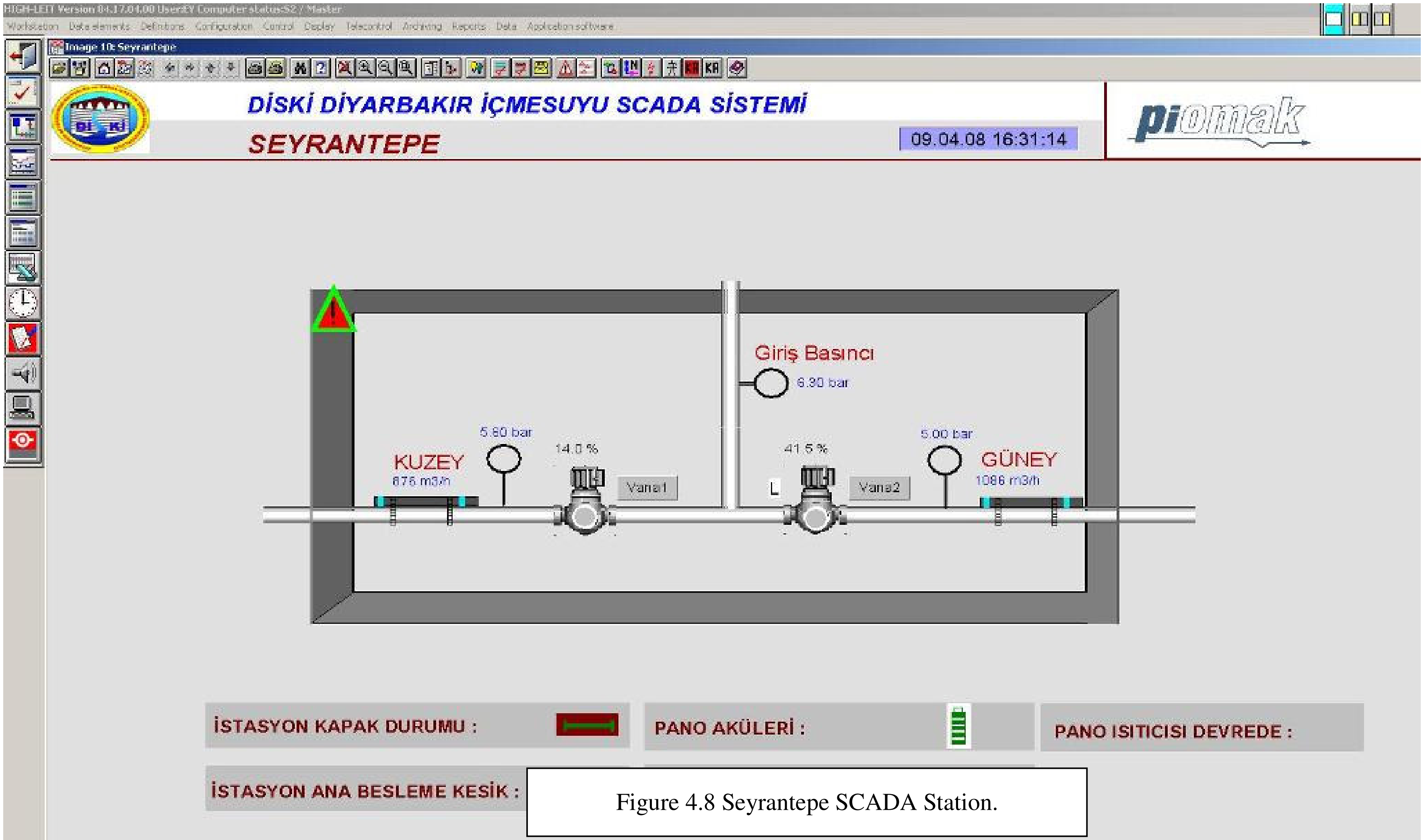

Figure 4.8 Seyrantepe SCADA Station.

CHAPTER 5: ANALYSIS OF PILOT REGION MURADİYE QUARTER IN DİYARBAKIR SUPPLY SYSTEM

Water comes from two different sources Gözeli Basin and Dicle Dam in Diyarbakır Supply Net. The raw water is pumped to plant and raw water is treated in treatment plant which was come into service 2001. Treated water is delivered to main distribution reservoirs and supply zones by gravity. The supply area is divided into main six supply zones and main zones are also divided to many sub-zones. There are 16 distribution reservoirs in that project. The total capacities of reservoirs are 197,500 m^3. The total laying pipes of supply net is nearly 452 km. The SCADA and GIS database were established in supply net and the workings are still going on.

The completed region is selected to realize the system of water supply net and monitories the amount water loss in particularly. Muradiye is one of the active fifteen stations of SCADA. The data’s of SCADA is also help to realize water distribution line of this pilot region. Muradiye was selected as a pilot region to control of unaccounted water. GIS and MIS workings firstly were started from Muradiye. Monitoring movement of water was especially simple in Muradiye because of one main feeding point. In MIS database the European Standards was applied. In other words, the streets and building were entered-numbered one by one. Normally, streets and buildings are used with their names in Turkey both government and municipal facilities. This type of information caused some misunderstandings and in European Standards city’s streets and buildings coded with numbers to avoiding that. Muradiye Quarter was designed to European Standards in MIS database. So that, you can easily reach the information’s using with building number in MIS database and monitor the subscriber’s information, consumed water and building characteristic which is shown in Figure 4.2 and Figure 4.3.

In this chapter, Muradiye Quarter will be gone to investigate which is found in Bağlar Region of city Diyarbakır. The amount of water loss will be calculated and allocation of water losses will be conducted such as ‘physical loss’ and ‘administrative loss’ (non physical). As before mentioned the structure of Bağlar Region is both consist of slum and new developed areas and nearly 500,000 people lived in and also the biggest part of city. From here Bağlar is reflected whole city's general situation. Muradiye is chosen which is small portion of Bağlar Region and render an opinion of city supply system to us for monitor whole city.

Muradiye settling is generally founded with old shanty houses and narrow streets. Before the recent workings, the management and control of municipal facilities in that region was very difficult because the number of settling houses, streets, and people was also unknown within the distorted urbanization. The leakage of water was very high in that region cause of older existing pipeline system.

5.1. INTRODUCTION OF MURADİYE QUARTER

Muradiye is a quarter of Bağlar Region. Muradiye consists of both residential (2593) and commercial (398) places. There is no park, mosques, public department and school in that region. Some information's of Muradiye is given in Table 5.1 Muradiye's population is between 15,000 to 17,000 ; nearly more than 5 people live in a single house. The approximate population is :

$$P_{MURADIYE} = P_{RESIDENTAL} + P_{COMMERCIAL} \quad \ldots\ldots \quad (5.1)$$

$$P_{MURADIYE} = 2593 \times 6 + 398 \times 3 = 16.752$$

Table 5.1 Information's of Muradiye Quarter

Population of Muradiye	16.752
Area of Muradiye	0.166 km^2
Numbers of Subscribers	2501
Numbers of Residential Place	2593
Numbers of Commercial Place	398
Numbers of Valves with Diameter Ø100	28
Numbers of Valves with Diameter Ø150	3
Numbers of Valves with Diameter Ø200	2
Length of Laying PVC Pipes with Diameter Ø100	4624.77 meters
Length of Laying ACP Pipes with Diameter Ø150	1080.52 meters
Length of Laying ACP Pipes with Diameter Ø200	655 meters

The following Figure 5.1 is the pipeline and settling view of Muradiye Quarter.

Figure 5.1 Muradiye Quarter’s Outlook.

5.2. MONTHLY WATER CONSUMPTION OF MURADİYE SUBSCRIBER'S

In this part, the amount of consumed water for Muradiye showed in Table 5.2, which was taken from Subscriber Accruement Service of DİSKİ. The data's are monthly consumed values of Muradiye Subscribers.

Table 5.2 Statistical Data's of Monthly Consumed Water

Date	Amount of Consumption (m^3/month)
December/2006	16,742
January/2007	17,334
February/2007	15,138
March/2007	18,581
April/2007	19,391
May./2007	19,379
June/2007	24,070
July/2007	24,682
August/2007	26,871
September/2007	25,700
October/2007	25,442
November/2007	21,188

The following figure (Figure 5.2) is illustration with graphic method that the monthly consumption of Muradiye Quarter.

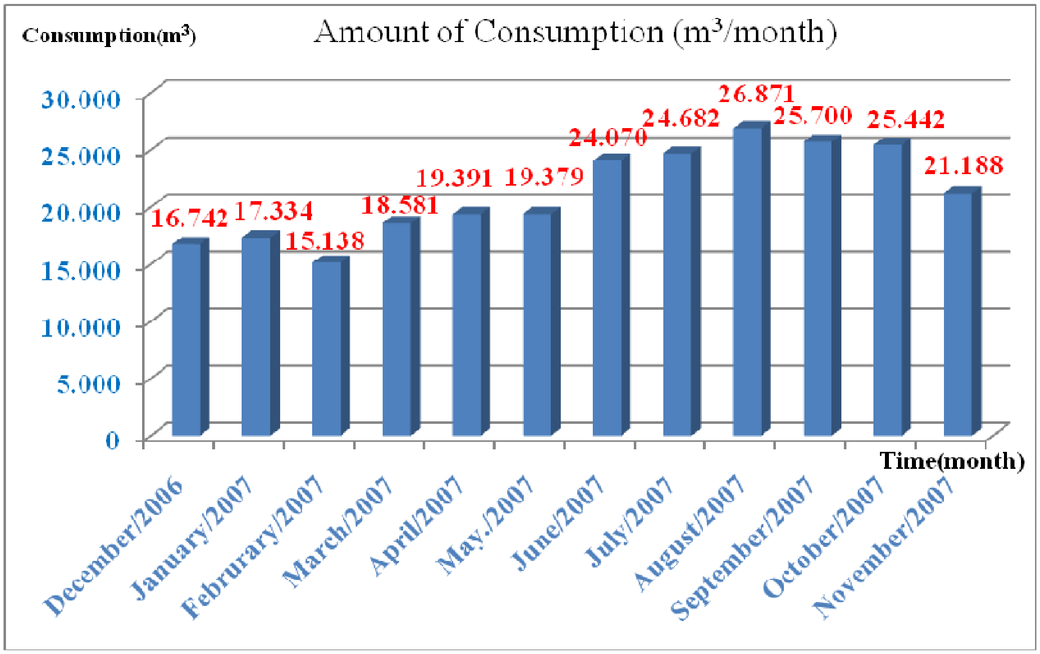

Figure 5.2 Montly Consumption Graph of Muradiye.

Generally, for a person that supply his life and biologic necessities minimum 25 litres of water must be consumed. The characteristics of subscriber's have effective behaviour on amount of consumed water. Although the modern healthy people must consume 150 litres in every day for their drinking, washing and cooking. The average water for daily consumption in the world, is 266 litres for industrialized countries ; 67 litres for Africa ; 143 litres for Asian ; 158 litres for Arabian countries ; 184 litres for Latin American countries. In Turkey, average daily consumption for each one is 111 litres. The annually consumption of a person must be minimum 8,000-10,000 m^3 to say that water richness country. In Turkey, annually consumption for each is 1,430 m^3 and in opposition to supposed Turkey is not water richness country. The sources must have been used in most effective way.

For Diyarbakır water supply project, DSİ (Devlet Su İşleri) and İller Bank made two different analyses uses their own estimated population projections for daily consumption. The following table is the summary of these calculations. (Table 5.3)

Table 5.3 Planned Water Demand for Diyarbakır Water Supply System [7]

DSİ			**İLLER BANK**		
Year	**Population**	**Consumed (l/p/d)**	**Year**	**Population**	**Consumed (l/p/d)**
1985	306,000	230			
1990	390,000	262			
1995	902,000	253	1995	800,000	250
2000	1,045,000	251	2000	930,000	270
2005	1,211,000	259	2005	1,080,000	300
2010	1,405,000	281	2010	1,250,000	300
2015	1,629,000	304	2015	1,450,000	300
2020	1,888,000	325	2020	1,680,000	330
2025	2,188,000	338	2025	1,950,000	330
2030	2,536,000	338	2030	2,250,000	330

As seen from Table 5.3 the water consumption values were very high for standards. These values were calculated with feasible leakage from pipeline. The amount of loss was expected nearly 25 %; also these values were the total of residential, commercial, and industry consumptions for one day.

In accordance with these information, the daily consumption for residential must be obtained. The annually consumption values were found at Table 5.3, hence using those values; average daily water consumption could be evaluated. The daily consumption of Muradiye subscriber is calculated with the following formulas:

$$Q_{Annualy} = 254.518 \quad m^3/year$$

$$Q_{Monthly} = \left(\frac{254.518}{12}\right) = 21.210 \quad m^3/month$$

$$Q_{Daily} = \frac{Q_{Monthly}}{30} = \frac{21.210}{30} = 707 \ m^3/day = 707000 \quad lt/day$$

5.3. SCADA DATA OF MURADİYE REGION

SCADA establishment were finished in September of 2007. The fifteen station installation is completed. The data's were started to read in September but some software problems occurred at same time. After the adjustment, the data's were more reliable. The region of Bağlar was the first part of the SCADA programme activation and Bağlar is divided into twenty-three station. Muradiye was one of these stations.

The Figure 5.3 is the view of Muradiye Station in SCADA screen. As seen from Figure, you can observe pipeline pressure and flow every second. The maximum flow and pressure of day- night in hours can also be seen from this screen. The stations gates, panel batteries, panel heater, main station supply connections, invertors charge malfunction are the other parameters that can easily control from this screen.

The main computer of SCADA is collected readings and saved in long term. In accordance with this information, SCADA helps to obtain reliable statistics of long term analysis about city water supply. Now, the daily water consumption at 24 hour in Muradiye is shown Table 5.4. From table the maximum consumption is seen between 10 o'clock to 17 o'clock; and 123,48 m^3/h at 13 o'clock. The minimum consumption is 79,05 m^3/h at 1 o'clock pm. The average daily consumption is 98,11 m3/h. The Figure 5.4 is the graph of daily consumption at 24 hour in Muradiye.

The inlet pressure data's are recorded at every 15 minutes in 24 hours where can be seen in Table 5.5. The minimum pressure is 2.36 bar ; the maximum is 4.13 bar. The Figure 5.5 is the graph of inlet pressure at every 24 minute in 24 hour.

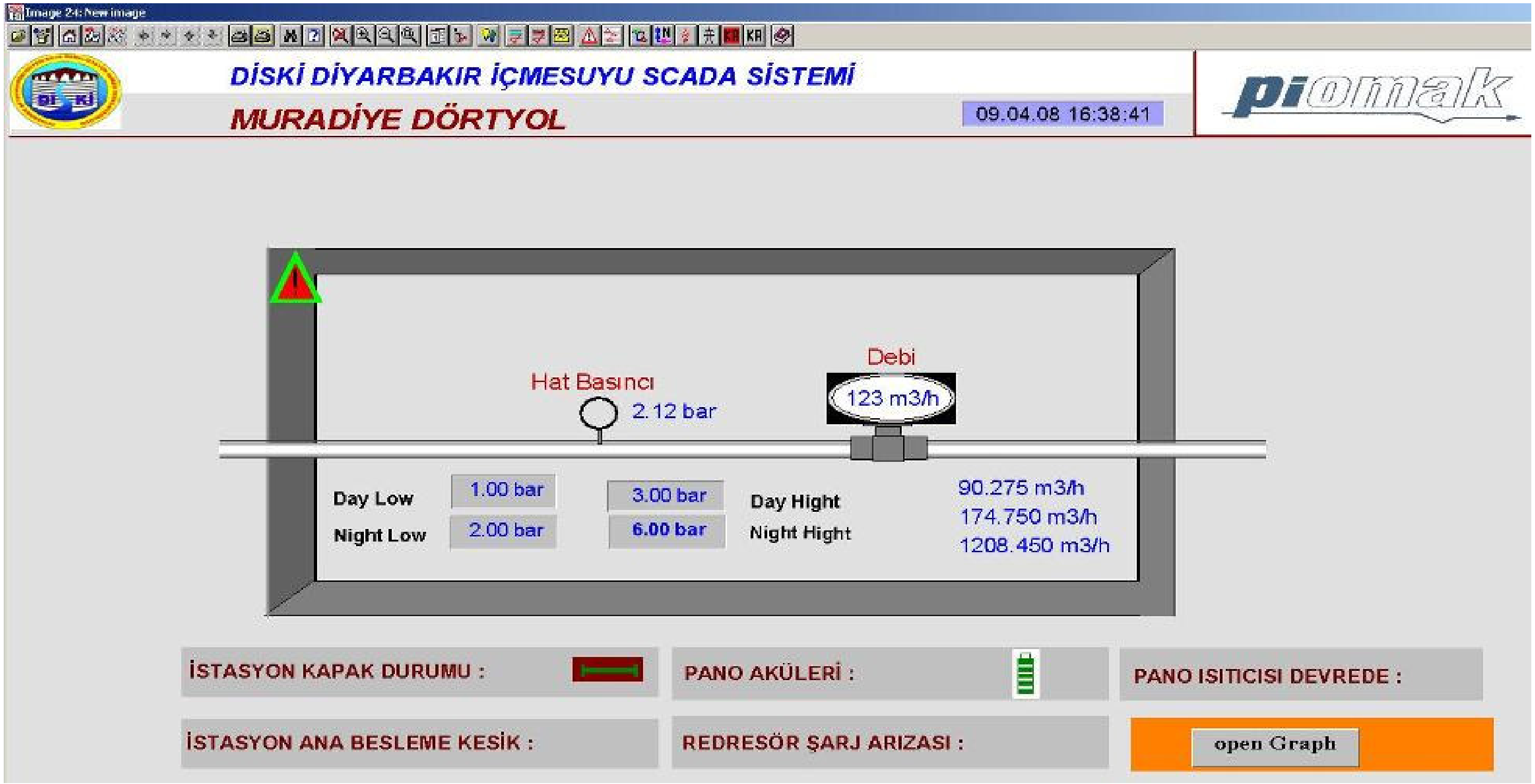

Figure 5.3 Muradiye Station Outlook in SCADA

Table 5.4 24 Hour-Flow of Muradiye

08/04/2008			
Time (hour)	**Flow (m^3)**	**Time (hour)**	**Flow (m^3)**
01:00	79,05	13:00	123,48
02:00	81,73	14:00	118,70
03:00	84,55	15:00	112,65
04:00	83,08	16:00	108,80
05:00	83,03	17:00	101,10
06:00	87,03	18:00	97,45
07:00	87,48	19:00	96,80
08:00	89,23	20:00	100,00
09:00	98,20	21:00	96,58
10:00	106,30	22:00	94,78
11:00	113,63	23:00	96,15
12:00	119,93	00:00	94,95
Sum	**2354,63**		
Average	**98,11**		
Minimum	**79,05**		
Maximum	**123,48**		

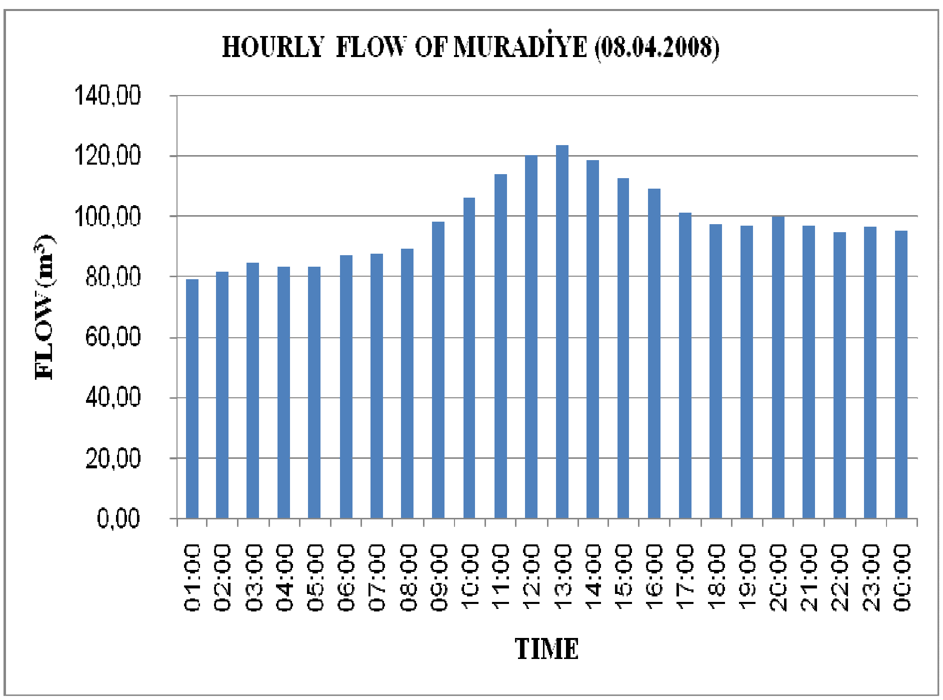

Figure 5.4 Graph of 24 Hour Flow.

Table 5.5 Pressure Values at 24 Hour

08/04/2008							
TIME	**PRESSURE (BAR)**	**TIME**	**PRESSURE (BAR)**	**TIME**	**PRESSURE (BAR)**	**TIME**	**PRESSURE (BAR)**
00:15	2.38	06:15	3.72	12:30	2.91	18:30	2.49
00:30	2.39	06:30	3.70	12:45	2.90	18:45	2.5
00:45	2.37	06:45	3.57	13:00	2.96	19:00	2.42
01:00	2.44	07:00	3.50	13:15	2.95	19:15	2.36
01:15	2.58	07:15	3.45	13:30	3.00	19:30	2.36
01:30	2.84	07:30	3.41	13:45	3.02	19:45	2.42
01:45	3.12	07:45	3.45	14:00	3.08	20:00	2.5
02:00	3.43	08:00	3.46	14:15	3.19	20:15	2.52
02:15	3.77	08:15	3.44	14:30	3.27	20:30	2.57
02:30	3.96	08:30	3.92	14:45	3.32	20:45	2.64
02:45	3.99	08:45	3.93	15:00	3.36	21:00	2.64
03:00	4.02	09:00	3.85	15:15	3.36	21:15	2.70
03:15	4.06	09:15	3.81	15:30	3.45	21:30	2.72
03:30	4.08	09:30	3.62	15:45	3.51	21:45	2.73
03:45	4.08	09:45	3.55	16:00	3.57	22:00	2.7
04:00	4.08	10:00	3.48	16:15	3.55	22:15	2.74
04:15	4.11	10:15	3.41	16:30	3.24	22:30	2.73
04:30	4.13	10:30	3.31	16:45	2.72	22:45	2.75
04:45	4.11	10:45	3.18	17:00	2.71	23:00	2.78
05:00	4.06	11:00	3.11	17:15	2.73	23:15	2.81
05:15	4.04	11:15	3.03	17:30	2.71	23:30	2.84
05:30	3.99	11:30	3.02	18:00	2.54	23:45	2.95
05:45	3.93	12:00	2.99	18:15	2.43	00:00	3.03
06:00	3.91	12:15	2.94	**Maximum = 4,13**			
				Minimum = 2,36			

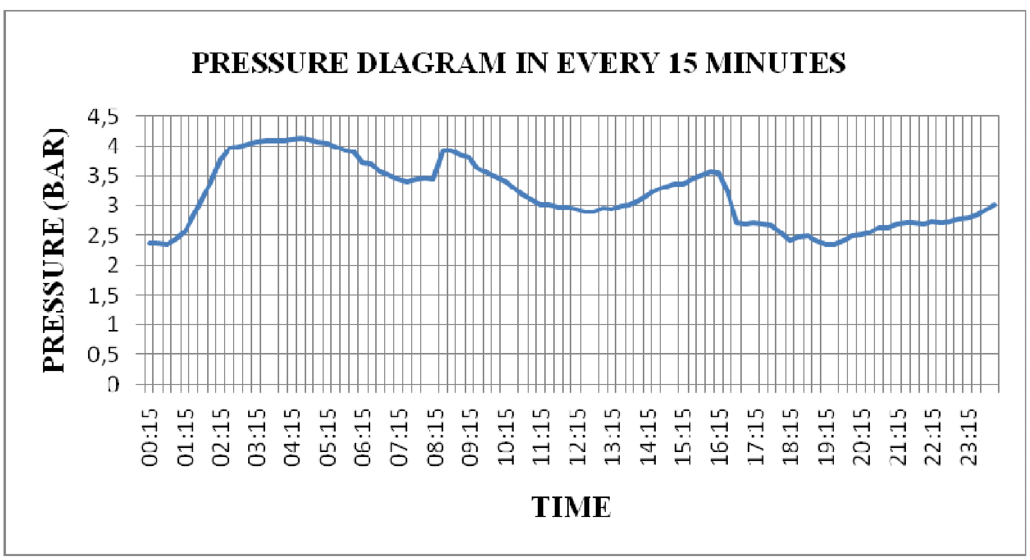

Figure 5.5 Graph of Pressure at 24 Hour.

5.4. MONITORING CONSUMPTION OF MURADİYE REGION

The standard daily water consumption for each is 111 litres in Turkey for the statistics. In the part 5.3, the average daily water consumption for Muradiye is 98,11 litres and is acceptable in the concern of Turkey general consumption value.

In this part, data's were assessed which were taken from SCADA, GIS, and Subscriber Accruement Service of DİSKİ.

First, Table 5.4 is the water consumption of Muradiye in March / 2008. The hourly and total daily consumption values can be seen from this table. The total supplied water is 72.361 m^3/ month in March. So that, the monthly supplied water for Muradiye is equal to:

$$Q_{SCADA} = 72.361 \ m^3/\text{month}$$

Table 5.6 Muradiye Region in Hourly Terms of Monthly Water Consumption

Day \ hour	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	00:00	TOTAL
01.03.2008	89,83	82,05	76,93	74,75	74,88	91,10	90,43	95,75	105,90	117,68	133,13	143,45	144,88	140,50	132,33	131,95	123,95	126,43	119,85	118,95	115,23	111,50	100,43	92,63	2634,45
02.03.2008	88,48	81,25	76,63	72,98	72,70	89,25	85,83	89,95	98,33	111,10	127,20	138,10	144,10	142,35	73,33	0,00	116,75	138,45	133,25	128,10	119,98	115,80	108,13	97,05	2449,05
03.03.2008	88,73	80,10	78,13	74,43	75,55	90,73	92,53	96,70	101,48	110,78	116,85	120,80	123,08	119,65	118,23	111,58	115,98	119,63	113,93	119,73	112,70	109,65	105,83	91,58	2488,30
04.03.2008	82,93	77,28	74,13	73,53	73,00	89,05	91,83	97,95	103,73	118,68	123,43	126,80	125,25	128,13	131,00	122,25	121,00	119,93	113,78	119,18	108,90	101,18	95,40	84,28	2502,55
05.03.2008	71,63	53,05	44,15	37,15	12,40	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	218,38
06.03.2008	0,00	0,00	0,00	0,00	0,00	24,20	89,93	113,55	116,15	117,03	117,10	116,35	117,90	116,45	115,28	115,05	114,73	110,85	113,90	113,90	113,35	107,55	103,13	98,58	2034,95
07.03.2008	94,40	97,23	106,43	104,38	99,80	116,58	115,75	114,20	117,10	118,25	117,65	120,55	117,53	116,18	117,38	115,33	114,28	116,25	113,78	114,50	112,28	110,78	108,45	97,65	2676,65
08.03.2008	89,55	84,73	79,20	77,13	77,40	95,23	96,75	101,10	111,68	114,63	115,95	116,63	118,20	118,98	117,88	117,65	113,00	112,90	112,18	112,23	112,20	112,00	113,40	101,10	2521,65
09.03.2008	90,93	80,05	75,85	72,38	75,05	92,95	93,53	96,03	56,75	42,40	131,13	129,30	126,58	113,20	23,70	33,68	117,73	144,43	132,43	132,55	126,78	124,45	120,95	107,20	2339,98
10.03.2008	94,73	86,60	81,05	78,45	78,08	95,35	99,78	102,70	107,80	112,93	117,58	121,95	125,45	120,88	122,05	122,65	122,53	118,18	118,03	112,83	114,65	113,35	111,13	93,00	2571,68
11.03.2008	87,35	79,48	74,30	74,75	74,18	92,30	93,03	103,33	113,20	119,05	135,58	138,75	128,18	129,25	117,90	130,65	131,28	113,95	113,78	113,18	109,28	108,80	99,15	89,13	2569,78
12.03.2008	87,35	81,15	77,48	75,85	76,98	93,40	94,48	85,55	91,25	113,88	113,63	114,50	121,13	115,13	115,43	117,50	114,63	113,05	112,45	112,63	109,63	108,90	110,50	93,93	2450,35
13.03.2008	85,08	78,90	75,28	74,28	74,83	91,68	95,28	98,25	104,08	110,85	115,50	116,58	117,88	117,80	109,03	22,23	30,65	32,53	121,35	149,50	128,65	117,00	116,15	92,03	2275,33
14.03.2008	85,30	77,58	75,00	73,18	74,15	93,15	93,00	97,20	104,75	114,43	34,23	38,03	40,98	42,38	43,48	147,68	156,95	139,73	129,75	125,55	119,68	111,95	103,80	92,68	2214,55
15.03.2008	86,08	79,13	76,15	71,50	72,65	88,88	86,50	94,50	100,55	110,25	118,70	119,23	118,88	119,40	114,53	112,13	115,33	111,68	112,40	112,60	110,63	107,28	96,93	95,68	2431,53
16.03.2008	90,40	77,88	73,85	71,93	72,18	86,20	84,73	92,95	100,55	108,53	115,10	114,68	115,58	116,85	116,08	115,40	109,45	102,73	95,33	98,18	102,88	113,35	116,13	105,33	2396,20
17.03.2008	97,40	81,75	78,05	74,33	75,00	91,93	93,90	98,65	106,58	112,43	115,48	113,10	117,55	118,53	116,45	112,55	113,08	113,50	115,48	113,45	105,40	104,10	107,15	88,58	2464,38
18.03.2008	83,48	77,10	72,70	72,78	75,15	87,75	91,00	94,63	102,43	112,78	126,85	114,63	121,00	120,93	131,18	126,23	114,80	116,18	110,55	103,70	104,00	96,43	89,25	80,68	2426,15
19.03.2008	76,55	75,68	77,23	74,68	74,43	91,08	91,00	96,80	101,78	108,80	115,30	117,48	117,68	117,83	113,15	116,43	111,80	111,55	108,70	110,25	106,05	103,60	102,48	91,55	2411,83
20.03.2008	84,85	77,70	72,88	71,70	73,78	88,10	91,33	93,03	103,65	115,45	119,38	135,33	133,40	129,45	122,15	107,80	112,60	117,80	113,50	107,88	102,78	98,28	92,05	84,45	2449,28
21.03.2008	86,38	80,08	74,58	72,60	75,13	90,93	91,55	96,40	101,55	114,18	111,83	114,10	115,70	115,90	113,80	108,98	108,23	112,10	111,55	108,73	107,85	103,23	105,75	91,28	2412,35
22.03.2008	83,63	75,60	72,65	72,38	73,48	86,58	90,20	95,65	102,18	111,50	117,35	121,55	120,65	119,78	117,18	113,43	113,63	114,93	112,65	111,80	110,83	108,28	106,03	94,63	2446,50
23.03.2008	87,30	79,25	73,90	71,53	73,73	88,33	88,05	96,18	107,23	115,95	125,60	128,58	130,53	131,40	125,90	107,33	111,03	113,00	110,10	110,40	110,08	107,13	96,63	90,93	2480,03
24.03.2008	90,53	83,70	79,68	76,13	77,25	96,15	96,28	103,23	109,45	111,13	117,95	121,13	119,90	116,55	115,83	115,85	115,75	114,48	112,13	110,28	106,18	93,83	79,55	84,50	2447,38
25.03.2008	92,98	83,38	76,25	74,98	76,30	93,78	97,00	100,65	111,15	90,23	49,45	53,05	49,55	49,85	56,45	61,50	184,28	150,53	137,55	127,38	123,43	120,53	109,33	96,43	2265,95
26.03.2008	84,20	75,98	72,28	69,98	70,90	87,10	95,65	100,45	109,63	121,13	132,65	117,30	119,73	117,18	69,13	111,90	110,98	109,28	108,85	96,70	88,48	83,63	79,10	81,65	2313,80
27.03.2008	86,25	76,00	70,63	68,08	70,60	86,95	91,93	94,63	105,00	113,65	119,98	124,40	125,40	123,95	120,65	114,18	110,85	112,00	109,85	99,23	85,23	69,05	64,48	56,48	2299,40
28.03.2008	66,35	71,73	77,43	75,85	74,25	88,65	88,88	95,05	102,48	101,63	108,55	113,15	110,75	109,40	108,55	114,23	109,13	108,30	105,35	106,60	106,18	103,23	100,23	86,40	2332,30
29.03.2008	80,00	70,65	68,30	64,85	68,50	80,13	80,48	87,95	100,48	114,18	122,38	112,43	112,65	113,63	107,38	108,63	107,93	108,53	107,90	106,18	105,63	102,30	91,95	86,93	2309,90
30.03.2008	83,25	3,63	65,53	67,15	68,53	83,35	83,90	89,03	102,83	106,48	114,43	118,73	117,00	112,45	108,65	107,78	109,78	107,48	104,73	94,23	87,53	77,70	74,05	74,05	2162,20
31.03.2008	68,10	79,30	80,65	73,83	70,85	73,45	91,28	89,90	95,73	102,05	109,00	113,65	116,90	115,03	116,30	116,30	110,00	112,15	107,10	111,10	103,20	103,53	103,65	101,33	2364,35
																								DAILY TOTAL	**72361,13**

For the GIS and MIS database, the population of Muradiye is 16.752; the daily water consumption is 111 litres for each. From here, the monthly demand of water for Muradiye is equal to:

$$P_{MURADIYE} = 16{,}752$$

$$Q_{Daily} = 16752 \times 111 = 1859472 \quad l = 1{,}860 \quad m^3/day$$

$$Q_{Monthly} = (1{,}860 \times 30) = 55{,}800 \quad m^3/month$$

The monthly consumption for Subscriber Accruement Service of DİSKİ is equal to:

$$Q_{Subscriber} = 30503{,}91 \text{ l/month} = 30{,}504\, m^3/\text{ month}$$

Now, there are three data's which represents the consumption and supplied water to Muradiye individually in March/ 2008. The supplied water is the data of SCADA, the accounted consumed water is the data of Subscriber Accruement Service of DİSKİ, and the demand water is the data of GIS-MIS. The difference between these values also represents water loss from pipeline of Muradiye. The following Table 5.7 and Figure 5.6 show these data's.

Table 5.7 Data's of Muradiye Regarding Month March

Amount of Water(m^3/month)	GIS-MIS (DEMAND)	SACADA (SUPPLIED)	Subscribers Accruement Service
	55.800	**72.361**	**30.504**

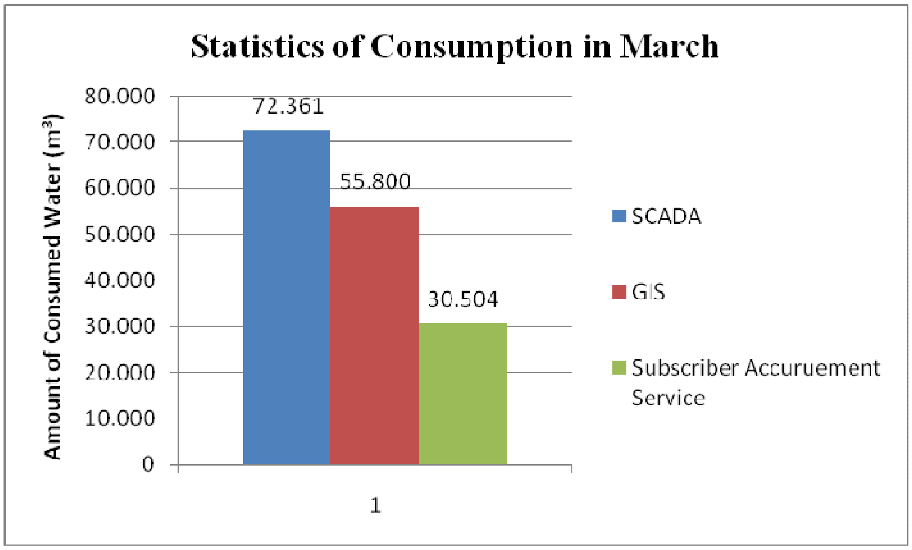

Figure 5.6 Graph of Consumption in March.

5.5. WATER LOSS CALCULATIONS FOR MURADİYE REGION

Water loss occurs in all distribution systems only the volume of loss varies, depending on the characteristics of the pipe network and other local factors, the water operational practice, and the level of technology and expertise applied to controlling it.

The evaluation of water loss in pipeline at Muradiye region gives chance for appraisal of whole water system in Diyarbakır. Water losses branch off two: Administrative Loss (Non-physical) and Physical Loss. These systems satisfy the detachment of total water loss. Physical loss is the leakage from distribution pipeline; administrative loss is consumed unaccounted water. Water loss in the Muradiye Region is calculated with relating equations:

$Q_{GIS} = 55.800\ m^3/month$

$Q_{SCADA} = 72.361\ m^3/month$

$Q_{Subscriber} = 30.504\ m^3/month$

$Q_{Physical\ Loss} = Q_{SCADA} - Q_{GIS} = 72.361 - 55.800 = 16.561\ m^3$

$Q_{Administrative\ Loss} = Q_{GIS} - Q_{Subscriber} = 55.800 - 30.504 = 25.296\ m^3$

$$Physical\ Loss = \frac{Q_{Phsical\ Loss}}{Q_{SCADA}} \times 100 = \frac{16.561}{72.361} \times 100 = 22.89\%$$

$$Administrative\ Loss = \frac{Q_{Administrative\ Loss}}{Q_{GIS}} \times 100 = \frac{25.296}{55.800} \times 100 = 45.33\%$$

The physical loss is 22.89% that is the leakage of treated water from treatment plant to supply pipeline. The administrative loss is 45.33%, which is the unaccounted water delivered from distribution network. The following Figure 5.7 is the graph of water losses in Muradiye Region.

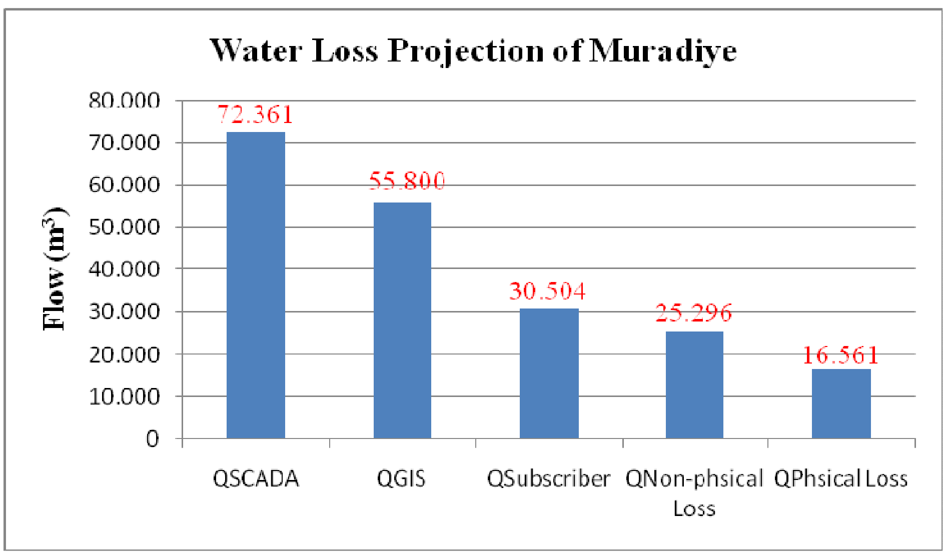

Figure 5.7 Graph of Water Losses in Muradiye Region.

Total water loss is the difference between the amount of water produced and the amount which is billed or consumed. The total loss in Muradiye Region from water supply system is:

$$\text{Water Loss} = \frac{\text{Phsical Loss} + \text{Administrative Loss}}{\text{Production}} \times 100$$

$$= \frac{16.561 + 25.296}{72.361} \times 100 = 57.84\%$$

International survey was made about water losses by the International Water Services Association (IWSA) in 1991. For the water loss statistics, amount of loss: 8-24% in developed countries, 15-24% newly industrialized countries, and 25-45% developing countries. In accordance with this information, water loss in Muradiye Region is too high from acceptable limits. This region is only small part of supply system, when considering the total amount of water loss in whole system it could be increased than 57.84%.

Furthermore, the previous study in MTA Region was also researched water loss in Diyarbakır network pipeline system. MTA Region is composed of both slum and new developed area. First, MTA was isolated. Then area was inspected, network and subscriber information's taking, extra vanes were placed to control one point supply and distribution, meters were placed each building entrance, the readings take at same time from meters and mathematical calculations made to obtain amount of losses. GIS (Geographical Information System) is used in this working. GIS is integrated with Customer Information System (CIS) and put together into MapInfo Professional medium. The network data's, buildings, addresses and subscriber's information were entered to system. Consequently, the water interrupted and indexes were read, after 20 days, the readings were taken again. The following Table 5.8 illustrates the statistics of water loss [19].

Table 5.8 Water Loss in MTA Region [19]

	Main Meter(m^3)	Total Index of Building Meters (m^3)	Water Loss (m^3)
MTA Region	**52.900**	**43.949**	**8.951**

This study was made in new distribution network; hence the leakage from pipes was also low in this region. The physical loss is:

$$\text{Physical Loss} = \frac{52.900 - 43.949}{52.900} \times 100 = 16.92\,\%$$

This amount was acceptable under the standards of water loss. At same time, this study emphasizes the main reason of water loss from supply line that is the unaccounted water. MTA region was controlled with flow-meters at main and sub-zones so the unaccounted water was controlled and prevented in that way. The amount of water loss difference between in Muradiye (57.84%) and MTA (16.92%) regions emanate mainly existing old network and unaccounted water from network. The reasons of unaccounted water must be inspected to rehabilitee the system.

5.6. IDENTIFICATION OF WATER LOSSES FROM NETWORK

Within all major water systems, there exists a difference in the amount of water supplied to the system, and the total amount accounted for the utility's customer billings. This difference is called unaccounted for water. The volume of unaccounted for water will depend largely on the characteristics of the pipe network and the leak detection and repair policy practised by the utility, such as: the pressure in the network; whether the soil type allows water to be visible at the surface; the “awareness” time (how quickly the loss is noticed); the repair time (how quickly the loss is corrected).

The total water loss is the sum of physical and non-physical (management) losses.

PHYSICAL LOSS: The major causes of physical loss are poor network design and quality control (transmission, storage and distribution pipeline leakage) and private pumping; aging pipe network; customer service connections; leakage at connections joints, valves and fittings.

NON-PYSICAL LOSS: The non-physical loss is occurred from meter inaccuracy (errors in customer meter); illegal and unregistered usage (secondary lines, un-metered customer, private well users); errors in customer billing, accounting and collections; meter tampering and removal (meter removal, meter reversal or broken meter); legal un-metered usage (parks, mosques, standpipe, municipality).

Meter accuracy are based upon the metered amount of water registered through customer meters, or unaccounted water. The customers are owned and maintained privately by the customer and meter inaccuracy is discovered by the customer when the amount of billed too large; and the meter reader is found to be damaged or stopped. The other factors affect meter accuracy are type of meter, age, installation, tilt and rotation, and meter seals.

Customer service connections losses is caused materials used galvanized steel or steel by customers. Both of these materials are highly susceptible to corrosion especially at the joints. The combination of aggressive water and materials susceptible to corrosion creates a serious water loss potential. The service connections are attached to crown of the water main and a valve placed at the tap and nipple with a 90° elbow is mounted vertically on the valve. This connection type is common in most Turkish cities and caused water losses.

Private plumping is the other source of water loss which is caused from the storage tank and service connection discharge to, the pump, roof tank and internal building plumping to each water meter.

Illegal usage is reasoned from unregistered connections exist in the water network system. This resulted unknown taps, secondary taps-lines, and non-metered services especially in rural areas. The secondary lines and taps occur after the pipeline installed. The customer may have a meter on one line, but has another non-metered line to be used as deemed necessary. Many of secondary lines are difficult to spot and confirm. Private well users also in this group which is consumed water without paying.

Legal non-metered usage is the other unaccounted water loss. There are two groups of water uses without metering: municipality, mosques and standpipes. The non-metered water is used for park usage, fire protection, employees and building usage in municipality. It is tradition in Diyarbakır not to bill mosques for water use. The public standpipes are exist in the older city and lower income areas that are used as water sources for residents.

Meter tampering and removal is the other source of water losses. The removal of meters is due to the lack of meter installation seals. In high rise buildings, the installation of meters is very tight and making removal of meters difficult. In the lower income areas, removal is easier.

In Muradiye, total loss amount is 57.84% from network; 22.88% of this amount is physical and 34.96% is non-physical loss. With the consideration that the total water loss is 100%, the physical loss appears to be 39.55%, and the non-physical loss would be 60.45%. The old existing pipeline appears to be the main factor that causes physical loss, while the main causatives for the administrative loss are illegal usage and meter tampering/removal. Mostly people living in Muradiye were placed there because of rural exodus. The emigration caused serious problems such as increased in unemployment, decreasing living standards and increased crime rate of city. The slow development in industry is the other reason of unemployment. Hence, the ascension unemployment is accelerated unaccounted for water in Muradiye Region.

5.7. PROGRESS IN WATER LOSS REDUCTION

Historically water and sewerage services in Diyarbakır have been managed internally by the Greater Municipality until 1995 and amount of unaccounted for was 90%. General Directory of Water supply and Sewerage in the Municipality of Greater Diyarbakır (Diyarbakır Büyükşehir Belediyesi Su ve Kanalizasyon İdaresi: DİSKİ) was formed in 1995. The only establishment of DİSKİ was decreased the amount of water loss. The previous Water Loss Reduction and Water Distribution Extension Study was determined that the unaccounted for water has been reduced to nearly 59% in 1998. This decrease in unaccounted for water is dramatic and impressive reduction. On the other hand, increase in the customer base, lack of investment for maintenance and repair of the water system, uncontrolled and unplanned expansion of system accelerated the amount water loss in recent years. Table 5.7 show the water customer's of DİSKİ in 1998 and 2008.

Table 5.9 DİSKİ's Customer Base

Customer Category	Water Customer			
	1998		2008	
	Number	Percent (%)	Number	Percent (%)
Residential	72,081	92.40	132,245	90.05
Commercial-Industrial	5,650	7.2	13,549	9.22
Government	205	0.30	883	0.60
Public	91	0.10	168	0.11
TOTAL	78,027	100	146,690	100

As seen from Table 5.9, the number of customer is doubled in last ten years. Furthermore, the new supply system was also put into service to supply increased demand. The department of DİSKİ developed and strengthened much more. The infrastructure of city has been improved with DİSKİ's efforts. The water and sewage treatment plants were founded. The new pipelines were added and some existing changed with news. The new systems were established such as GIS, MIS, Oracle, MapInfo and SCADA. In conclusion, with the alternating the city that is expanding and developing, the municipality service and facility is changed and moved along to improve living standards. However, these developments are limited with funds. The inadequate budgets are restricted whole system improvement. The completion of SCADA and GIS-MIS will be received Diyarbakır Supply Project to one step up from today. The water loss will also be detected after completion of these programmes.

The following Table 5.10 illustrates progress in combat of unaccounted water in the near future time with starting usage of new technologies SCADA [17].

Table 5.10 Statistics of Water Loss Ratio of Diyarbakır Water Supply System [17]

Year	**Production (m^3)**	**Accounted (m^3)**	**Loss (m^3)**	**Rate of Loss**
2004	50,154,000	15,046,200	35,107,800	70%
2005	50,471,000	16,655,430	33,815,570	67%
2006	53,373,000	19,534,518	33,838,482	63.4%

Diyarbakır is undeveloped city so amount of water loss is much higher than other big cities. However, the rate of loss was decreased with using advanced technologies; it was also seen from Table 5.8. The loss rate was decreased to 57.84% at Muradiye Region in March/2008. But still, this amount is very high for proper water system. The unit price of water in Diyarbakır is 1.3 YTL. The cost of implementation of SCADA to the whole city system is roughly 1,500,000 YTL , and system must renewed every five year.

With the consideration that the most recent current annual water production in Diyarbakır is 55,000,000 m^3, and the current loss being at least 60%, it is possible to compare the financial gain after the implementation of SCADA and GIS-MIS system in the city. The cost of full application to such new technology in Diyarbakır is roughly 1,500,000 YTL. In order to find the annual cost of this new technology, this number should be divided by 5 years, which is the period allowed for benefiting from this system (i.e. 1,500,000 ÷ 5 = 300,000 YTL). This annual cost of the new technology should be compared with the value of the water lost annually from the system. If the aim of the system is to reduce the loss from 60% to 20% (the latter is the highest water loss that is internationally acceptable). The cost of water loss would be the cost of 40% of the annual water produced for the city. The volume of the annual loss is 40% x 55,000,000 = 22,000,000 m^3. The cost of this loss could be calculated with the use of the current price of one single m^3, which is 1.3 YTL. Consequently, the values of the annually lost water is 22,000,000 x 1.3 = 28,000,000 YTL. The result is an astonishing difference between 28,000,000 YTL of the loss and 300,000 YTL for the annual cost of new technology that would enable for the elimination of this loss. The ratio between the gain and the cost is about 93 times more profitable than leaving the system without the new technology. Such numbers would be even more astonishing when counting the gain and loss for many years ahead.

In general, a 10 to20 percent allowance for unaccounted-for water is normal. But a loss of more than 20 percent requires priority attention and rehabilitees of system.

Nowadays water is the most important element for survival human being. Most of the world suffers inadequate clean water sources. Therefore, proper water usage must be first target to combat water loss. The utilities have to allocate sufficient funds to prevent losses. Within the advances in technologies and expertise should make it possible to reduce losses and unaccounted-for-water to less than 10 percent. The following Table 5.11 is the summary of causes and suggestions for rehabilitation of Diyarbakır Supply System to combat water losses [17].

Table 5.11 Reasons of Unaccounted for Water in Diyarbakır [17]

Cause of Unaccounted Water	Source of Losses	Recommended Corrections
Meter Accuracy	Customer Meters	• New meters • Bulk metering of buildings eliminating a large percentage of existing customer meters • Existing meter calibration • Own customer meters
Customer Service Connections	Service Connections	• Install meter close to main • Change Tapping Methods • Change tapping arrangements • Change materials
Private Plumbing	Storage Tank/System Pump: Leakage/ Overflow Roof Tank: Overflow/ Cleaning Building Internal Plumbing	• Bulk Metering of Buildings
Illegal Usage	Secondary Lines Un-metered Customers Private Well Users	• GIS-MIS system installation • Extensive customer and property audits • Bulk metering in system, SCADA and hydraulic model • Tapping and service connection inspection personal
Legal Un-metered Usage	Municipality Mosques/Standpipes	• Metering of all users
Meter Tampering and Removal	Meter Removal Meter Reversal Broken Meter	• Meter Seals installed
Pipeline Leakage	Pipeline Leakage	• GIS-MIS system • Improving piping and installation standards • Comprehensive leak detection and correction programme; purchase leak detection equipment; training personnel

CHAPTER-6: ANALYSIS HYDRAULIC MODEL OF MURADİYE QUARTER'S IN EPANET

6.1. EPANET

EPANET is a computer program that performs extended period simulation of hydraulic and water quality behaviour within pressurized pipe networks. A network consists of pipes, nodes (pipe junctions), pumps, valves and storage tanks 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 a chemical species throughout the network during a simulation period comprised of multiple time steps [20]. In addition to chemical species, water age and source tracing can also be simulated.

EPANET was developed by the Water Supply and Water Resources Division (formerly the Drinking Water Research Division) of the U.S. Environmental Protection Agency's National Risk Management Research Laboratory. It is public domain software that may be freely copied and distributed.

EPANET is designed to be a research tool for improving our understanding of the movement and fate of drinking water constituents within distribution systems. It can be used for many different kinds of applications in distribution systems analysis. Sampling program design, hydraulic model calibration, chlorine residual analysis, and consumer exposure assessment are some examples. EPANET can help assess alternative management strategies for improving water quality throughout a system. These can include:

- altering source utilization within multiple source systems,
- altering pumping and tank filling/emptying schedules,
- use of satellite treatment, such as re-chlorination at storage tanks.
- targeted pipe cleaning and replacement.

Running under Windows, EPANET provides an integrated environment for editing network input data, running hydraulic and water quality simulations, and viewing the results in a variety of formats. These include colour-coded network maps, data tables, time series graphs, and contour plots.

6.2. HYDRAULIC MODELLING CAPABILITIES

Full-featured and accurate hydraulic modelling is a prerequisite for doing effective water quality modelling. EPANET contains a state-of-the-art hydraulic analysis engine that includes the following capabilities:

- places no limit on the size of the network that can be analyzed
- computes friction head loss using the Hazen-Williams, Darcy-Weisbach, or Chezy-Manning formulas
- includes minor head losses for bends, fittings, etc.
- models constant or variable speed pumps
- computes pumping energy and cost
- models various types of valves including shutoff, check, pressure regulating, and flow control valves
- allows storage tanks to have any shape (i.e., diameter can vary with height)
- considers multiple demand categories at nodes, each with its own pattern of time variation
- models pressure-dependent flow issuing from emitters (sprinkler heads)
- can base system operation on both simple tank level or timer controls and on complex rule-based controls.

6.3. STEPS IN USING EPANET

One typically carries out the following steps when using EPANET to model a water distribution system [20]:

1. Draw a network representation of your distribution system import a basic description of the network placed in a text file.
2. Edit the properties of the objects that make up the system.
3. Describe how the system is operated.
4. Select a set of analysis options.
5. Run a hydraulic/water quality analysis.
6. View the results of the analysis.

6.4. HYDRAULIC SIMULATION MODEL

EPANET's hydraulic simulation model computes junction heads and link flows for a fixed set of reservoir levels, tank levels, and water demands over a succession of points in time. From one time step to the next reservoir levels and junction demands are updated according to their prescribed time patterns while tank levels are updated using the current flow solution [20-21]. The solution for heads and flows at a particular point in time involves solving simultaneously the conservation of flow equation for each junction and the head loss relationship across each link in the network. This process, known as "hydraulically balancing" the network, requires using an iterative technique to solve the nonlinear equations involved. EPANET employs the "Gradient Algorithm" for this purpose. The hydraulic time step used for extended period simulation (EPS) can be set by the user. A typical value is 1 hour.

6.5. OVERVIEW OF EPANET

The basic EPANET workspace is pictured below (Figure 6.1). It consists of the following user interface elements: a Menu Bar, two Toolbars, a Status Bar, the Network Map window, a Browser window, and a Property Editor window [20].

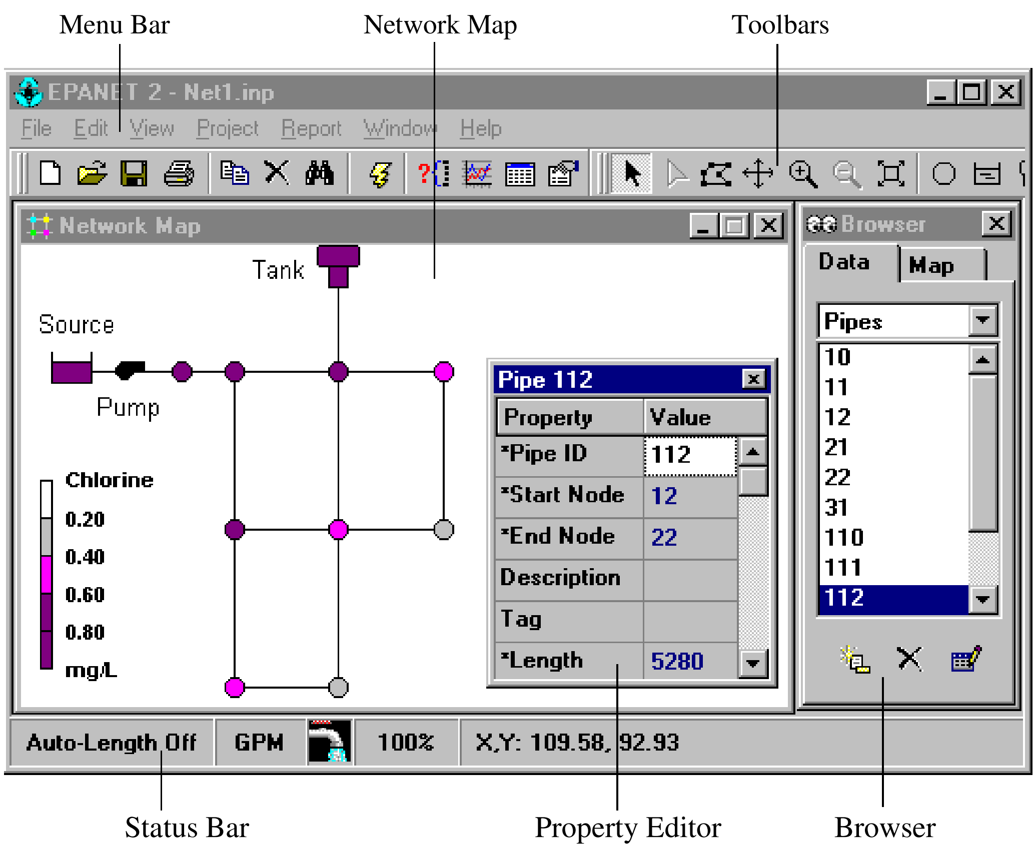

Figure 6.1 Overview of EPANET.

6.6. COMPONENTS OF EPANET

EPANET models a water distribution system as a collection of links connected to nodes. The links represent pipes, pumps, and control valves. The nodes represent junctions, tanks, and reservoirs.

Junctions: 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 above some reference (usually mean sea level), water demand (rate of withdrawal from the network) and initial water quality. The output results computed for junctions at all time periods of a simulation are: hydraulic head (internal energy per unit weight of fluid)*,* pressure and water quality.

Reservoirs: Reservoirs are nodes that represent an infinite external source or sink of water to the network. They are used to model such things as lakes, rivers, groundwater aquifers, and tie-ins to other systems. Reservoirs can also serve as water quality source points. The primary input properties for a reservoir are its hydraulic head (equal to the water surface elevation if the reservoir is not under pressure) and its initial quality for water quality analysis. Because a reservoir is a boundary point to a network, its head and water quality cannot be affected by what happens within the network. Therefore it has no computed output properties.

Tanks: Tanks are nodes with storage capacity, where the volume of stored water can vary with time during a simulation. The primary input properties for tanks are: bottom elevation (where water level is zero), diameter (or shape if non-cylindrical), initial, minimum and maximum water levels, initial water quality. The principal outputs computed over time are: hydraulic head (water surface elevation) water quality. Tanks are required to operate within their minimum and maximum levels. EPANET stops outflow if a tank is at its minimum level and stops inflow if it is at its maximum level. Tanks can also serve as water quality source points.

Pipes: Pipes are links that 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: start and end nodes, diameter, length, roughness coefficient (for determining head loss) , status (open, closed, or contains a check valve). The status parameter allows pipes to implicitly contain shutoff (gate) valves and check (non-return) valves (which allow flow in only one direction). The water quality inputs for pipes consist of: bulk reaction coefficient wall reaction coefficient. Computed outputs for pipes include: flow rate, velocity, head loss, Darcy-Weisbach friction factor, average reaction rate (over the pipe length), and average water quality (over the pipe length). The hydraulic head lost by water flowing in a pipe due to friction with the pipe walls can be computed using one of three different formulas: Hazen-Williams formula, Darcy-Weisbach formula and Chezy-Manning formula. (Table 6.1; 6.2) Each formula uses following equation (Eq.6.1) to compute head loss between start and end node of the pipe [20]:

$$h_L = A \times q^B \quad \ldots\ldots (6.1)$$

Table 6.1 Pipe Head Loss Formulas

Formula	**Resistance Coefficient (A)**	**Flow Exponent (B)**
Hazen-Williams	$4.727\ C^{-1.852}\ d^{-4.871}\ L$	1.852
Darcy-Weisbach	$0.0252\ f\ (\varepsilon,d,q) d^{-5}\ L$	2
Chezy-Manning	$4.66\ n^2\ d^{-5.33}\ L$	2

C = Hazen-Williams roughness coefficient
ε = Darcy-Weisbach roughness coefficient (ft)
f = friction factor (dependent on ε, d and q)
n = Manning roughness coefficient
d = pipe diameter
L = pipe length
q = flow rate

Table 6.2 Roughness Coefficient for Pipes

Material of Pipe	Hazen-Williams (C)	Darcy-Weisbach (ε) (feet*10^{-3})	Manning's (n)
Cast Iron	130-140	0.85	0.012-0.015
Concrete or Concrete Lined	120-140	1.0-10	0.012-0.017
Galvanized Iron	120	0.5	0.015-0.017
Plastic	140-150	0.005	0.011-0.015
Steel	140-150	0.15	0.015-0.017
Clay	110		0.013-0.015

Pumps: Pumps are links that impart energy to a fluid thereby raising its hydraulic head. The principal input parameters for a pump are its start and end nodes and its pump curve (the combination of heads and flows that the pump can produce). In place of a pump curve, the pump could be represented as a constant energy device, one that supplies a constant amount of energy (horsepower or kilowatts) to the fluid for all combinations of flow and head. The principal output parameters are flow and head gain. Flow through a pump is unidirectional and EPANET will not allow a pump to operate outside the range of its pump curve. Variable speed pumps can also be considered by specifying that their speed setting be changed under these same types of conditions. As with pipes, pumps can be turned on and off at preset times or when certain conditions exist in the network. EPANET can also compute the energy consumption and cost of a pump.

Valves: Valves are links that limit the pressure or flow at a specific point in the network. Their principal input parameters include: start and end nodes, diameter, setting, status. The computed outputs for a valve are flow rate and head loss. The different types of valves included in EPANET are: Pressure Reducing Valve (PRV), Pressure Sustaining Valve (PSV), Pressure Breaker Valve (PBV), Flow Control Valve (FCV), Throttle Control Valve (TCV), and General Purpose Valve (GPV).

6.7. NETWORK MODEL OF MURADİYE IN EPANET

6.7.1. Input Parameters of Network

EPANET can be used in two ways; draw network with EPANET tools or loaded network with map programmes (such as MapInfo, GIS). In this project, network is transferred from MapInfo Professional Programme to EPANET workspace.

First, a new file was opened and the current project defaults were edited to defaults window as seen from below figure. (Figure 6.2)

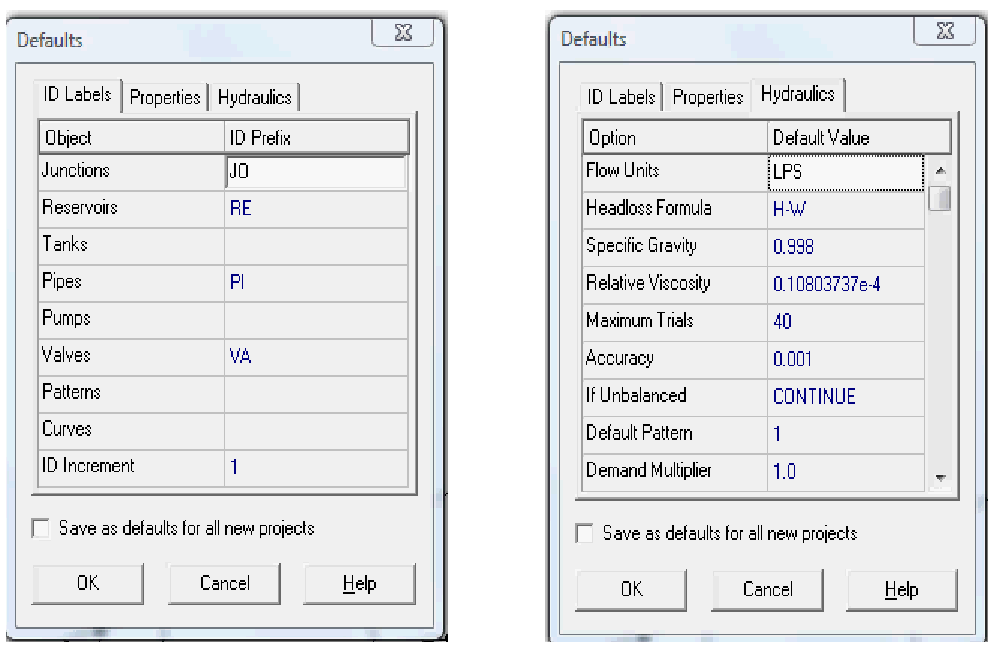

Figure 6.2 EPANET's Default Window.

The project's flow unit is in LPS (litre per second); head loss is evaluated with Hazen-Williams formula. The specific gravity and relative viscosity is formed as selected hydraulic analysis formula (Hazen-Williams). After transferring network of Muradiye, the basic settings were added to project. The coordinates of project is atomically added to EPANET from map programme. However, the other components must be entered or controlled from beginning.

EPANET has data browser which satisfy easily entrance of network components. The joints parameters were entered to project with EPANET data browser. The parameters were elevation, base demand and junction ID. As seen from Figure 6.3 , this process will be made with data browser. The total number of junction is 170.

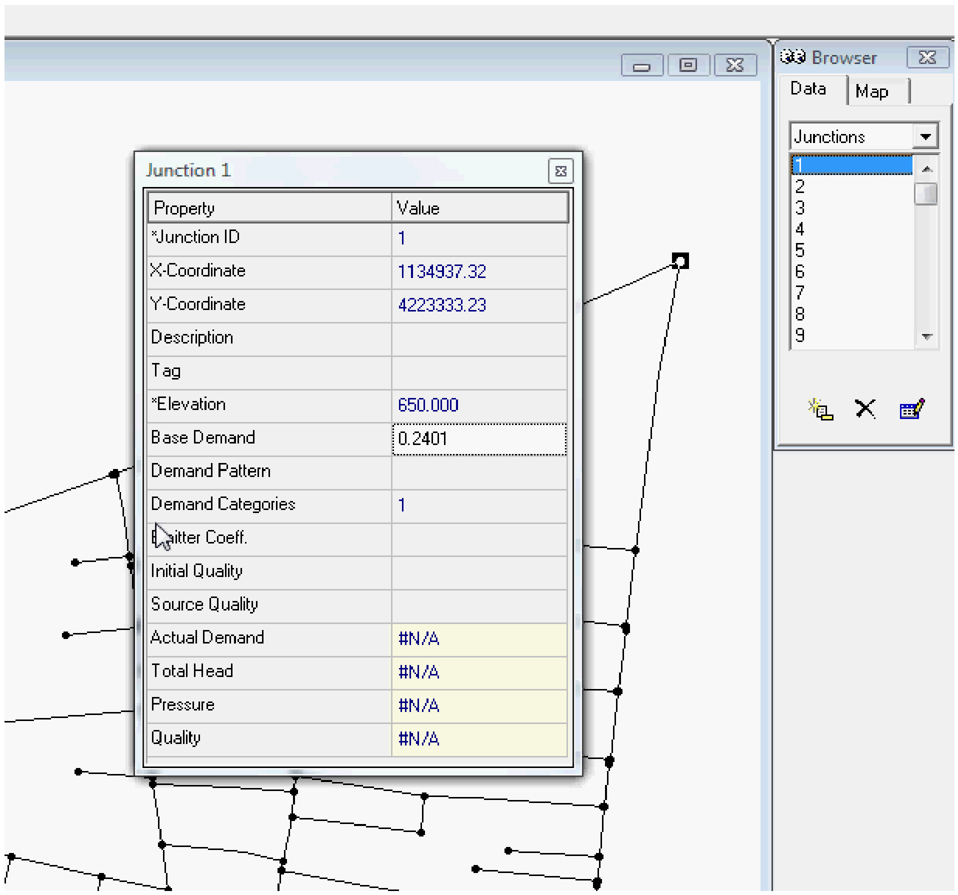

Figure 6.3 Junction Setting Windows in EPANET.

After finishing joints setting, the pipe information's were edited to data browser. The pipe parameters such as pipe length, diameter, and status (open, close or contains valve) and roughness were entered to browser. The following Figure 6.4 is illustrated pipe's properties window. The total numbers of pipes are 166. The main pipes are ACP (asbestos cement pipes) and secondary pipes are PVC (polyvinyl chloride).

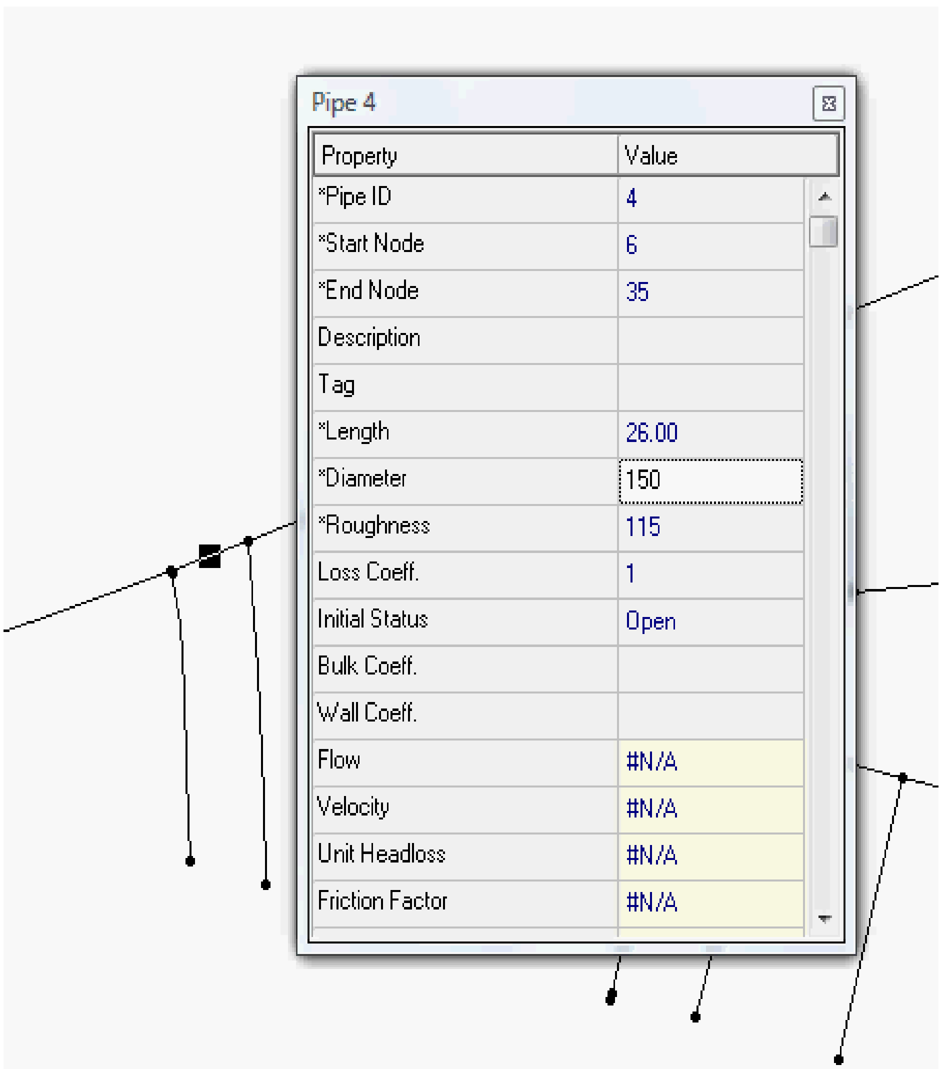

Figure 6.4 Pipe Property Window in EPANET.

The existed valves in the network must be placed in the network which was between pipes and joints. The diameter, setting and status have to enter EPANET. The following Figure 6.5 is the one of the property window of valve. In this network, type of valves is Flow Control Valves with Ø100 mm diameter.

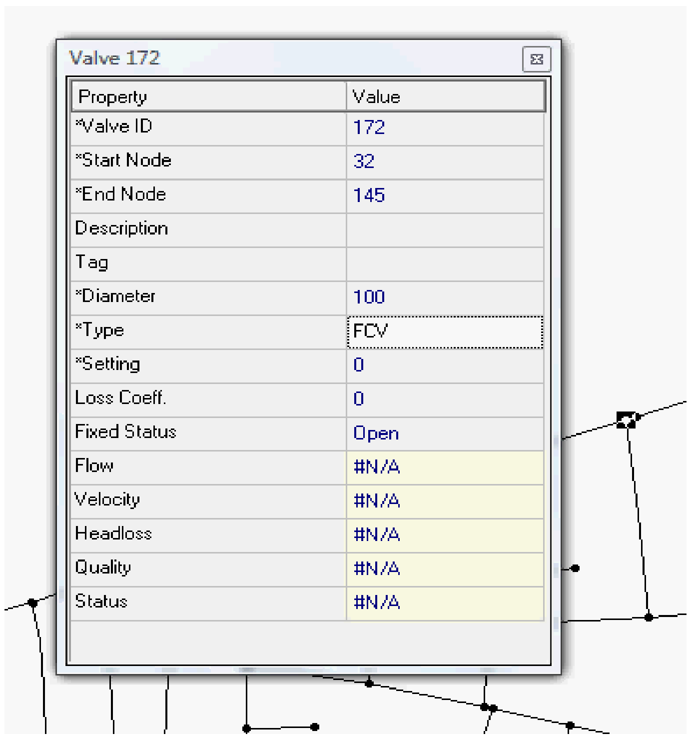

Figure 6.5 Valve Property Window in EPANET.

All projects must have at least one tank or reservoir to run the system. You need to create pressure in the system to move the water in the network. In this example, the system was fed by a reservoir to run the system. The input property of reservoir was hydraulic head. The realization of reservoir head was depend on the population served by node; social characteristics of the end users; the time of day; climatic conditions; and type of usage. The SCADA monthly supplied water statistics used to calculate total head of reservoir. The Figure 6.6 is the overview of Muradiye Quarter in EPANET.

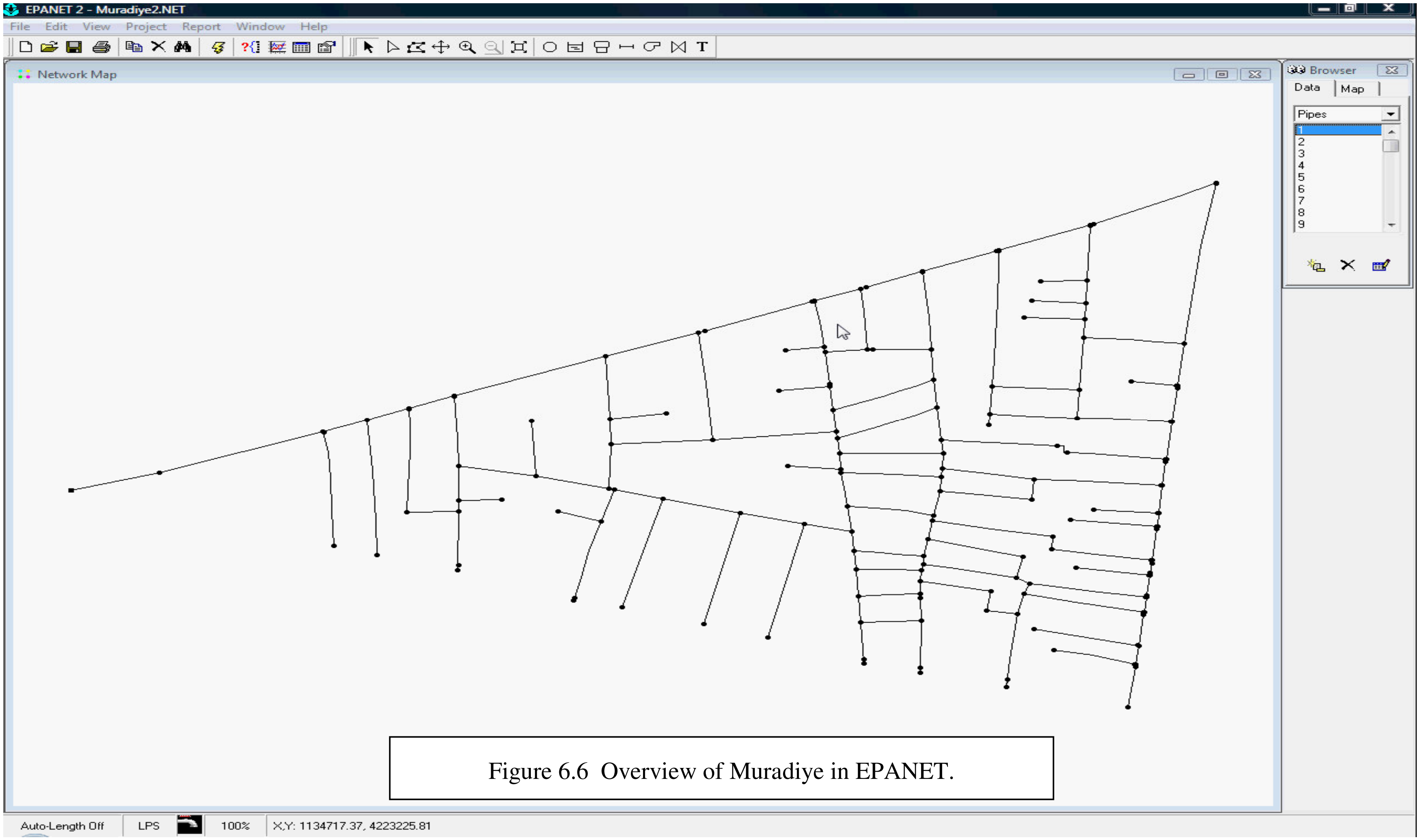

Figure 6.6 Overview of Muradiye in EPANET.

6.7.2. Run an Analysis of Muradiye Network

After a network has been suitably described, its hydraulic behaviour can be analyzed. The progress of the analysis will be displayed in a Run Status window. If the analysis runs successfully, the end of run icon will appear in the Run Status section of the Status Bar at the bottom of the EPANET workspace. Any error or warning messages will also appear in a Status Report window. The Figure 6.7 shows the successful running network project of Muradiye.

The results could be seen on both tables and graphics. In Muradiye network, the table results of all joints, valves and pipes were very long tables. Only the small part of result table was illustrated in that chapter. The full report of Muradiye network is declared in Appendix A.

After the successful run, the outputs of pipes in Muradiye network were flow, velocity and unit head loss; joints outputs were pressure, head and demand. The following figures show the graphical results of network.

The maximum daily consumption occurs at 11:00 am. Figure 6.8 shows the pressure and flow in network at 11:00 am, this time duration is selected because of the monitoring maximum consumption. The colours identify the amount of flow in network and the nodal pressures are placed on the joints.

The minimum daily consumption occurs at 24:00 pm. Figure 6.9 illustrates the pressure and flow in network at 24:00 p.m., in this hour the minimum consumption is screened in network. Also, colours identify the amount of flow in network and the nodal pressures are placed on the joints.

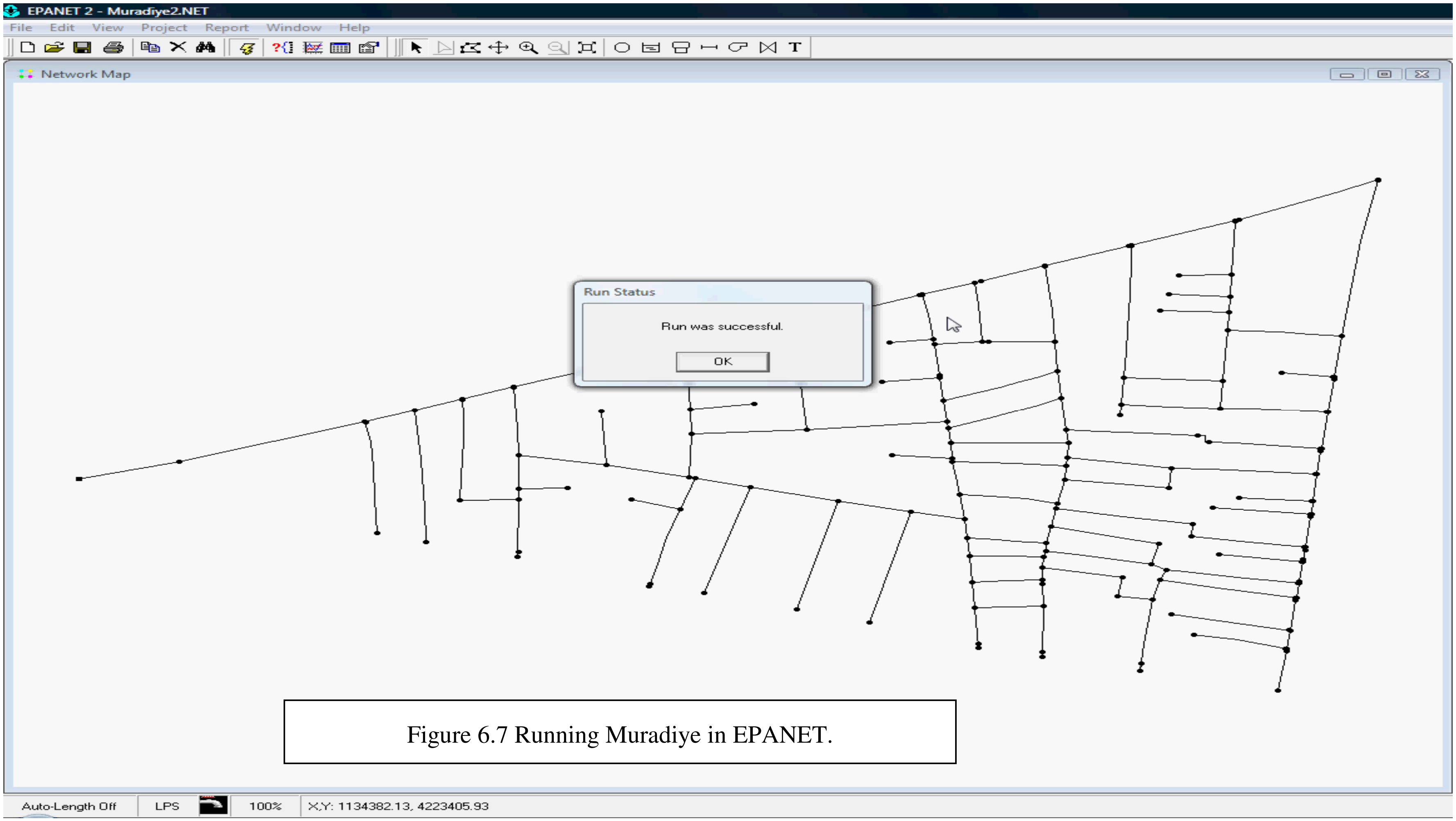

Figure 6.7 Running Muradiye in EPANET.

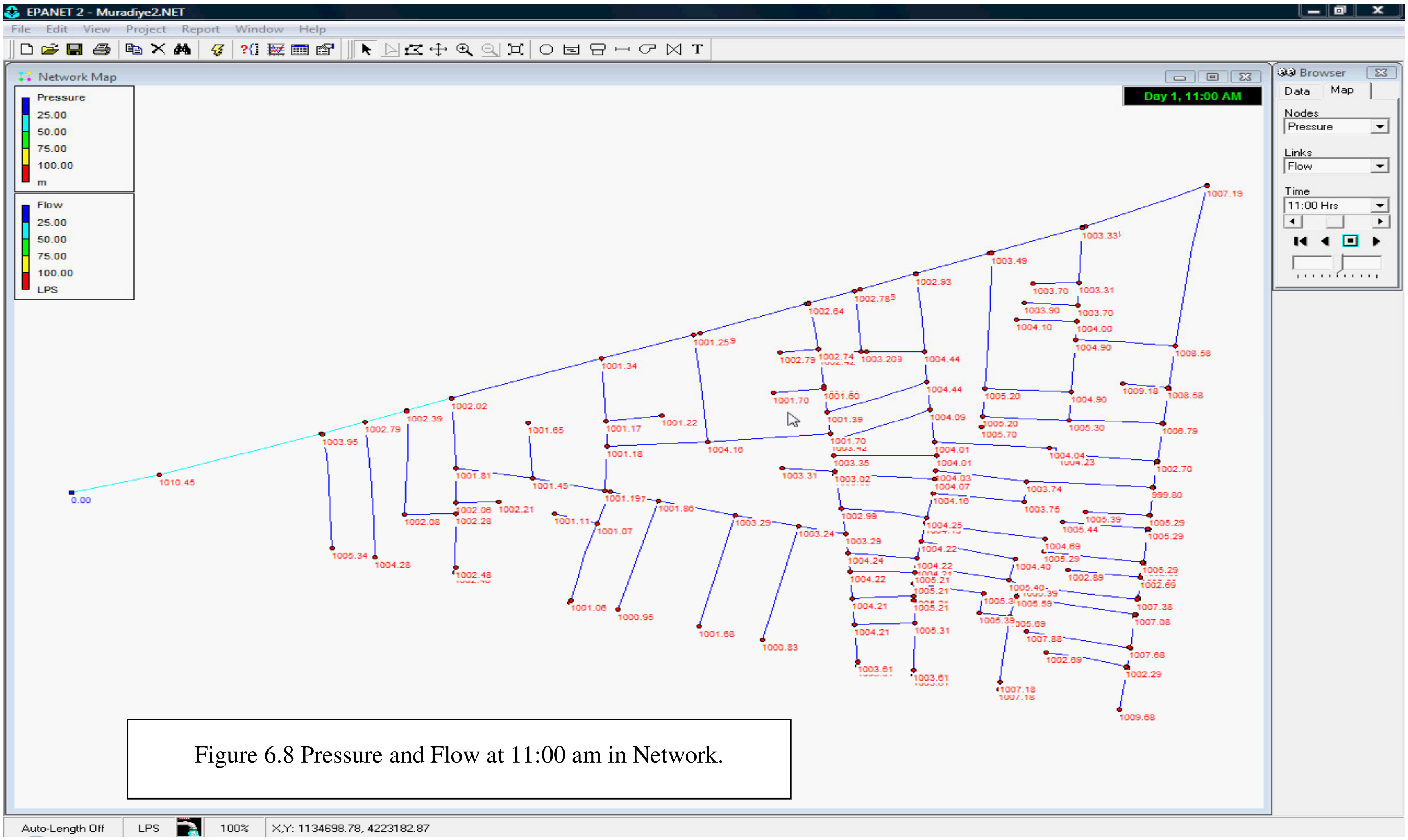

Figure 6.8 Pressure and Flow at 11:00 am in Network.

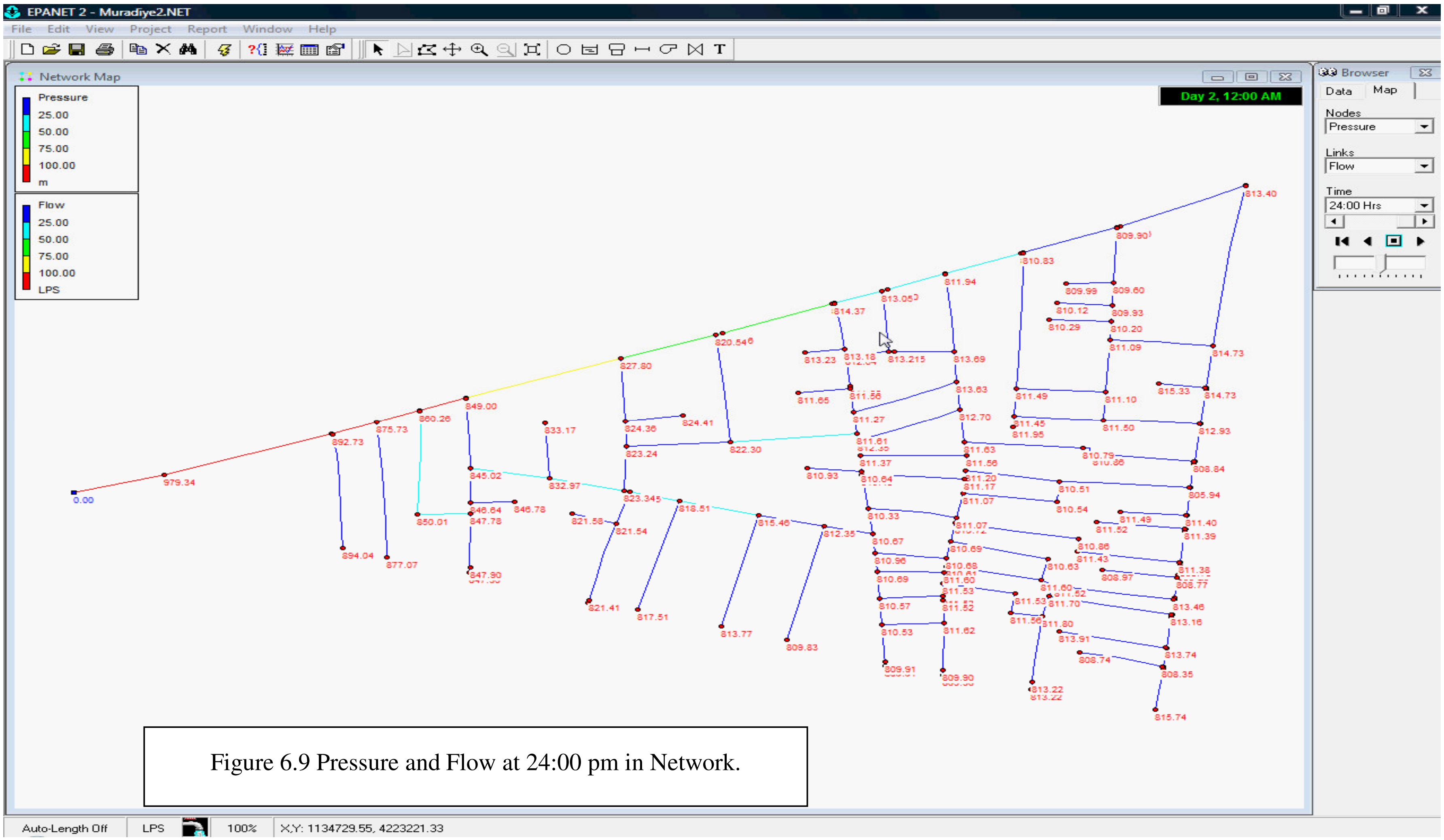

Figure 6.9 Pressure and Flow at 24:00 pm in Network.

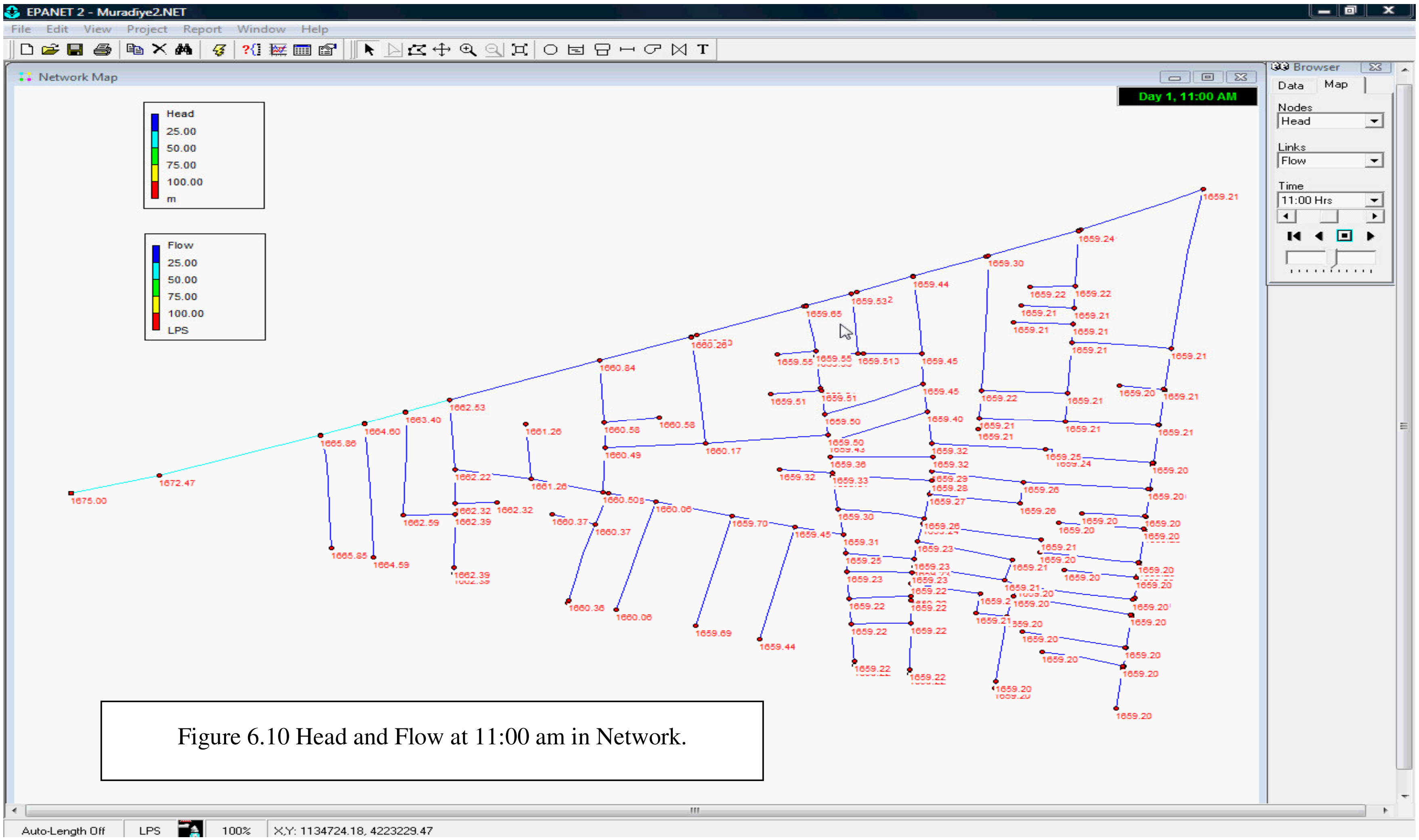

Figure 6.10 Head and Flow at 11:00 am in Network.

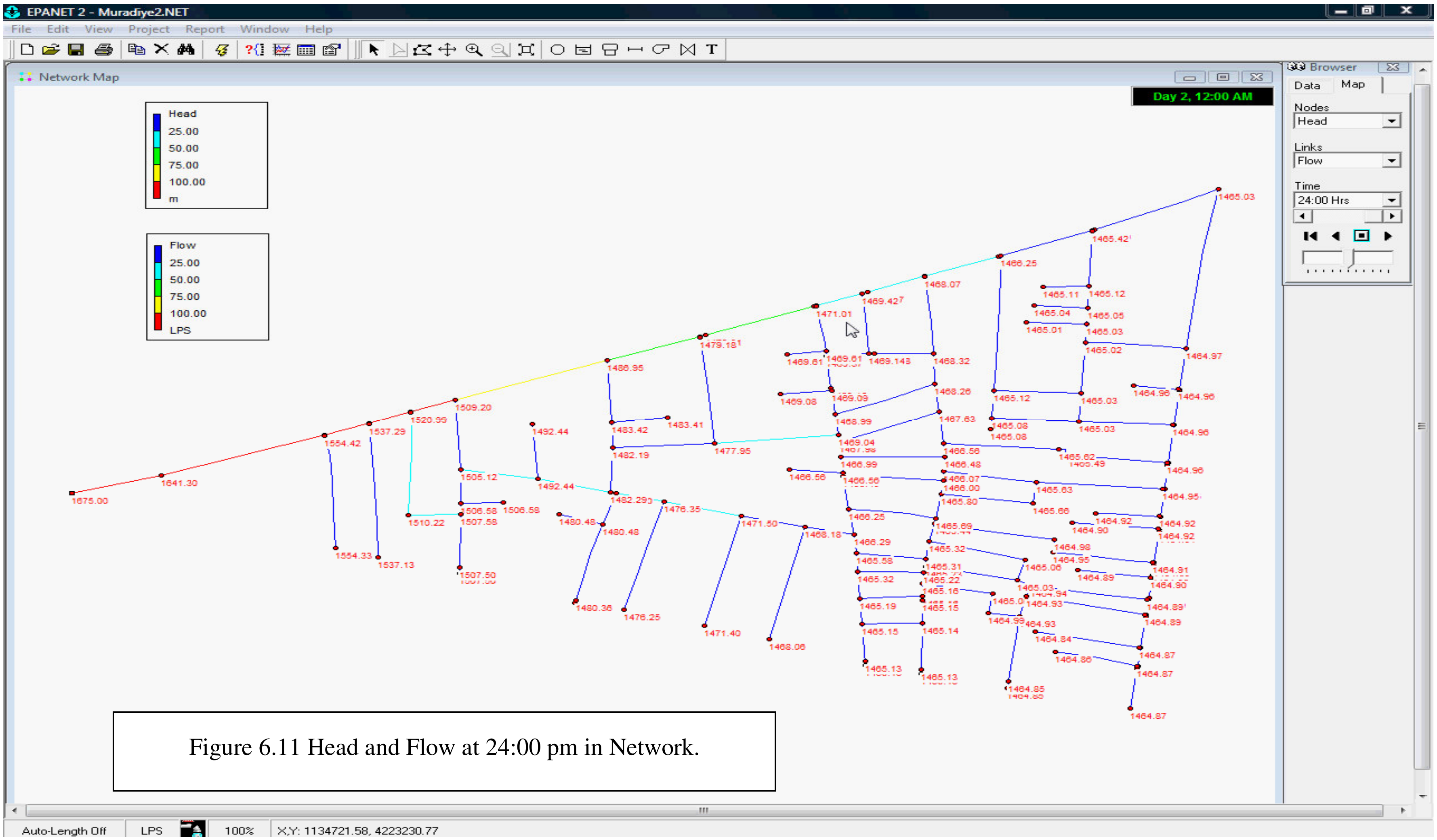

Figure 6.11 Head and Flow at 24:00 pm in Network.

The following figures are graphical representation of pressure and head in selected joints (J1, J2, J3, J4, J5, J6, J7, J8, J9, and J10) at 11:00 am.

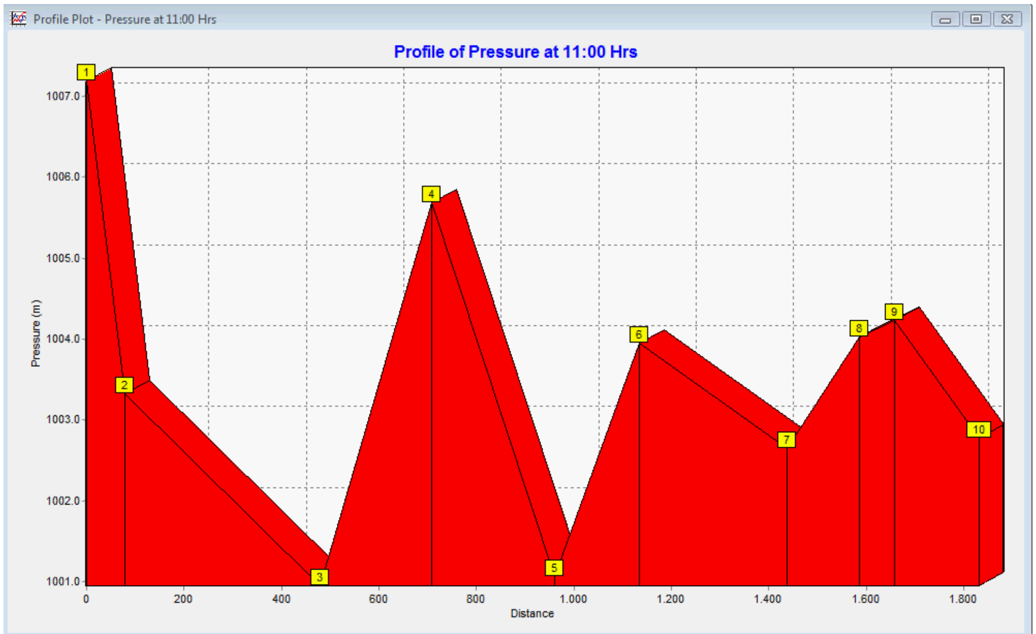

Figure 6.12 Pressure in Selected Nodes at 11:00 am.

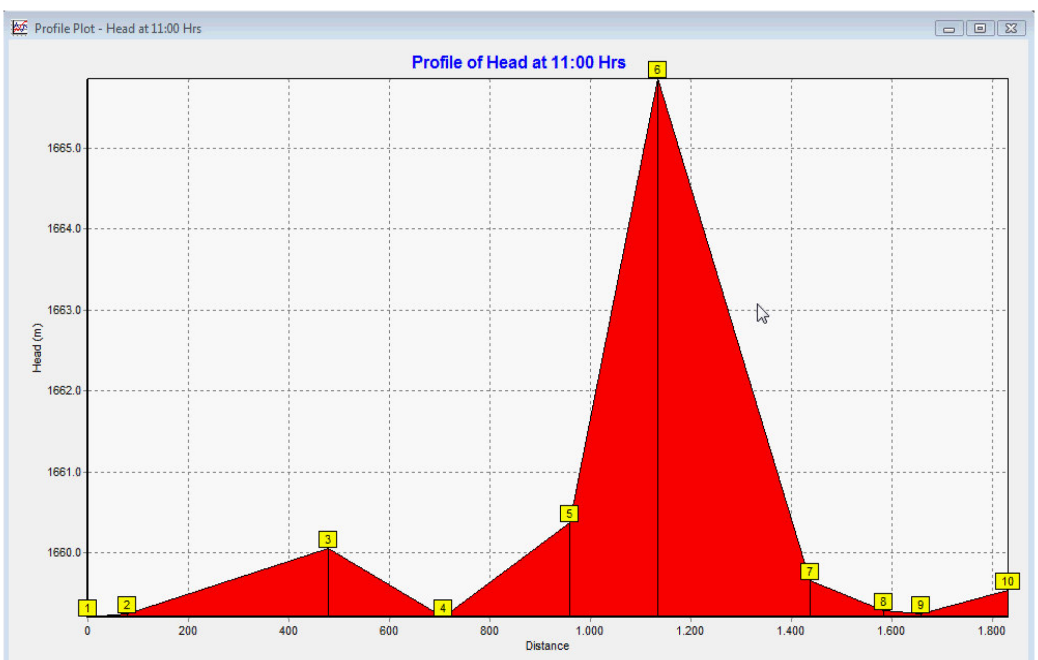

Figure 6.12 Head in Selected Nodes at 11:00 am.

The following figures are graphical projection of pressure and head in selected joints (J1, J2, J3, J4, J5, J6, J7, J8, J9, and J10) at 24:00 pm.

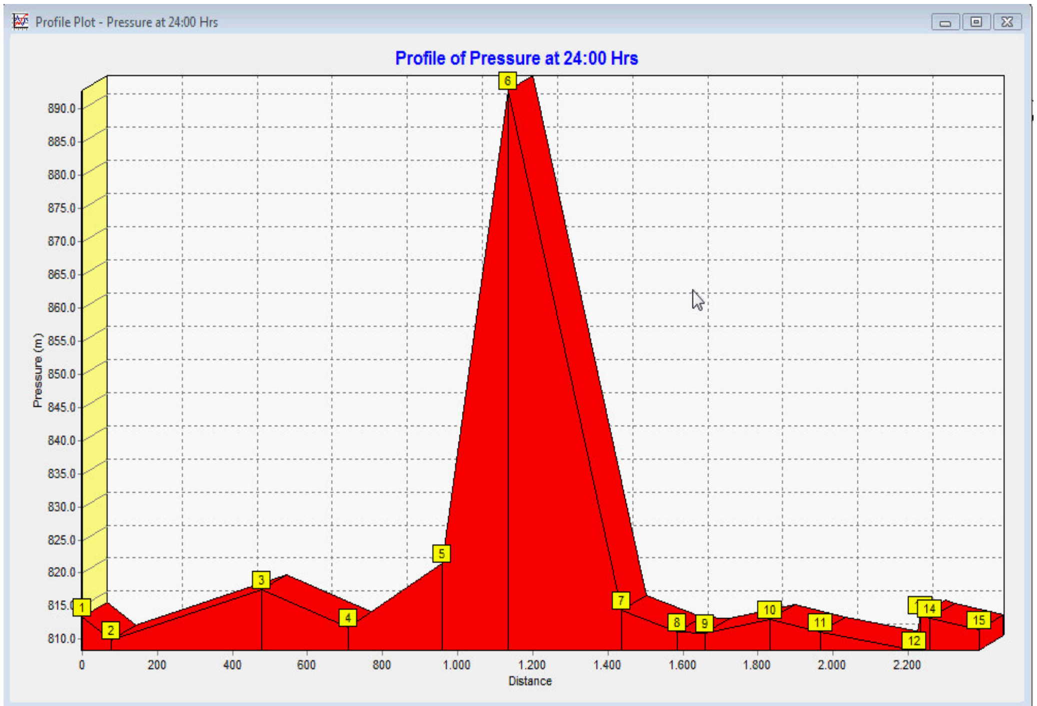

Figure 6.14 Pressure in Selected Nodes at 24:00 pm.

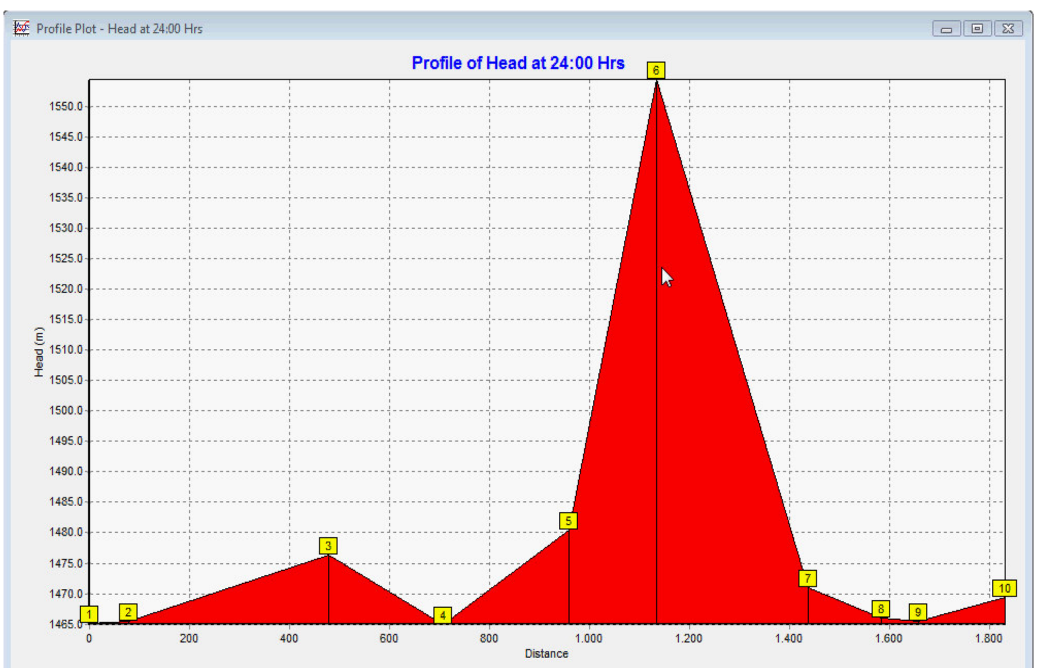

Figure 6.15 Head in Selected Nodes at 24:00 pm.

As explained above, table results of network are too long for project in that chapter. The following figures were taken from EPANET and the evaluated flow, velocity and unit head losses for network's pipes were in it. (Figure 6.17)

The nodal results table is summed up in Figure 6.16, the pressure and head in joints were illustrated in these table.

Project: Diyarbakır Su ve Kanalizasyon İdaresi
Network Table - Nodes at 11:00 Hrs

Node ID	Nodes	Base Demand LPS	Demand LPS	Head m	Elevation m
Junc 1	650.000	0.2401	0.48	1659.21	1007.19
Junc 2	653.900	0.1657	0.33	1659.24	1003.33
Junc 3	657.100	0.2861	0.57	1660.06	1000.95
Junc 4	651.500	0.0478	0.10	1659.20	1005.69
Junc 5	657.300	0.0783	0.16	1660.37	1001.07
Junc 6	659.900	0.4533	0.91	1665.86	1003.95
Junc 7	655.000	0.2108	0.42	1659.65	1002.64
Junc 8	653.250	0.0530	0.11	1659.29	1004.03
Junc 9	653.000	0.2078	0.42	1659.24	1004.23
Junc 10	654.750	0.0994	0.20	1659.53	1002.77
Junc 11	652.300	0.0428	0.09	1659.21	1004.90
Junc 12	654.900	0.0430	0.09	1659.20	1002.29
Junc 13	649.500	0.0717	0.14	1659.20	1007.68
Junc 14	650.100	0.0346	0.07	1659.20	1007.08
Junc 15	652.000	0.0247	0.05	1659.22	1005.21
Junc 16	653.000	0.0163	0.03	1659.23	1004.21
Junc 17	653.100	0.0190	0.04	1659.24	1004.13
Junc 18	653.100	0.0328	0.07	1659.27	1004.16
Junc 19	652.000	0.0633	0.13	1659.21	1005.20
Junc 20	653.300	0.0873	0.17	1659.32	1004.01
Junc 21	653.000	0.0596	0.12	1659.22	1004.21

Figure 6.16 Table of Junctions Outputs.

Project: Diyarbakır Su ve Kanalizasyon İdaresi
Network Table - Links at 11:00 Hrs

	Length	Diameter	Roughness	Flow	Velocity	Unit Head Loss	Friction Factor	Status
Link ID	m	mm		LPS	m/s	m/km		
Pipe 1	150.50	150	115	39.49	2.23	43.93	0.026	Open
Pipe 2	29.00	150	115	29.82	1.69	30.10	0.031	Open
Pipe 3	26.00	150	115	37.06	2.10	46.17	0.031	Open
Pipe 4	26.00	150	115	38.05	2.15	48.51	0.031	Open
Pipe 5	56.00	150	115	17.67	1.00	10.43	0.031	Open
Pipe 6	33.00	150	115	9.67	0.55	3.58	0.035	Open
Pipe 7	1.34	150	115	14.22	0.80	30.99	0.141	Open
Pipe 8	37.00	150	115	7.57	0.43	2.23	0.036	Open
Pipe 9	55.00	150	115	5.36	0.30	1.13	0.036	Open
Pipe 10	1.82	150	115	7.94	0.45	7.85	0.114	Open
Pipe 11	32	200	115	0.91	0.03	0.01	0.044	Open
Pipe 12	121	200	115	1.87	0.06	0.04	0.042	Open
Pipe 13	8	200	115	1.93	0.06	0.07	0.077	Open
Pipe 14	25	200	115	2.47	0.08	0.07	0.045	Open
Pipe 15	32	200	115	1.14	0.04	0.02	0.055	Open
Pipe 16	20	200	115	1.46	0.05	0.03	0.054	Open
Pipe 17	14.27	200	115	0.81	0.03	0.01	0.061	Open

Figure 6.17 Table of Network Links Results.

6.8. APPRAISAL OF MURADİYE NETWORK

The average monthly supplied water was converted LPS and entered to one feed point as a reservoir head. The elevation of junctions was taken from city's topographic map; and each nodal demand was calculated for the formula of one half of pipe length over total number of pipes. The pipes length and roughness entered to the Table 6.2.

The reasons for water loss in Muradiye: the unknown pipes which were added to network that exist on network but unknown or the other leakages from network such as from meters, building entrances or illegal pipe connections. The both reasons must be inspected that region immediately. The loss from network is very high when considering area of Muradiye. Totally, Muradiye is slump area and the interference chance to network is easily for illegal usage but difficult to staff to catch illegal usage because of the conditions.

The population in Muradiye is estimated from GIS and supplied water from feeding point is known from flow meter of SCADA. Therefore physical loss and administrative loss is separated. And this thesis inspects the total water loss and allocate to physical and non physical loss for Muradiye Region. The calculations show the huge amount of loss which is unacceptable to use modern monitoring technologies in infrastructure of city. The main reason is unfinished SCADA and GIS-MIS working facilities in Diyarbakır. It is supposed that after the completion of SCADA and GIS-MIS, the physical and non-physical losses will be decreased into acceptable standards values. DİSKİ must be accelerates these workings to intercept loss from network because of the high cost of treated water leakage has economical defects on their budget. Of course, this loss is caused high selling water.

The physical loss is sourced from mostly pipeline leakage. DİSKİ piping and installation standards should be increased. The completion of SCADA is the other real solution of leakage from pipeline. The old pipelines should also be replaced with new pipes to decreased loss from network. New developed areas infrastructure must be installed give attention to use national standards.

The water losses in the city combat immediately. The first target the way of combat losses must be adjust metered consumption in Muradiye and whole city. The customer service connections should be inspected. The meters must be controlled and checked in that region for the meter accuracy. If necessary meter which are defect, broken or old must be replaced with new meters. The tapping methods and arrangements should be changed to combat leakage from customer meters.

Muradiye is mostly residential region and metering all customers' consumption is the second target. Anyway, customer's data were entered to GIS-MIS. The new research in that region addresses un-metered usage. Secondary line means customer may have a meter on one line, but has another un-metered line to be used water. Hence, the secondary lines should be found and prohibited from network. The intentionally reversed meter is the other source of illegal usage and should be obtained to combat losses.

Consequently, the main factors of water losses caused by leakage from customer connections; leakage in private plumping included in the public system as a result of poor metering placement; meter inaccuracy; uncontrolled waste of un-metered water; illegal and secondary service connections; meter tampering-removal and pipeline leakage.

CHAPTER–7: CONCLUSION

The research shows that high water loss from network is the main problem of Diyarbakır water supply system. For visualizing and evaluating the amount of water loss from network in Diyarbakır, a pilot region is selected in water supply system. This pilot region is called Muradiye. Water loss ratio of Muradiye was determined by the aid of new systems namely SCADA and GIS-MIS.

This research aimed to classify and define the total water loss into two categories in Diyarbakır water supply net. The first category is physical loss, which occurs due to unintentional leakage from pipes, and the second category is administrative loss, which is in the category of any water that is consumed but unpaid by the consumer.

The investigations reveal that, on the long term, it would be better to replace the existing pipeline system by a new one to reduce physical loss in network. In fact, the water loss that results from the leakage of old pipeline systems is a loss that has nothing to do with the other types of loss where human is deliberately abusing and wasting water, or, overlooking the lack of balance between the supplied volume/discharge and the one received by the consumer.

Observations show that rooting the causes of administrative loss is much more difficult when compared with the case for physical loss. It could be concluded that in order to aid the reduction of the loss in Muradiye, it would be necessary to categorise the causatives as following:

1- Water-meter inaccuracy.
2- Leaking joints at the consumption point.
3- Illegal Usage of water.
4- Meter Tampering and/or Removal.

Among these four causatives, illegal usage is the main source of unaccounted for water in the Muradiye region, and in fact, the detection of this causative and minimizing its effect is not an easy task at all. Illegal water usage is usually performed through bypassing the water meter of the flat or building by means of a branch directly linked to the main supply line. Consequently, water would be consumed without passing through the water meter of DİSKİ. This is directly related to the quality of water management in DİSKİ.

The advantages of the implementation of new technologies in water supply systems in general are basically the following:

1- Water bills to a more fair.
2- Minimizing water losses in both types: physical and administrative.
3- Prolonging the age of water source due minimizing loss and waste.
4- Minimize the cost of managing the system because of the relatively low number of employees required to operate the new system.
5- Discourage illegal use of water.
6- Centralize the operation and management of water supply system, and also, centralize the location of all relevant data.

After the implementation of such facilities (i.e. SCADA and GIS-MIS) in some zones within the city of Diyarbakır, a clearly significant improvement was observed regarding pinpointing the source/s of both the physical and administrative losses, which lead to a relatively easier solution to the problem. In fact, it seems obvious that the best solution to detect both types of water losses in any water supply system, the SCADA, along with the GIS-MIS would be sufficient to decrease the loss down to the internationally acceptable level that is 15-20%. The main obstacle against the implementation of this new technology is the relatively initial high cost. On the other hand, this research shows that the cost of water losses (both types) from the network in average is about 93 times larger than the cost of implementing the new technology (İ.E. SCADA, GIS, MIS etc.) that would be sufficient to minimize the losses.

There is always that classic question whether the purchase and implementation of such technology (training staff to use it properly and efficiently) would worth that cost or not. In our case, where the only responsible authority for water supply systems is the municipality, which belongs to the Government, the long bureaucratic procedures required appointing a contractor and start the execution consumes such a long time that could significantly delay the project to an unlimited time. The evaluation of the urgency of the implementation of such improvement on the system is directly related to both the availability of funds to initiate such projects, and to the response of the relevant authority towards the water loss problem.

In fact, the responsible authority has to pay attention to complete the installation of the recommended new technologies on the existing water systems on time. The Authority must control all contract activities at site in order to improve the quality of the executed works and to minimize any probable delays. The water system operators as well as all the relevant staffs should have enough technical skills to use and control such new technologies. In order to achieve a highly qualified level to control new technologies efficiently, it is recommended that the authority should arrange courses of different levels to the engineers and staff that need to improve their knowledge about the new technologies. Some of these courses may be available within Turkey, and others may be available only abroad, but certainly worth the cost.

Future research in this field, especially in water system of Diyarbakır, is likely to be fruitful when investigating the methods that would sufficiently and efficiently reduce the water losses. Obviously, the research is supposed to investigate the way to combat the problem with the consideration of time factor as well as the economic cost of implementing the new technologies recommended in this thesis.

With time, Diyarbakır water supply system is likely to be fully controlled by SCADA, GIS and MIS. This should enable future research to obtain all the necessary information and accurate measurements and statistics that would be sufficient to propose certain solution with clear plan for each responsible zone where water losses appear to be significantly high. Naturally, such development in the implementation of new technology and supporting any relevant research and/or investigation needs significant amount of funds. It should be remembered that funding such purposes is rewarded many times fold after achieving the aim of controlling water losses.

This could be enable to find out the whole water loss from Diyarbakır network; and discover the most problematic area on net about water losses; and find out the reasons of its; and also make recommendations to solve the water loss problems in Diyarbakır Water Supply System in related region. If this search is made together with DİSKİ, the necessary funds could find from EU project fund; and with the help of responsible staffs correct measurement taken from network and this enable to obtain the effective working on water loss in Diyarbakır network.

APPENDIX-A: THE INPUTS and OUTPUTS of MURADİYE NETWORK in EPANET

[TITLE]
Project: Diyarbakır Su ve Kanalizasyon İdaresi
Scenario: Muradiye Drinking Water Network Hydraulic Model
Date: 01/05/2008
[JUNCTIONS]

ID	Nodes	Demand
1	650.000	0.2401
2	653.900	0.1657
3	657.100	0.2861
4	651.500	0.0478
5	657.300	0.0783
6	659.900	0.4533
7	655.000	0.2108
8	653.250	0.0530
9	653.000	0.2078
10	654.750	0.0994
11	652.300	0.0428
12	654.900	0.0430
13	649.500	0.0717
14	650.100	0.0346
15	652.000	0.0247
16	653.000	0.0163
17	653.100	0.0190
18	653.100	0.0328
19	652.000	0.0633
20	653.300	0.0873
21	653.000	0.0596
22	653.000	0.0602
23	653.000	0.0422
24	653.000	0.0422
25	654.300	0.0777
26	654.300	0.0368
27	654.000	0.0354
28	654.000	0.0505
29	656.100	0.0545
30	653.80	0.1416
31	654.500	0.1115
32	657.000	0.1687
33	659.000	0.0783
34	658.500	0.0873
35	659.800	0.0783
36	652.000	0.3072
37	653.500	0.2410
38	658.400	0.1672
39	657.300	0.1325
40	654.300	0.1416
41	655.100	0.0111
42	651.900	0.0648
43	653.000	0.0663
44	653.300	0.1822

45	653.000	0.0417
46	651.900	0.2169
47	651.800	0.2048
48	651.900	0.0753
49	652.000	0.1024
50	660.000	0.1594
51	657.50	0.2861
52	655.000	0.2108
53	654.750	0.1416
54	653.800	0.1416
55	648.60	0.3645
56	657.400	0.1009
57	657.400	0.1461
58	651.900	0.0241
59	655.000	0.0479
60	649.800	0.0482
61	659.800	0.0459
62	650.400	0.0858
63	648.600	0.0964
64	654.500	0.0223
65	654.900	0.0617
66	654.500	0.0352
67	654.500	0.1461
68	654.500	0.0669
69	651.900	0.0669
70	651.900	0.0241
71	648.600	0.0964
72	653.900	0.1657
73	655.000	0.0108
75	656.600	0.3072
76	655.900	0.0753
77	652.000	0.0397
78	651.900	0.0994
79	657.300	0.1325
80	653.500	0.0482
81	653.900	0.1295
82	654.400	0.1385
83	654.300	0.1416
84	654.800	0.1145
85	654.300	0.0368
86	658.250	0.0524
87	657.800	0.1536
88	657.40	0.1619
89	653.200	0.0362
90	653.500	0.0515
91	651.800	0.0452
92	651.900	0.0663
93	651.600	0.2108
94	658.100	0.0722
95	658.500	0.2952

96	654.000	0.2471
97	657.300	0.0580
98	656.200	0.0933
99	654.200	0.1205
100	654.000	0.0888
101	655.800	0.0505
102	652.300	0.1401
103	653.000	0.1973
104	653.300	0.2108
105	653.200	0.1837
106	653.000	0.1566
107	653.000	0.1205
108	652.000	0.1114
109	652.500	0.2530
110	652.800	0.2169
111	651.800	0.0499
112	655.900	0.0753
113	650.000	0.1674
114	657.300	0.1958
115	658.500	0.2680
116	653.200	0.0211
117	654.500	0.1506
118	649.300	0.1958
119	658.300	0.3373
120	651.800	0.1205
121	647.500	0.1084
122	653.600	0.0904
123	651.750	0.1657
124	656.000	0.2861
125	654.000	0.0919
126	658.100	0.0662
127	657.600	0.09698
128	657.350	0.0976
129	657.250	0.1114
130	653.500	0.1054
131	653.30	0.1205
132	653.100	0.1506
133	651.500	0.0241
134	654.300	0.1205
135	657.900	0.1657
136	653.600	0.0934
137	648.000	0.0843
138	655.800	0.0892
139	654.750	0.0693
140	659.900	0
141	659.800	0.0783
142	659.000	0.0783
143	658.500	0.0873
144	657.500	0.2861
145	657.000	0.1687

146	655.000	0.2108
147	654.750	0.0994
148	654.500	0.1115
149	653.800	0.1416
150	653.900	0.1657
151	650.000	0.2401
152	648.600	0.3645
153	648.600	0.09634
154	650.400	0.0858
155	654.500	0.1461
156	657.400	0.1009
157	651.900	0.0753
158	651.900	0.0241
159	651.900	0.0669
160	654.500	0.0352
161	649.800	0.0482
162	650.100	0.0346
163	649.500	0.0717
164	654.900	0.0430
166	650.000	0.1674
167	653.600	0.0904
168	653.600	0.0934
169	657.300	0.1958
170	657.900	0.1657

[RESERVOIRS]

ID	Head	Pattern
74	1675	

N1: NODE1, N2: NODE2, L: Length, D: Diameter, R: Roughness, ML: Minor Loss

[PIPES]

ID	N1	N2	L	D	R	ML	Status
1	50	6	150.5	150	115	1	Open
2	33	34	29.0	150	115	1	Open
3	35	33	26.0	150	115	1	Open
4	6	35	26.0	150	115	1	Open
5	51	32	56.0	150	115	1	Open
6	7	10	33.0	150	115	1	Open
7	52	7	1.34	150	115	1	Open
8	53	31	37.0	150	115	1	Open
9	30	72	55.0	150	115	1	Open
10	54	30	1.82	150	115	1	Open
11	55	71	32	200	115	1	Open
12	1	55	121	200	115	1	Open
13	48	70	8	200	115	1	Open
14	56	48	25	200	115	1	Open
15	57	56	32	200	115	1	Open
16	58	69	20	200	115	1	Open
17	13	12	14.27	200	115	1	Open
18	59	13	23.79	200	115	1	Open
19	60	14	11.5	200	115	1	Open

20	61	60	1.54	200	115	1	Open
21	62	67	48.5	200	115	1	Open
22	63	62	28.5	200	115	1	Open
23	64	66	1.97	200	115	1	Open
24	34	51	95.00	150	115	1	Open
26	66	61	15.23	200	115	1	Open
27	67	57	1.87	200	115	1	Open
28	14	59	1.54	200	115	1	Open
29	12	65	2.04	200	115	1	Open
30	68	64	7.41	200	115	1	Open
31	69	68	2.32	200	115	1	Open
32	70	58	2.11	200	115	1	Open
33	71	63	2.06	200	115	1	Open
34	2	1	79.70	150	115	1	Open
35	72	2	1.9	150	115	1	Open
36	31	54	47.00	150	115	1	Open
37	10	53	3.24	150	115	1	Open
38	73	52	70.00	150	115	1	Open
39	32	73	3.6	150	115	1	Open
40	74	50	52.94	150	115	1	Open
41	3	98	95	100	145	1	Open
42	75	99	102	100	145	1	Open
43	76	112	3.28	100	115	1	Open
44	4	113	55.57	100	145	1	Open
45	77	78	17.29	100	145	1	Open
46	78	122	30	100	145	1	Open
47	29	101	16.78	100	145	1	Open
48	27	85	12.23	100	145	1	Open
49	79	39	2.77	100	115	1	Open
50	80	37	16	100	145	1	Open
51	81	90	17.11	100	145	1	Open
52	5	114	65	100	145	1	Open
53	6	115	89.00	100	145	1	Open
54	7	84	38	100	145	1	Open
55	41	83	28	100	145	1	Open
56	8	37	65	100	145	1	Open
57	70	123	55	100	145	1	Open
58	82	124	95	100	145	1	Open
59	9	116	7	100	145	1	Open
60	10	83	47	100	145	1	Open
61	11	55	59	100	145	1	Open
62	12	117	50	100	145	1	Open
63	13	118	65	100	145	1	Open
64	14	93	70	100	145	1	Open
65	15	92	22	100	145	1	Open
66	47	93	8.09	100	145	1	Open
67	16	111	75	100	145	1	Open
68	17	109	84	100	145	1	Open
69	18	80	70	100	145	1	Open
70	19	42	53	100	145	1	Open

71	36	102	56	100	145	1	Open
72	20	116	79	100	145	1	Open
73	21	78	33	100	145	1	Open
74	22	49	34	100	145	1	Open
75	23	108	37	100	145	1	Open
76	24	107	40	100	145	1	Open
77	25	106	52	100	145	1	Open
78	26	105	61	100	145	1	Open
79	27	44	60.50	100	145	1	Open
80	28	104	70	100	145	1	Open
81	29	43	71.00	100	145	1	Open
82	83	40	3.37	100	145	1	Open
83	72	81	43	100	145	1	Open
84	30	36	102	100	145	1	Open
85	31	103	65.50	100	145	1	Open
86	84	41	3.69	100	145	1	Open
87	32	96	82.03	100	145	1	Open
88	51	88	53.74	100	145	1	Open
89	33	95	98.00	100	145	1	Open
90	34	38	55.50	100	145	1	Open
91	35	119	112.0	100	145	1	Open
92	85	125	30.50	100	145	1	Open
93	86	94	8.59	100	145	1	Open
94	86	126	22.00	100	145	1	Open
95	38	87	51.00	100	145	1	Open
96	87	127	32.20	100	145	1	Open
97	88	97	19.26	100	145	1	Open
98	88	128	32.4	100	145	1	Open
99	5	129	37	100	145	1	Open
100	89	11	14.22	100	145	1	Open
101	90	89	12.02	100	145	1	Open
102	81	130	35	100	145	1	Open
103	90	131	40	100	145	1	Open
104	89	132	50	100	145	1	Open
105	19	133	8	100	145	1	Open
106	36	19	21	100	145	1	Open
107	91	4	18	100	145	1	Open
108	92	91	15	100	145	1	Open
109	9	67	69	100	145	1	Open
110	37	56	80	100	145	1	Open
111	93	4	15.83	100	145	1	Open
112	66	134	40	100	145	1	Open
113	94	135	55.00	100	145	1	Open
114	95	94	24.00	100	145	1	Open
115	96	97	58.61	100	145	1	Open
116	96	101	71.99	100	145	1	Open
117	97	79	33	100	145	1	Open
118	38	86	17.41	100	145	1	Open
119	79	87	44	100	145	1	Open
120	39	98	31	100	145	1	Open

121	39	5	26	100	145	1	Open
122	98	82	46	100	145	1	Open
123	82	99	40	100	145	1	Open
124	99	100	29.5	100	145	1	Open
125	21	136	31	100	145	1	Open
126	22	21	19.8	100	145	1	Open
127	23	22	20	100	145	1	Open
128	24	23	14	100	145	1	Open
129	100	24	14	100	145	1	Open
130	25	100	19.26	100	145	1	Open
131	26	25	25.82	100	145	1	Open
132	85	26	2.26	100	145	1	Open
133	28	27	11.75	100	145	1	Open
134	101	28	5.94	100	145	1	Open
135	40	103	38	100	145	1	Open
136	41	76	25	100	145	1	Open
137	11	102	46.5	100	145	1	Open
138	102	42	21.50	100	145	1	Open
139	42	62	55	100	145	1	Open
140	103	43	22	100	145	1	Open
141	43	104	29	100	145	1	Open
142	104	20	29	100	145	1	Open
143	20	44	10.29	100	145	1	Open
144	44	8	17.62	100	145	1	Open
145	105	18	10.9	100	145	1	Open
146	106	17	6.31	100	145	1	Open
147	18	106	16.62	100	145	1	Open
148	17	45	13.83	100	145	1	Open
149	45	107	13.38	100	145	1	Open
150	45	110	72	100	145	1	Open
151	107	16	5.4	100	145	1	Open
152	16	108	5.19	100	145	1	Open
153	108	15	8.21	100	145	1	Open
154	15	49	13.17	100	145	1	Open
155	46	69	72	100	145	1	Open
156	109	46	9	100	145	1	Open
157	110	111	16.58	100	145	1	Open
158	111	47	8.85	100	145	1	Open
159	47	60	68	100	145	1	Open
160	71	137	28	100	145	1	Open
161	48	120	40	100	145	1	Open
162	112	138	29.62	100	145	1	Open
163	112	29	18.1	100	145	1	Open
164	84	139	23	100	145	1	Open
165	8	105	17.62	100	145	1	Open
166	49	77	13.17	100	145	1	Open
25	65	121	36	200	110	0	Open

N1: NODE1, N2: NODE2, D: Diameter, ML: Minor Loss

[VALVES]

ID	N1	N2	D	Type	Setting	ML
167	6	140	100	FCV	0	0
168	35	141	100	FCV	0	0
169	33	142	100	FCV	0	0
170	34	143	100	FCV	1	0
171	51	144	100	FCV	0	0
172	32	145	100	FCV	0	0
173	7	146	100	FCV	0	0
174	10	147	100	FCV	0	0
175	31	148	100	FCV	0	0
176	30	149	100	FCV	0	0
177	72	150	100	FCV	0	0
178	1	151	100	FCV	0	0
179	55	152	100	FCV	0	0
180	71	153	100	FCV	0	0
181	62	154	100	FCV	0	0
182	67	155	100	FCV	0	0
183	56	156	100	FCV	0	0
184	48	157	100	FCV	0	0
185	70	158	100	FCV	0	0
186	69	159	100	FCV	0	0
187	66	160	100	FCV	0	0
188	60	161	100	FCV	0	0
189	14	162	100	FCV	0	0
190	13	163	100	FCV	0	0
191	12	164	100	FCV	0	0
192	113	166	100	FCV	0	0
193	122	167	100	FCV	0	0
194	136	168	100	FCV	0	0
195	114	169	100	FCV	0	0
196	135	170	100	FCV	0	0

[STATUS]

ID	Status/Setting
167-196	Open

[PATTERNS]

ID	Multipliers					
1	1	2	2	5	8	10
1	15	17	24	20	16	14
1	10	8	15	20	16	8
1	5	4	2	2	1.5	1

[TIMES]
Duration 24
Hydraulic Timestep 1:00
Quality Timestep 0:05
Pattern Timestep 6
Pattern Start 0:00
Report Timestep 1:00
Report Start 0:00
Start ClockTime 12 am
Statistic None

[OPTIONS]
Units LPS
Headloss H-W
Specific Gravity 0.998
Viscosity 0.10803737e-4
Trials 40
Accuracy 0.001
Unbalanced Continue 10
Pattern 1
Demand Multiplier 1.0
Emitter Exponent 0.5
Quality None mg/L
Diffusivity 1
Tolerance 0.01

[COORDINATES]

Node	X-Coord	Y-Coord
1	1134937.32	4223333.23
2	1134865.77	4223301.84
3	1134592.66	4223009.68
4	1134822.03	4223004.62
5	1134580.11	4223075.03
6	1134418.96	4223143.63
7	1134703.92	4223243.75
8	1134778.24	4223115.85
9	1134850.82	4223127.84
10	1134730.87	4223253.05
11	1134860.52	4223215.44
12	1134890.53	4222966.29
13	1134892.28	4222980.52
14	1134895.41	4223005.79
15	1134765.43	4223029.99
16	1134767.37	4223042.49
17	1134772.78	4223075.55
18	1134776.89	4223098.22
19	1134805.61	4223157.10
20	1134777.90	4223137.12
21	1134730.93	4222998.34
22	1134729.58	4223018.19

23	1134728.16	4223038.59
24	1134727.24	4223053.01
25	1134722.97	4223086.73
26	1134719.52	4223112.43
27	1134718.42	4223126.96
28	1134717.48	4223138.73
29	1134715.06	4223160.32
30	1134811.19	4223282.26
31	1134766.99	4223266.12
32	1134636.77	4223219.67
33	1134468.73	4223161.76
34	1134494.89	4223171.34
35	1134444.58	4223152.94
36	1134807.21	4223178.50
37	1134831.64	4223107.29
38	1134497.75	4223117.25
39	1134587.71	4223099.30
40	1134737.94	4223206.67
41	1134710.13	4223204.74
42	1134856.37	4223154.27
43	1134773.06	4223183.62
44	1134778.72	4223126.81
45	1134769.62	4223062.02
46	1134841.60	4223053.86
47	1134828.65	4223027.70
48	1134903.98	4223081.28
49	1134765.45	4223019.83
50	1134324.03	4223112.52
51	1134582.77	4223201.67
52	1134702.65	4223243.31
53	1134733.95	4223254.11
54	1134809.47	4223281.64
55	1134918.92	4223210.79
56	1134906.10	4223102.49
57	1134907.91	4223120.62
58	1134902.81	4223069.48
59	1134895.22	4223004.26
60	1134896.93	4223017.25
61	1134897.14	4223018.78
62	1134911.67	4223151.67
63	1134914.76	4223177.13
64	1134899.08	4223035.96
65	1134890.27	4222964.26
66	1134898.85	4223033.99
67	1134908.13	4223122.49
68	1134899.92	4223043.36
69	1134900.17	4223045.67
70	1134903.02	4223071.59
71	1134915.01	4223179.18
72	1134863.98	4223301.20

73	1134640.19	4223220.82
75	1134676.96	4222987.00
76	1134712.76	4223180.38
77	1134765.45	4223016.76
78	1134765.93	4222999.40
79	1134584.99	4223099.91
80	1134830.13	4223091.53
81	1134862.29	4223258.96
82	1134660.76	4223081.70
83	1134734.56	4223206.49
84	1134709.67	4223208.43
85	1134719.34	4223114.70
86	1134497.64	4223091.43
87	1134542.33	4223110.10
88	1134585.45	4223153.35
89	1134860.87	4223229.72
90	1134861.66	4223241.77
91	1134803.73	4223007.11
92	1134806.70	4223022.08
93	1134826.01	4223020.01
94	1134497.62	4223082.80
95	1134467.54	4223082.29
96	1134644.85	4223137.65
97	1134586.07	4223134.01
98	1134616.08	4223092.52
99	1134697.90	4223073.53
100	1134725.83	4223067.58
101	1134716.94	4223143.56
102	1134857.61	4223176.06
103	1134772.12	4223206.80
104	1134775.28	4223162.11
105	1134777.94	4223109.12
106	1134773.14	4223079.67
107	1134767.35	4223048.78
108	1134766.35	4223038.19
109	1134842.28	4223063.42
110	1134825.34	4223048.17
111	1134820.92	4223032.10
112	1134712.96	4223178.38
113	1134815.24	4222949.20
114	1134563.87	4223014.61
115	1134425.01	4223056.80
116	1134845.02	4223133.18
117	1134843.00	4222977.19
118	1134831.47	4222992.98
119	1134450.01	4223049.55
120	1134866.33	4223083.87
121	1134886.02	4222933.79
122	1134765.20	4222960.09
123	1134852.63	4223076.31

124	1134639.52	4222997.19
125	1134688.55	4223117.29
126	1134522.31	4223092.05
127	1134539.65	4223152.31
128	1134617.73	4223157.58
129	1134554.96	4223082.87
130	1134835.59	4223258.26
131	1134830.34	4223243.80
132	1134825.68	4223231.02
133	1134804.93	4223148.66
134	1134855.78	4223040.01
135	1134497.17	4223037.75
136	1134732.72	4222967.15
137	1134888.05	4223182.44
138	1134683.34	4223175.46
139	1134686.94	4223205.99
140	1134419.03	4223143.19
141	1134444.62	4223152.50
142	1134468.74	4223161.38
143	1134494.93	4223170.86
144	1134582.79	4223201.31
145	1134636.82	4223219.19
146	1134704.01	4223243.34
147	1134730.92	4223252.56
148	1134767.05	4223265.58
149	1134811.18	4223281.67
150	1134863.96	4223300.70
151	1134937.25	4223332.89
152	1134918.48	4223210.85
153	1134914.31	4223179.27
154	1134910.97	4223151.71
155	1134907.45	4223122.57
156	1134904.95	4223102.59
157	1134903.32	4223081.33
158	1134902.43	4223071.64
159	1134899.32	4223045.78
160	1134898.11	4223034.09
161	1134896.14	4223017.38
162	1134894.80	4223005.91
163	1134891.53	4222980.68
164	1134889.85	4222966.49
166	1134815.85	4222954.69
167	1134765.21	4222963.83
168	1134732.52	4222970.24
169	1134564.50	4223016.99
170	1134497.20	4223042.11
74	1134272.43	4223098.86

[VERTICES]

Link	X-Coord	Y-Coord
12	1134928.17	4223285.70
34	1134915.56	4223323.06
41	1134595.26	4223019.05
41	1134600.15	4223036.70
41	1134606.24	4223058.89
44	1134819.50	4222984.68
44	1134817.68	4222970.16
52	1134573.13	4223053.21
52	1134567.96	4223029.60
53	1134421.77	4223127.89
53	1134423.24	4223107.90
53	1134424.00	4223084.74
53	1134424.63	4223069.48
54	1134706.93	4223228.01
54	1134708.41	4223218.47
56	1134813.12	4223110.34
59	1134848.79	4223127.91
59	1134848.94	4223132.90
60	1134732.55	4223235.31
61	1134871.14	4223214.95
61	1134886.75	4223214.17
61	1134902.46	4223212.65
62	1134865.34	4222973.26
62	1134843.12	4222977.11
62	1134843.12	4222977.11
62	1134843.12	4222977.11
63	1134831.47	4222992.98
64	1134854.89	4223013.92
65	1134789.32	4223025.46
67	1134785.96	4223039.25
68	1134810.44	4223068.82
68	1134826.76	4223065.99
69	1134805.49	4223094.75
70	1134822.25	4223156.04
70	1134830.83	4223155.60
72	1134794.40	4223136.33
72	1134817.09	4223134.87
73	1134748.86	4222999.03
74	1134747.22	4223019.13
75	1134748.79	4223038.75
76	1134742.60	4223051.38
76	1134751.57	4223050.47
76	1134758.54	4223049.59
77	1134739.48	4223085.45
77	1134756.93	4223083.76
78	1134735.77	4223111.86
78	1134751.17	4223110.86
79	1134751.81	4223127.04

80	1134738.00	4223146.33
80	1134752.27	4223152.22
80	1134761.56	4223156.22
81	1134743.75	4223170.63
81	1134753.89	4223175.07
81	1134762.25	4223178.64
84	1134810.93	4223263.13
84	1134810.22	4223250.76
84	1134810.29	4223243.80
84	1134808.80	4223216.49
84	1134808.22	4223198.68
85	1134770.56	4223230.97
87	1134641.01	4223180.01
89	1134469.18	4223149.08
89	1134469.06	4223128.87
89	1134468.68	4223115.70
90	1134496.75	4223138.01
91	1134447.42	4223114.16
91	1134449.12	4223076.05
106	1134805.61	4223157.10
109	1134863.83	4223126.93
109	1134888.84	4223124.56
110	1134851.41	4223106.37
110	1134879.80	4223104.61
118	1134497.66	4223098.31
120	1134602.95	4223095.81
131	1134720.96	4223100.87
135	1134748.12	4223206.76
136	1134711.45	4223191.82
137	1134859.33	4223197.01
139	1134872.27	4223153.83
139	1134892.31	4223152.91
141	1134774.16	4223171.52
150	1134785.96	4223058.09
150	1134805.94	4223053.04
155	1134866.47	4223050.31
155	1134885.04	4223047.48
159	1134838.54	4223026.49
159	1134864.54	4223022.20
161	1134874.55	4223083.45
175	1134767.05	4223265.55
178	1134937.24	4223332.86

Project: Diyarbakır Su ve Kanalizasyon İdaresi
Network Table - Nodes at 11:00 Hrs
Elevation: Relative to reference elevation on the Treatment Plant

Node ID	Nodes	Base-Demand LPS	Demand LPS	Head m	Elevation m
Junc 1	650.000	0.2401	0.48	1659.21	1007.19
Junc 2	653.900	0.1657	0.33	1659.24	1003.33
Junc 3	657.100	0.2861	0.57	1660.06	1000.95
Junc 4	651.500	0.0478	0.10	1659.20	1005.69
Junc 5	657.300	0.0783	0.16	1660.37	1001.07
Junc 6	659.900	0.4533	0.91	1665.86	1003.95
Junc 7	655.000	0.2108	0.42	1659.65	1002.64
Junc 8	653.250	0.0530	0.11	1659.29	1004.03
Junc 9	653.000	0.2078	0.42	1659.24	1004.23
Junc 10	654.750	0.0994	0.20	1659.53	1002.77
Junc 11	652.300	0.0428	0.09	1659.21	1004.90
Junc 12	654.900	0.0430	0.09	1659.20	1002.29
Junc 13	649.500	0.0717	0.14	1659.20	1007.68
Junc 14	650.100	0.0346	0.07	1659.20	1007.08
Junc 15	652.000	0.0247	0.05	1659.22	1005.21
Junc 16	653.000	0.0163	0.03	1659.23	1004.21
Junc 17	653.100	0.0190	0.04	1659.24	1004.13
Junc 18	653.100	0.0328	0.07	1659.27	1004.16
Junc 19	652.000	0.0633	0.13	1659.21	1005.20
Junc 20	653.300	0.0873	0.17	1659.32	1004.01
Junc 21	653.000	0.0596	0.12	1659.22	1004.21
Junc 22	653.000	0.0602	0.12	1659.22	1004.21
Junc 23	653.000	0.0422	0.08	1659.23	1004.22
Junc 24	653.000	0.0422	0.08	1659.25	1004.24
Junc 25	654.300	0.0777	0.16	1659.30	1002.99
Junc 26	654.300	0.0368	0.07	1659.31	1003.00
Junc 27	654.000	0.0354	0.07	1659.36	1003.35
Junc 28	654.000	0.0505	0.10	1659.43	1003.42
Junc 29	656.100	0.0545	0.11	1659.50	1001.39
Junc 30	653.80	0.1416	0.28	1659.30	1003.49
Junc 31	654.500	0.1115	0.22	1659.44	1002.93
Junc 32	657.000	0.1687	0.34	1660.26	1001.25
Junc 33	659.000	0.0783	0.16	1663.40	1002.39
Junc 34	658.500	0.0873	0.17	1662.53	1002.02
Junc 35	659.800	0.0783	0.16	1664.60	1002.79
Junc 36	652.000	0.3072	0.61	1659.22	1005.20
Junc 37	653.500	0.2410	0.48	1659.26	1003.74
Junc 38	658.400	0.1672	0.33	1662.22	1001.81
Junc 39	657.300	0.1325	0.26	1660.38	1001.07
Junc 40	654.300	0.1416	0.28	1659.50	1003.19
Junc 41	655.100	0.0111	0.02	1659.53	1002.42
Junc 42	651.900	0.0648	0.13	1659.21	1005.29
Junc 43	653.000	0.0663	0.13	1659.45	1004.44
Junc 44	653.300	0.1822	0.36	1659.32	1004.01
Junc 45	653.000	0.0417	0.08	1659.23	1004.22
Junc 46	651.900	0.2169	0.43	1659.20	1005.29
Junc 47	651.800	0.2048	0.41	1659.20	1005.39
Junc 48	651.900	0.0753	0.15	1659.20	1005.29
Junc 49	652.000	0.1024	0.20	1659.22	1005.21
Junc 50	660.000	0.1594	0.32	1672.47	1010.45
Junc 51	657.50	0.2861	0.57	1660.84	1001.34
Junc 52	655.000	0.2108	0.42	1659.69	1002.68
Junc 53	654.750	0.1416	0.28	1659.52	1002.76
Junc 54	653.800	0.1416	0.28	1659.32	1003.50
Junc 55	648.60	0.3645	0.73	1659.21	1008.58

Junc 56	657.400	0.1009	0.20	1659.20	999.80
Junc 57	657.400	0.1461	0.29	1659.20	999.80
Junc 58	651.900	0.0241	0.05	1659.20	1005.29
Junc 59	655.000	0.0479	0.10	1659.20	1002.19
Junc 60	649.800	0.0482	0.10	1659.20	1007.38
Junc 61	659.800	0.0459	0.09	1659.20	997.40
Junc 62	650.400	0.0858	0.17	1659.20	1006.79
Junc 63	648.600	0.0964	0.19	1659.20	1008.58
Junc 64	654.500	0.0223	0.04	1659.20	1002.69
Junc 65	654.900	0.0617	0.12	1659.20	1002.29
Junc 66	654.500	0.0352	0.07	1659.20	1002.69
Junc 67	654.500	0.1461	0.29	1659.20	1002.70
Junc 68	654.500	0.0669	0.13	1659.20	1002.69
Junc 69	651.900	0.0669	0.13	1659.20	1005.29
Junc 70	651.900	0.0241	0.05	1659.20	1005.29
Junc 71	648.600	0.0964	0.19	1659.20	1008.58
Junc 72	653.900	0.1657	0.33	1659.24	1003.33
Junc 73	655.000	0.0108	0.02	1660.20	1003.19
Junc 75	656.600	0.3072	0.61	1659.44	1000.83
Junc 76	655.900	0.0753	0.15	1659.51	1001.61
Junc 77	652.000	0.0397	0.08	1659.22	1005.21
Junc 78	651.900	0.0994	0.20	1659.22	1005.31
Junc 79	657.300	0.1325	0.26	1660.50	1001.19
Junc 80	653.500	0.0482	0.10	1659.26	1003.75
Junc 81	653.900	0.1295	0.26	1659.22	1003.31
Junc 82	654.400	0.1385	0.28	1659.70	1003.29
Junc 83	654.300	0.1416	0.28	1659.51	1003.20
Junc 84	654.800	0.1145	0.23	1659.55	1002.74
Junc 85	654.300	0.0368	0.07	1659.32	1003.01
Junc 86	658.250	0.0524	0.10	1662.32	1002.06
Junc 87	657.800	0.1536	0.31	1661.26	1001.45
Junc 88	657.40	0.1619	0.32	1660.58	1001.17
Junc 89	653.200	0.0362	0.07	1659.21	1004.00
Junc 90	653.500	0.0515	0.10	1659.21	1003.70
Junc 91	651.800	0.0452	0.09	1659.21	1005.39
Junc 92	651.900	0.0663	0.13	1659.21	1005.30
Junc 93	651.600	0.2108	0.42	1659.20	1005.59
Junc 94	658.100	0.0722	0.14	1662.39	1002.28
Junc 95	658.500	0.2952	0.59	1662.59	1002.08
Junc 96	654.000	0.2471	0.49	1660.17	1004.16
Junc 97	657.300	0.0580	0.12	1660.49	1001.18
Junc 98	656.200	0.0933	0.19	1660.06	1001.86
Junc 99	654.200	0.1205	0.24	1659.45	1003.24
Junc 100	654.000	0.0888	0.18	1659.31	1003.29
Junc 101	655.800	0.0505	0.10	1659.50	1001.70
Junc 102	652.300	0.1401	0.28	1659.21	1004.90
Junc 103	653.000	0.1973	0.39	1659.45	1004.44
Junc 104	653.300	0.2108	0.42	1659.40	1004.09
Junc 105	653.200	0.1837	0.37	1659.28	1004.07
Junc 106	653.000	0.1566	0.31	1659.26	1004.25
Junc 107	653.000	0.1205	0.24	1659.23	1004.22
Junc 108	652.000	0.1114	0.22	1659.23	1005.21
Junc 109	652.500	0.2530	0.51	1659.21	1004.69
Junc 110	652.800	0.2169	0.43	1659.21	1004.40
Junc 111	651.800	0.0499	0.10	1659.21	1005.40
Junc 112	655.900	0.0753	0.15	1659.51	1001.60
Junc 113	650.000	0.1674	0.33	1659.20	1007.18
Junc 114	657.300	0.1958	0.39	1660.36	1001.06
Junc 115	658.500	0.2680	0.54	1665.85	1005.34
Junc 116	653.200	0.0211	0.04	1659.25	1004.04
Junc 117	654.500	0.1506	0.30	1659.20	1002.69

Junc 118	649.300	0.1958	0.39	1659.20	1007.88
Junc 119	658.300	0.3373	0.67	1664.59	1004.28
Junc 120	651.800	0.1205	0.24	1659.20	1005.39
Junc 121	647.500	0.1084	0.22	1659.20	1009.68
Junc 122	653.600	0.0904	0.18	1659.22	1003.61
Junc 123	651.750	0.1657	0.33	1659.20	1005.44
Junc 124	656.000	0.2861	0.57	1659.69	1001.68
Junc 125	654.000	0.0919	0.18	1659.32	1003.31
Junc 126	658.100	0.0662	0.13	1662.32	1002.21
Junc 127	657.600	0.09698	0.19	1661.26	1001.65
Junc 128	657.350	0.0976	0.20	1660.58	1001.22
Junc 129	657.250	0.1114	0.22	1660.37	1001.11
Junc 130	653.500	0.1054	0.21	1659.22	1003.70
Junc 131	653.30	0.1205	0.24	1659.21	1003.90
Junc 132	653.100	0.1506	0.30	1659.21	1004.10
Junc 133	651.500	0.0241	0.05	1659.21	1005.70
Junc 134	654.300	0.1205	0.24	1659.20	1002.89
Junc 135	657.900	0.1657	0.33	1662.39	1002.48
Junc 136	653.600	0.0934	0.19	1659.22	1003.61
Junc 137	648.000	0.0843	0.17	1659.20	1009.18
Junc 138	655.800	0.0892	0.18	1659.51	1001.70
Junc 139	654.750	0.0693	0.14	1659.55	1002.79
Junc 140	659.900	0	0.00	1665.86	1003.95
Junc 141	659.800	0.0783	0.16	1664.60	1002.79
Junc 142	659.000	0.0783	0.16	1663.40	1002.39
Junc 143	658.500	0.0873	0.17	1662.53	1002.02
Junc 144	657.500	0.2861	0.57	1660.84	1001.34
Junc 145	657.000	0.1687	0.34	1660.26	1001.25
Junc 146	655.000	0.2108	0.42	1659.65	1002.64
Junc 147	654.750	0.0994	0.20	1659.53	1002.77
Junc 148	654.500	0.1115	0.22	1659.44	1002.93
Junc 149	653.800	0.1416	0.28	1659.30	1003.49
Junc 150	653.900	0.1657	0.33	1659.24	1003.33
Junc 151	650.000	0.2401	0.48	1659.21	1007.19
Junc 152	648.600	0.3645	0.73	1659.21	1008.58
Junc 153	648.600	0.09634	0.19	1659.20	1008.58
Junc 154	650.400	0.0858	0.17	1659.20	1006.79
Junc 155	654.500	0.1461	0.29	1659.20	1002.70
Junc 156	657.400	0.1009	0.20	1659.20	999.80
Junc 157	651.900	0.0753	0.15	1659.20	1005.29
Junc 158	651.900	0.0241	0.05	1659.20	1005.29
Junc 159	651.900	0.0669	0.13	1659.20	1005.29
Junc 160	654.500	0.0352	0.07	1659.20	1002.69
Junc 161	649.800	0.0482	0.10	1659.20	1007.38
Junc 162	650.100	0.0346	0.07	1659.20	1007.08
Junc 163	649.500	0.0717	0.14	1659.20	1007.68
Junc 164	654.900	0.0430	0.09	1659.20	1002.29
Junc 166	650.000	0.1674	0.33	1659.20	1007.18
Junc 167	653.600	0.0904	0.18	1659.22	1003.61
Junc 168	653.600	0.0934	0.19	1659.22	1003.61
Junc 169	657.300	0.1958	0.39	1660.36	1001.06
Junc 170	657.900	0.1657	0.33	1662.39	1002.48
Resvr 74	1675	#N/A	-39.81	1675.00	0.00

Project: Diyarbakır Su ve Kanalizasyon İdaresi
Network Table - Links at 11:00 Hrs

Link ID	Flow LPS	Velocity m/s	Unit-Headloss m/km	Fr.F	Status
Pipe 1	39.49	2.23	43.93	0.026	Open
Pipe 2	29.82	1.69	30.10	0.031	Open
Pipe 3	37.06	2.10	46.17	0.031	Open
Pipe 4	38.05	2.15	48.51	0.031	Open
Pipe 5	17.67	1.00	10.43	0.031	Open
Pipe 6	9.67	0.55	3.58	0.035	Open
Pipe 7	14.22	0.80	30.99	0.141	Open
Pipe 8	7.57	0.43	2.23	0.036	Open
Pipe 9	5.36	0.30	1.13	0.036	Open
Pipe 10	7.94	0.45	7.85	0.114	Open
Pipe 11	0.91	0.03	0.01	0.044	Open
Pipe 12	1.87	0.06	0.04	0.042	Open
Pipe 13	1.93	0.06	0.07	0.077	Open
Pipe 14	2.47	0.08	0.07	0.045	Open
Pipe 15	1.14	0.04	0.02	0.055	Open
Pipe 16	1.46	0.05	0.03	0.054	Open
Pipe 17	0.81	0.03	0.01	0.061	Open
Pipe 18	1.49	0.05	0.03	0.054	Open
Pipe 19	1.29	0.04	0.03	0.061	Open
Pipe 20	0.98	0.03	0.00	0.000	Open
Pipe 21	0.40	0.01	0.00	0.075	Open
Pipe 22	0.16	0.01	0.00	0.000	Open
Pipe 23	1.45	0.05	0.08	0.139	Open
Pipe 24	23.96	1.36	17.72	0.028	Open
Pipe 26	1.07	0.03	0.02	0.066	Open
Pipe 27	1.43	0.05	0.08	0.150	Open
Pipe 28	1.59	0.05	0.10	0.148	Open
Pipe 29	0.34	0.01	0.00	0.000	Open
Pipe 30	1.50	0.05	0.04	0.069	Open
Pipe 31	1.63	0.05	0.06	0.093	Open
Pipe 32	1.50	0.05	0.07	0.121	Open
Pipe 33	0.35	0.01	0.00	0.000	Open
Pipe 34	2.83	0.16	0.34	0.039	Open
Pipe 35	3.16	0.18	1.25	0.115	Open
Pipe 36	8.22	0.47	2.55	0.035	Open
Pipe 37	7.85	0.44	5.24	0.078	Open
Pipe 38	14.65	0.83	7.22	0.031	Open
Pipe 39	14.67	0.83	16.50	0.071	Open
Pipe 40	39.81	2.25	47.75	0.028	Open
Pipe 41	-0.57	0.07	0.08	0.030	Open
Pipe 42	-0.61	0.08	0.09	0.029	Open
Pipe 43	1.57	0.20	1.41	0.069	Open
Pipe 44	0.67	0.09	0.11	0.030	Open
Pipe 45	0.31	0.04	0.03	0.032	Open
Pipe 46	0.36	0.05	0.04	0.037	Open
Pipe 47	-0.75	0.10	0.15	0.033	Open
Pipe 48	3.22	0.41	2.62	0.030	Open
Pipe 49	8.77	1.12	41.69	0.066	Open
Pipe 50	0.70	0.09	0.14	0.034	Open
Pipe 51	1.06	0.14	0.30	0.032	Open
Pipe 52	0.78	0.10	0.15	0.029	Open
Pipe 53	0.54	0.07	0.07	0.030	Open
Pipe 54	3.71	0.47	2.78	0.024	Open
Pipe 55	1.60	0.20	0.60	0.028	Open
Pipe 56	1.52	0.19	0.50	0.026	Open
Pipe 57	0.33	0.04	0.03	0.033	Open
Pipe 58	0.57	0.07	0.08	0.030	Open

Pipe 59	-2.04	0.26	1.30	0.038	Open
Pipe 60	1.42	0.18	0.45	0.027	Open
Pipe 61	0.50	0.06	0.06	0.031	Open
Pipe 62	0.30	0.04	0.02	0.032	Open
Pipe 63	0.39	0.05	0.04	0.033	Open
Pipe 64	-0.44	0.06	0.05	0.032	Open
Pipe 65	1.22	0.16	0.37	0.030	Open
Pipe 66	0.63	0.08	0.13	0.039	Open
Pipe 67	0.97	0.12	0.22	0.028	Open
Pipe 68	1.38	0.18	0.42	0.026	Open
Pipe 69	0.80	0.10	0.15	0.029	Open
Pipe 70	0.54	0.07	0.07	0.031	Open
Pipe 71	0.69	0.09	0.12	0.030	Open
Pipe 72	2.08	0.26	0.89	0.025	Open
Pipe 73	0.25	0.03	0.02	0.035	Open
Pipe 74	0.52	0.07	0.07	0.034	Open
Pipe 75	0.90	0.11	0.20	0.029	Open
Pipe 76	1.52	0.19	0.52	0.027	Open
Pipe 77	1.95	0.25	0.82	0.026	Open
Pipe 78	1.53	0.19	0.51	0.026	Open
Pipe 79	1.72	0.22	0.64	0.026	Open
Pipe 80	1.31	0.17	0.38	0.027	Open
Pipe 81	1.88	0.24	0.74	0.026	Open
Pipe 82	2.74	0.35	3.27	0.053	Open
Pipe 83	1.53	0.20	0.53	0.027	Open
Pipe 84	2.01	0.26	0.83	0.025	Open
Pipe 85	-1.10	0.14	0.28	0.028	Open
Pipe 86	3.35	0.43	4.56	0.049	Open
Pipe 87	2.33	0.30	1.10	0.025	Open
Pipe 88	5.14	0.65	4.94	0.023	Open
Pipe 89	6.93	0.88	8.30	0.021	Open
Pipe 90	5.51	0.70	5.62	0.022	Open
Pipe 91	0.67	0.09	0.11	0.029	Open
Pipe 92	0.18	0.02	0.01	0.035	Open
Pipe 93	-5.54	0.70	8.14	0.032	Open
Pipe 94	0.13	0.02	0.01	0.047	Open
Pipe 95	10.48	1.33	18.74	0.021	Open
Pipe 96	0.19	0.02	0.01	0.030	Open
Pipe 97	4.62	0.59	4.64	0.026	Open
Pipe 98	0.20	0.02	0.01	0.029	Open
Pipe 99	0.22	0.03	0.01	0.029	Open
Pipe 100	0.34	0.04	0.04	0.043	Open
Pipe 101	0.72	0.09	0.15	0.035	Open
Pipe 102	0.21	0.03	0.01	0.035	Open
Pipe 103	0.24	0.03	0.01	0.031	Open
Pipe 104	0.30	0.04	0.03	0.036	Open
Pipe 105	0.05	0.01	0.00	0.000	Open
Pipe 106	0.71	0.09	0.13	0.032	Open
Pipe 107	1.00	0.13	0.26	0.032	Open
Pipe 108	1.09	0.14	0.33	0.034	Open
Pipe 109	1.62	0.21	0.57	0.026	Open
Pipe 110	1.74	0.22	0.64	0.026	Open
Pipe 111	-0.23	0.03	0.01	0.021	Open
Pipe 112	0.24	0.03	0.01	0.031	Open
Pipe 113	0.66	0.08	0.11	0.030	Open
Pipe 114	6.34	0.81	8.09	0.024	Open
Pipe 115	-5.44	0.69	5.46	0.022	Open
Pipe 116	7.27	0.93	9.24	0.021	Open
Pipe 117	-0.93	0.12	0.21	0.029	Open
Pipe 118	-5.30	0.67	6.13	0.026	Open
Pipe 119	-9.97	1.27	17.36	0.021	Open

Pipe 120	7.35	0.94	10.24	0.023	Open
Pipe 121	1.16	0.15	0.34	0.030	Open
Pipe 122	6.59	0.84	7.97	0.022	Open
Pipe 123	5.74	0.73	6.25	0.023	Open
Pipe 124	4.88	0.62	4.79	0.024	Open
Pipe 125	0.37	0.05	0.04	0.033	Open
Pipe 126	0.74	0.09	0.15	0.033	Open
Pipe 127	1.38	0.18	0.48	0.030	Open
Pipe 128	2.37	0.30	1.40	0.030	Open
Pipe 129	3.97	0.50	3.74	0.029	Open
Pipe 130	-0.74	0.09	0.15	0.032	Open
Pipe 131	1.37	0.17	0.44	0.029	Open
Pipe 132	2.97	0.38	4.87	0.067	Open
Pipe 133	5.02	0.64	6.11	0.029	Open
Pipe 134	6.43	0.82	12.60	0.037	Open
Pipe 135	2.46	0.31	1.29	0.026	Open
Pipe 136	1.72	0.22	0.70	0.029	Open
Pipe 137	-0.24	0.03	0.02	0.035	Open
Pipe 138	0.17	0.02	0.01	0.028	Open
Pipe 139	0.58	0.07	0.08	0.030	Open
Pipe 140	0.96	0.12	0.24	0.031	Open
Pipe 141	2.70	0.34	1.59	0.026	Open
Pipe 142	3.59	0.46	2.70	0.025	Open
Pipe 143	1.34	0.17	0.52	0.035	Open
Pipe 144	2.70	0.34	1.71	0.029	Open
Pipe 145	2.23	0.28	1.35	0.033	Open
Pipe 146	3.01	0.38	2.85	0.038	Open
Pipe 147	1.37	0.17	0.48	0.031	Open
Pipe 148	1.58	0.20	0.67	0.032	Open
Pipe 149	0.39	0.05	0.04	0.035	Open
Pipe 150	1.11	0.14	0.28	0.028	Open
Pipe 151	1.67	0.21	0.99	0.043	Open
Pipe 152	0.67	0.09	0.17	0.047	Open
Pipe 153	1.35	0.17	0.56	0.038	Open
Pipe 154	0.08	0.01	0.01	0.234	Open
Pipe 155	0.44	0.06	0.05	0.032	Open
Pipe 156	0.88	0.11	0.25	0.039	Open
Pipe 157	0.67	0.09	0.13	0.034	Open
Pipe 158	1.54	0.20	0.71	0.036	Open
Pipe 159	0.50	0.06	0.06	0.031	Open
Pipe 160	0.17	0.02	0.01	0.045	Open
Pipe 161	0.24	0.03	0.02	0.039	Open
Pipe 162	0.18	0.02	0.01	0.038	Open
Pipe 163	1.24	0.16	0.39	0.031	Open
Pipe 164	0.14	0.02	0.01	0.041	Open
Pipe 165	1.07	0.14	0.30	0.031	Open
Pipe 166	0.39	0.05	0.05	0.036	Open
Pipe 25	0.22	0.01	0.00	0.000	Open
Valve 167	0.00	0.00	0.00	0.000	Open
Valve 168	0.16	0.02	0.00	0.000	Open
Valve 169	0.16	0.02	0.00	0.000	Open
Valve 170	0.17	0.02	0.00	0.000	Open
Valve 171	0.57	0.07	0.00	0.000	Open
Valve 172	0.34	0.04	0.00	0.000	Open
Valve 173	0.42	0.05	0.00	0.000	Open
Valve 174	0.20	0.03	0.00	0.000	Open
Valve 175	0.22	0.03	0.00	0.000	Open
Valve 176	0.28	0.04	0.00	0.000	Open
Valve 177	0.33	0.04	0.00	0.000	Open
Valve 178	0.48	0.06	0.00	0.000	Open
Valve 179	0.73	0.09	0.00	0.000	Open

Valve 180	0.19	0.02	0.00	0.000	Open
Valve 181	0.17	0.02	0.00	0.000	Open
Valve 182	0.29	0.04	0.00	0.000	Open
Valve 183	0.20	0.03	0.00	0.000	Open
Valve 184	0.15	0.02	0.00	0.000	Open
Valve 185	0.05	0.01	0.00	0.000	Open
Valve 186	0.13	0.02	0.00	0.000	Open
Valve 187	0.07	0.01	0.00	0.000	Open
Valve 188	0.10	0.01	0.00	0.000	Open
Valve 189	0.07	0.01	0.00	0.000	Open
Valve 190	0.14	0.02	0.00	0.000	Open
Valve 191	0.09	0.01	0.00	0.000	Open
Valve 192	0.33	0.04	0.00	0.000	Open
Valve 193	0.18	0.02	0.00	0.000	Open
Valve 194	0.19	0.02	0.00	0.000	Open
Valve 195	0.39	0.05	0.00	0.000	Open
Valve 196	0.33	0.04	0.00	0.000	Open

APPENDIX-B: MAP of MURADİYE NETWORK

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