5. PLAN FORMULATION

5.1 Basic Concepts for the Formulations of Plans

The plan was made up to the year 2015 based on the deficiencies in the existing system, the results of water resources development potentials for DAWSSA examined, and considering the level of urgency for water requirements identified through the study.

The basic concepts for the formulations of plans are as follows:

i) Reducing unaccounted for water (UFW) in the existing distribution system,

ii) Maximizing the use of all existing water resources,

iii) Looking for opportunities to increase available water by sharing existing resources with others before developing new resources,

iv) Consisting with the Proposed Damascus City Urban Development Master Plan.

5.2 Service Area

The areas to be served in the future by the water supply system are determined, as described below taking into account following information and data from DAWSSA, and by the field investigation carried by the Study Team.

(1) Master Plan and Land Use Plan

Damascus Municipality has been preparing the New Damascus City and Regional Master Plan for the targeted year 2020. The conceptual development plan for the Damascus City (the City) is proposed by the Damascus Municipality as shown in Figure 3.2.1.

According to the Master Plan, the administrative area of the City will expand from 106 km^2 in 1995 to 180 km^2 in the year 2020. The Master Plan has prepared a general land use plan for the year 2020 which covers the city administrative area as shown in Table 3.2.3. While this land use plan is not approved yet by the Government, this is considered to provide a basic guideline for identifying future service area requirements.

The service areas to be supplied by DAWSSA will be dependant on the implementation plan for the enlargement and development of the City. The implementation plan, however, has not yet been prepared by Damascus Municipality. The Study Team and DAWSSA, have proposed a tentative implementation schedule for the enlargement and development of the City, considering the probability of water resource development within the area of DAWSSA's future water rights, as shown in Table 5.2.1.

(2) Informal areas

Informal connection areas were identified with the survey conducted by the Study Team and DAWSSA as shown in Figure 5.2.1. Total informal area is estimated 10.5 km^2 with approximately 10 % of total area of the City (106 km^2), as shown in Table 5.2.2. The Damascus Municipality has been started to improve infrastructures in the informal areas, such as water supply, electricity supply and sewerage. The future service area shall include the informal areas according to the improvement schedule to be prepared by the Damascus Municipality and DAWSSA.

(3) Service area

Based on the City Master Plan, Land Use Plan in the Future, and Tentative Implementation Schedule, together with consideration on the improvement of informal areas, the projection of the future service area up to the year 2015 is proposed as shown in Table 5.2.3. The served area up to the year 2015 is summarized below;

(Unit : km^2)

	1995	2002	2005	2010	2015
Villages	5.12	5.12	5.12	5.12	5.12
New development Area	0.25	1.49	4.49	12.10	23.80
The Existing City	106.25	106.25	106.25	106.25	106.25
Total	111.62	112.86	115.86	123.49	135.17

Land use in the water supply service area is classified by Damascus Municipality as described in the Section 3.2. Land use of the existing city and villages served by DAWSSA will not be changed so much from the existing conditions according to the New Damascus City Master Plan.

5.3 Population Projection

This section presents the population projections for Damascus City Governate, areas along the Barada river valley serviced by DAWSSA and new development areas which will require servicing in the future. The projections are based on census data obtained from the Central Bureau of Statistics (CBS). Reference is also made to the Master Plan being prepared by the Municipality of Damascus for new development areas. The population projections are used to estimate domestic water consumption demands and plan for the appropriate development of the water supply system until the year 2015. Census data and population estimates are presented in detail in Appendix G of the supporting report.

5.3.1 Central Bureau of Statistics (CBS) Population Projections

In 1994 the CBS conducted a detailed census across the nation. The country's average annual growth rate over the 1981-94 period was 3.3%. The average annual growth rate in Damascus has not followed the national trend and has declined steadily over the past 15 years to an average of 1.75% per annum over the 1981-94 period. This is one of the lowest in the country for large urban centers. The total population located within DAWSSA's current jurisdiction reached 1.57 million in 1995. This population includes all inhabitants of informal settlements and rural areas along the Barada river served by DAWSSA. While growth rates for Damascus City have declined, growth rates in rural Damascus have increased rapidly over the same period by an average of about 5% per year. Population projections provided by CBS are summarized as follows:

Year	Population	% Growth rate**
1995	1,414,000	
2000	1,539,000	1.71
2005	1,673,000	1.68
2010	1,802,000*	1.50
2015	**1,942,000***	**1.50**
2020	2,092,000*	1.50

* population projections are not officially published and based on discussion
** rate based on compound growth formula $P_t = P_o (1+r)^t$

The CBS forecasts declining growth rates for Damascus City until the year 2005 when the population is expected to reach 1.673 million. Projections beyond the year 2005 are not published, however discussions with CBS officials indicates they expect the average growth rate to continue declining to 1.5% and hold steady until the year 2015 when the population of Damascus City would reach 1.942 million.

5.3.2 Damascus Municipality Master Plan Population Projections

The Municipality of Damascus is currently preparing a new master plan to guide urban development up to the year 2020. The basic concept is to provide new development areas along the pattern of the existing City, and extend the administrative boundary to include existing informal areas. New residential developments located on the outskirts of Damascus City are proposed to accommodate future growth. The plan assumes average growth rates in

Damascus City will decline to 0.6 % per year by 2015 when the population is expected to reach 1.934 million as shown below:

Year	Population	% Growth rate**
1995	1,468,000	
2000	1,621,000	2.00%
2005	1,772,000	1.80%
2010	1,878,000	1.17%
2015	**1,934,000**	**0.59%**
2020	2,000,000	0.67%

** rate based on compound growth formula $Pt=Po(1+r)^t$

Based on the results of the previous master plan, it is not unreasonable to expect that population densities inside the City Govemate will increase, especially if unauthorized construction continues. Therefore, the lower growth rates anticipated by the Municipal Master appear to be slightly optimistic. For these reasons, the Water Supply Master Plan assumes a slightly higher growth rate scenario for Damascus City based on an average of 2% per annum.

The Municipal Master Plan projects that growth rates for population centers outside Damascus will increase from 4.5% in 1995 to 5.78 % in 2015. The master plan does not yet identify populations projections for the proposed residential development areas. Based on the rural growth rates developed in the Municipal Master Plan the service population outside of the existing administrative boundary is estimated to the year 2015 as follows:

Year	Population in Rural Governate*	Average growth rate %	DAWSSA Service Population Outside Damascus City
1994			138,526**
1995	375,000	4.50	144,760
2000	468,000	4.53	180,660
2005	600,000	5.09	231,615
2010	770,000	5.12	297,240
2015	**1,020,000**	**5.78**	**393,746**
2020	1,260,000	4.32	486,392

* obtained from Municipal Master Plan
** based on population census and JICA study team estimates refer to Table 5.3.1

5.3.3 Informal Population

In order to estimate water demand, and rationalize unaccounted for water it is important to estimate how many people are informally connected to the distribution system. Unfortunately official statistics identifying this component of the population are unavailable. The JICA study team has, with DAWSSA's assistance, estimated the informally connected population based on two calculation methods.

The first method compares the total number of households reported by the census for all of Damascus City to the total number of domestic subscribers reported by DAWSSA. Taking the difference between the two provides 42,512 unmetered households. Assuming an average of 8 persons per informal dwelling yields an estimated informally connected population of 340,096. When adjusted to include the informal areas of Takadom and Kudsaya which are not included in census figures the informally connected population becomes 400,000.

The second calculation method, preferred by DAWSSA, consists of calculating the ratio of informal dwellings to the total number of dwellings in a district reported by census. This ratio is then applied to the total population in the district to estimate the proportional number of informally connected people. This method yields an informal population of 398,922 based on 1994 census data. Applying a growth factor of 2% for 1995 gives a total informal service population of 407,000. This figure is adopted for the Water Supply Master Plan.

5.3.4 Population Projections for Water Supply Master Plan

The total service population for water demand projections is estimated for existing and future development sites proposed by the Municipality Master Plan. It is assumed that DAWSSA's mandate will expand to include the new development sites proposed by the plan. This study examines three possible population growth scenarios:

Scenario 1. A high growth forecast based on the population momentum created by a young age distribution. This scenario forecasts a service population increasing along an exponential growth curve. The result is a total service population of 3.2 million by the year 2015.

Scenario 2. A moderate growth forecast which shows de-concentration to other urban centers outside Damascus City Governate. A stable average annual growth rate of 2 % is assumed for Damascus City Governate and growth rates established by the municipal master plan are assumed for new development areas and existing rural service areas along the Barada river. This forecast results in a total service population of 2.5 million by the year 2015.

Scenario 3. A slightly lower growth forecast based on the municipal master plan which assumes a high level of migration to new development sites outside Damascus City and a sharply declining growth rate for Damascus City. This forecast results in a slightly lower total service population of 2.3 million by the year 2015.

There is no strong indication from current trends that population growth rates in Damascus City will suddenly increase over the study period. Past urban growth trends indicate stable or slightly declining growth rates in large urban centers are likely to continue. Therefore the exponential growth scenario of scenario 1 does not appear to be likely.

The population forecast provided by the Municipal Master Plan is based on annual growth rates which decline sharply from 2% to 0.6 % within a 20 year period. This reduction is considered slightly optimistic. Although birth rates will likely continue to decline in response to rising education levels, the momentum created by the relatively young population distribution makes a continued sharp decline in growth rates highly unlikely. Therefore the present study assumes that scenario 2 with it's moderately distributive growth forecast is the most likely growth scenario. This growth forecast results in a service population of 2.5 million by the year 2015.

5.4 Water Requirement

5.4.1 Water Use Condition

(1) Service area and population served

The service area in the year 2015 will reach an estimated 135.17 km^2 including the existing villages as described in the above-mentioned Section 5.2. The future service area at 5 years intervals is shown in Figure 5.2.2.

The existing population served is estimated at 1,150,000 multiplying the total number of billed domestic connections by the average number of persons per domestic connection (6 persons per family from the result of the interview survey carried out by the JICA Study Team). Targeted population to be served in 2015 is estimated at 2,501,000. Population and population density in the service area is summarized in Table 5.2.3.

Total population in the informal areas is estimated at approximately 407,000 persons in 1995 as shown in Table 5.2.2. The informally connected population will decrease according to the improvement projects identified in the master plan for the informal areas as follows:

	1995	2000	2005	2010	2015
Number of Informal Residents (1000 persons)	407	157	17	0	0
Percentage of Informal residents to Total population (%)	26	10	1	0	0

The existing population in the service area based on Census data is 1,239,000 as described in the Section 5.3. Targeted population served and proportion of population served are follows:

	1995	2000	2005	2010	2015
Service Level (%)	74	90	100	100	100
Population Served (1000 persons)	1,150	1,563	1,949	2,205	2,501

Almost 100 % of the population are served by the DAWSSA water supply with the exception of some of the number of the informal residents, in 1995.

(2) Water consumption

DAWSSA, at present classifies their consumers into 5 water categories, Water Right Obligations, Public & Religious Use, Domestic Use, Governmental Use and Commercial & Industrial Use mainly as shown in Table 5.4.1. Public & Religious consumption appears to include Uncounted for Water (UFW), since most mosques and churches have no meter or no meter reading. Domestic Use in the past 5 years accounted for almost 70 % to the total water consumption excluding Public & Religious Use as shown in Table 5.4.1. Table 5.4.2 shows the existing water consumption without UFW in 1995 from the billing records. Billed water consists of Domestic Use with 73 %, Commercial Use with 4 %, Industrial Use with 1 % and Government Use with 22 %.

Since 70 % in total water consumption is domestic users, it is proposed, for the purpose of projecting future water consumption to classify consumers into 2 major categories, Domestic Use and Non-Domestic Use. Non-Domestic Use is further classified into 14 categories as described below. For this Study, the projection of future water consumption is forecasted by the classified water use method instead of the past trend method.

(3) Domestic use

1) Classification of income level

The population served is classified into three income groups and one informal group. The informal group is divided into two income groups, Middle income (17.5 %) and Low income (82.5 %). All groups are able to afford a service connection and are willing to pay for water according to the result of the interview survey. It is assumed that all groups will receive water from properly connected and metered services.

Future distribution of income level in the year 2020 is forecast in the Damascus Municipal Master Plan with High income (20 %), Middle income (40 %) and Low income (40 %). As detail information on this distribution is not available, the Study Team and DAWSSA has assumed the future distribution of income level based on the interview survey and economic trends as follows;

(Unit : % to the Total Population)

	1995	2000	2005	2010	2015
High Class	16.7	17.5	18.4	19.2	20.0
Middle Class	18.0	23.5	29.0	34.5	40.0
Low Class	39.3	49.0	52.7	46.3	40.0
Informal Residents	26.0	10.0	0.0	0.0	0.0

The assumed population distribution for the low income class has a tendency to increase until 2005, because the majority of informal residents that will be connected officially with the network are in the low income class. Socio-economic conditions are assumed to improve after the year 2005 when the improvement project for the informal areas are completed. This will mean a corresponding increase in the middle income earners after the year 2005.

2) Existing unit water consumption

Unit water consumption per capita was studied by the interview survey, the meter reading survey, and a review of billing records. The resulting average unit domestic water consumption for each group is summarized below;

(Unit : lpcd)

Class	Interview Survey	Meter Reading	Billing Records
High	194	212 - 236	-
Middle	183	143 - 173	-
Low	177	-	-
Average	177		110

Taking into account an average consumption per residential connection of 674 l/connection/day which is derived from billing record for the year 1995, per capita consumption is estimated as 110 lpcd by assuming 6 persons per household. Table 5.4.3 shows the ratio of water supply suspension from 1991 to 1995. On average, service is interrupted 4 days per month. The interview survey also indicated that 45 % of residents were supplied with water for less than 12 hours per day. The actual water demand is largely unmet and therefore expected to be higher than the per capita consumption of 110 lpcd. Considering water supply conditions and water meter malfunctions (see Table 5.4.2), the existing average water demand is probably closer to 170 lpcd and is applied as the base for establishing future domestic unit water consumption.

3) Future unit water consumption

The following general assumptions are made in order to forecast future water consumption;

- Based on past economic trends and current economic indicators, regional economy will continue to grow rapidly.
- At the present, the problems of informal areas has interrupted the economic development in the City.
- Socio-economic conditions will improve after the year 2005, when most of the informal areas will be formally serviced. This will result a large middle income class and a corresponding increase in water demand.
- Unit consumption for each income class is estimated base on the results of the interview survey, meter reading and billing data.
- The percentage in each income class to the total population is based on forecasts providing by Damascus Municipality.

Three alternatives scenarios for the development of future unit domestic water consumption were considered: Alternative 1 assumes continuing economic development based on recent trends, Alternative 2 assumes increasing water consumption according to high economic development, and Alternative 3 assumes increasing water consumption after 2005. The alternatives are described as follows:

(Alternative 1 - low growth in demand)

- Water demand increases gradually from 1995 up to 2015 according to population projections.
- Unit consumption for both the Middle and Low income classes is estimated considering potential water demand and willingness to pay.
- Unit consumption for each income class does not change over time.

(Alternative 2 - rapid growth in demand)

- Water demand increases rapidly from 1995 up to 2015 according to population projections.
- Potential unit water consumption for Middle and Low income classes is higher than the willingness to pay level.
- Unit consumption each income class does not changed all the time.

(Alternative 3 - moderate growth in demand)

- Water demand increase gradually based on population projections from 1995 up to 2005 and increases rapidly after 2005, when informal areas are improved.
- Potential unit water consumption for Middle and Low income classes is estimated considering potential water demand and willingness to pay from 1995 to 2005. After 2005, unit water consumption is higher than the willingness to pay level.
- Unit consumption of Middle and Low income class increase gradually after 2005 based on assumed improvements in socio-economic conditions.

The unit consumption by income class for tree alternatives are described as follows:

(Unit : lpcd)

	Alternative 1	Alternative 2	Alternative 3				
Class	1995-2015	1995-2015	1995	2000	2005	2010	2015
High	250	250	250	250	250	250	250
Middle	200	220	190	200	200	210	220
Low	170	190	160	170	170	180	190
Average			170	180	193	204	214

Water demand projection in this study are based on the unit consumption described for Alternative 3. The proposed unit water consumption per capita assumes the upper limit of unit domestic water consumption per capita is 250 lpcd. This upper limit is considered to be conservative since per capita consumption in the other developed countries is generally less than 250 lpcd as compared with domestic water consumption. Unit water consumption in the future is summarized in Table 5.4.4.

(4) Non-domestic use

Future water demand for non-domestic use will be projected based on the analytical results of records, questionnaire survey and information provided by DAWSSA and other relevant data collected, such as the Future Urban Development Plan (conceptual Plan), land use plan and statistical data. The details of projection for non-domestic use are described in the following.

1) Billing records

Table 5.4.2 summarizes water consumption per connection per day for three categories, Commercial, Industrial and Governmental in 1995. The estimated unit water consumption per connection is 0.61 m^3/connection/day for Commercial Use, 1.29 m^3/connection/day for Industrial Use and 17.59 m^3/connection/day for Governmental Use, considering malfunction loss. It should be noted that the unit water consumption calculated from billing record does not represent actual demand because a lack of production capacity resulted in frequent and lengthy interruption in service.

2) Questionnaire survey

A questionnaire survey was issued to the major water consumers, Hotels, Hospitals, Schools, Factories and Governmental Offices including Sports Facilities through DAWSSA. The results of the questionnaire survey are summarized as average unit water consumption per connection below;

a) Governmental Offices & Facilities	:	51 m^3/d
b) Schools	:	14 m^3/d
c) University	:	254 m^3/d
d) Hospitals	:	370 m^3/d
e) Sports Facilities	:	176 m^3/d
f) Hotels	:	148 m^3/d

g) Large Commercial users	:	10 m^3/d
h) Others (commercial users)	:	1 m^3/d
i) Theaters	:	44 m^3/d
j) Factories	:	128 m^3/d
k) Manufacturing	:	0.60 m^3/d

3) Religious & public facilities from meter reading and information

Meter reading survey was carried out to some of the Religious Facilities. The results of meter reading are 44 m^3/day for the Um-Ayad Mosque, 4 m^3/day for other mosques and churches. Based on the information from Damascus Municipality, water consumption per public tap is estimated about 40 m^3/day to 50 m^3/day. Water to public fountains is supplied by the Municipality. Special uses, such as airport in the City, military division and others, are estimated about 3,000 m^3/day as bulk water supply.

4) Future unit water consumption and number of facilities

Future unit water consumption are proposed as shown in Table 5.4.4, considering the above results and information from DAWSSA. Basic factors for water demand projections are summarized as shown in Table 5.4.5. The number of main users are estimated based on the area to be expanded according to the Urban Development Plan, since Damascus Municipality has no detailed information about the main facilities. However, the conceptual plan for the City development and the land use plan indicates that the future land use pattern in the City and surrounding area of the City will not be changed from the existing land use pattern, except for Residential and Commercial areas. The non-domestic water demand projection is therefore estimated based on the present water consumption and land use pattern.

5.4.2 Water Demand Projection

(1) Classified water use method

The water consumption forecast was determined by using the water use classification method instead of the past trend method as described in the previous section. Water use is classified as follows;

a) Accounted Water
(i) Billed Water
- Domestic

- Governmental (office, school, University, Hospital and others)
- Commercial (commercial users with large water consumption, hotels and Theaters)
- Industrial (factory and manufacturing)

(ii) Un-billed Water
- Water right obligation
- Religious & Public Use (mosques & churches and public taps & special area zone)

b) Un-accounted For Water (UFW)
(i) Meter Malfunction (under estimation of meters & no meter reading)
(ii) Informal use including Domestic and Non-domestic uses
(iii) System Losses including leakage from the informal areas

(2) Assumptions for water demand projections

Water demand projections are based on the following assumption;

a) The population served is estimated based on the census, the number of persons per family from the interview survey and the number of billed water connections in 1995.
b) The service area is based on the Urban Development Plan.
c) Water consumption for religious & public use is estimated based on the results of the interview survey and the water meter reading survey, carried out for this Study. Data provided by DAWSSA for the water consumption for the religious & public use includes the UFW and was therefore not used.
d)Unit domestic water consumption is based on Alternative 3 described in the previous section.
e) Unaccounted For Water (UFW) is estimated based on the data from the leakage survey, the interview survey and billing record.

(3) Unaccounted For Water (UFW)

The overall unaccounted for water at present is estimated at 63 % of water production and consists of 14.4 % for Meter Malfunction, 13.6 % for Informal Use and 34.7 % for System Losses. For the developing estimates of water production required, it is assumed that the following figures are, at present, most realistic, and are adopted for projecting required water production.

a) Target unaccounted for water in the year 2015 is 25 %.
b) Target annual reduction rate of UFW at every five years are shown below;

Year	Annual Reduction Rate of UFW	Percentage of UFW
1995		63 %
2000	24 %	39 %
2005	8 %	31 %
2010	3 %	28 %
2015	3 %	25 %

c) Amount of UFW is estimated as follow;

(Unit : 1000 m^3/d)

Type of UFW	1995	2000	2005	2010	2015
Meter Malfunction	88.6	23.5	0	0	0
Informal Use	81.4	31.0	8.1	0	0
System Losses	204.0	241.3	241.6	254.8	248.7
Total	374.0	295.8	249.7	254.8	248.7

Meter malfunction including no meter reading is estimated based on the review of 1995 billing data. Informal use is estimated at 200 lpcd per capita water demand.

(4) Seasonal load factor

A seasonal load factor of 1.14 is assumed based on a review DAWSSA's historical records. The peak demand is in August, based on observed correlation between climatic changes and fluctuations of billed consumption in 1995, average water production of the past 10 years.

(5) Water demand projection

Water demand projections are prepared for the three unit water consumption alternatives, as shown in Tables 5.4.6, 5.4.7, and 5.4.8 and summarized as follows:

(Unit : 1,000 m^3/d)

	1995	2000	2005	2010	2015
Alternative 1	678.0	741.7	802.9	863.7	928.1
Alternative 2	678.0	788.3	859.2	925.2	994.8
Alternative 3	678.0	750.8	813.3	900.4	994.8

As previous discussed, Alternative 3 is selected as the most likely economic growth scenario and recommended for planning the future water supply system, as shown in Table 5.4.8. Classified water demand projection at 5 year intervals are summarized as follows;

(Unit : 1000 m^3/d)

Classification	1995	2000	2005	2010	2015
A. Domestic Use	126.1	272.1	376.9	449.4	535.2
B. Non-Domestic Use					
B.1 Governmental Use	37.3	99.7	102.4	109.2	119.6
B.2 Commercial Use	7.8	23.9	24.6	26.2	28.7
B.3 Industrial Use	1.5	6.2	6.3	6.7	7.4
B.4 Water Right Obligation	40.7	42.5	42.5	42.5	42.5
B.5 Religious & Public Use	10.5	10.6	10.9	11.6	12.7
Total	223.9	455.0	563.6	645.6	746.1
Effective Ratio of Total Water Requirement (%)	37	61	69	72	75

* : Water consumption in 1995 is estimated from billing record.

5.4.3 Forecasted Water Requirement

(1) Daily water requirement

Daily water requirements is projected below :

(Unit : 1000 m^3/d)

	1995*	2000	2005	2010	2015
1. Accounted Water Demand	224.1	455.0	563.6	645.6	746.1
2. UFW	374.0	295.8	249.7	254.8	248.1
2.1 Meter Malfunction	88.6	23.5	0.0	0.0	0.0
2.2 Informal Use	81.4	31.0	8.1	0.0	0.0
2.3 System Losses	204.0	241.3	241.6	254.8	248.7
3. Average Water Requirement	678.0	750.8	813.3	900.4	994.8
4. Maximum Water Requirement (Load Factor : 1.14)	759.4	855.9	927.2	1,026.5	1,134.1
5. Water requirement per capita (lpcd)	285	291	289	293	298

* Data in 1995 are provided by DAWSSA and JICA.

(2) Annual water requirement

Based on the projected water demand, monthly and annual water requirements are estimated as shown in Table 5.4.9. Water requirement at 5 year intervals is estimated respectively as 274.0 MCM/year in 2000, 296.9 MCM/year in 2005, 328.6 MCM/year in 2010 and 363.1 MCM/year in 2015.

(3) Water supply for new development areas

The schedule for providing water supply services to the new development areas is shown in Table 5.4.10. The schedule was formulated considering to availability of water resource capacity, the selection of priority schemes by DAWSSA and the conceptual plan for the Urban development in the City prepared by Damascus Municipality. Water requirement estimates assuming the ratio of water losses is 25 % even in the newly constructed areas.

According to the schedule, Dummar Extension Area (1st phase) and the residential area in Special Area Zone (State Factory) will be require water supply in 2000, Kudsaya New Suburb will need require water supply by 2005. After the year 2005, a deficit will occur between DAWSSA's improved water production capacity and the water demand.

It is assumed that the development of new residential areas proposed by Damascus Municipality can only proceed if new water resources are developed. Assad Suburb (1st phase and 2nd phase), however, can be supplied in 2010, because this area has its own water supply wells located in the rural area. By 2010, DAWSSA, will not be able to supply water to Dummar Extension Area (2nd phase), Assad Suburb Extension Area and Assad City, since the estimated water production from new water resources schemes will not be able to meet the water demand of these new development areas.

(4) Water requirements in proposed service areas

Service Areas are proposed as shown in Figure 5.2.2. Water supply to the proposed service areas is estimated as shown in Tables 5.4.10, from the year 2000 up to the year 2015. Figures 5.4.1 and 5.4.2 respectively show water requirements to proposed service areas in the year 2005 and 2015. The estimated water requirement takes into consideration that the land use pattern in the existing service areas will not change significantly.

Water requirement in proposed Service areas is summarized at 5 year intervals as follows;

(1000 m^3/day)

Year	2000	2005	2010	2015
Villages	53.7	56.9	60.5	65.3
New Development Areas	8.5	21.5	43.6	73.3
Existing City	688.6	737.9	796.3	856.2
Total	750.8	816.3	900.4	994.8

(5) Proposed water production

Raw water production is proposed as shown in Figure 5.4.3. Production and conveyance losses are assumed to be low at less than 1 %, since Figeh spring, the main water resource, is conveyed through the tunnel and the other water resources are groundwater. In this figure, the past average water requirement in 1986 and 1990 is assumed based on the average water requirement in 1995. Daily maximum water requirement is calculated by using the load factor of 1.14.

It is supposed that a water deficit will occur after the year 2005, since the capacity of water resource is limited to 296.9 MCM/year (9.4 m^3/sec) based on DAWSSA's existing water rights. Therefore DAWSSA must develop new water resources after the year 2005 to meet increases in demand. Efforts to save water and reduce consumption should be coordinated with Damascus Municipality and the Ministry of Irrigation (MOI) to reduce the need for new resources.

Cooperation with the MOI will be requested to resolve the water deficit after the year 2005. The MOI has the overall responsibility for authorizing water rights and the development of water resources development in the rural areas where a potentiality of water resources is identified in this study.

5.5 Water Resources Development Plan

5.5.1 Water Resources Issues

(1) Water resources organization in Syria

The Ministry of Irrigation (MOI) is the governmental body within Syria that is designated the responsibility for coordinating water usage and planning future water resources development. The Ministry has the authority to issue licenses for the abstraction of water from surface and underground sources. Due to the historical development of the EPEF it was given the right to the water from Figeh and groundwater within the municipality of Damascus. These rights have been carried over to EPEF's successor establishment, DAWSSA. Within the municipality, the management of water resources, other than those utilized by DAWSSA, is under the overall control of the MOI. However the licensing of abstractions has been delegated to the Damascus Municipality. Possibly as a result of these three organizations all having an interest in Damascus, water resources planning and abstraction licensing is somewhat haphazard.

(2) Water resources studies

(a) Observation well network rehabilitation

DAWSSA has a network of 19 observation wells within the City. They are mainly located within the existing wellfields. Recently 7 new observation wells have been drilled in locations remote from DAWSSA wellfields. These holes can provide information on the citywide changes in water levels away from the direct influence of the main centers of pumping. However it has been reported by the water resources directorate that all but one of these holes can not be used for their intended purpose because they are 'full of sand'. It is proposed to rehabilitate the new observation wells to make them suitable for inclusion in a citywide monitoring scheme.

The rehabilitation program should comprise two parts. In the first instance the nature of the problem should be identified, each hole should be plumbed to measure the total depth. Secondly any material in the holes should be removed by airlift pumping, if unsuccessful by redrilling the collapse material. It is recommended that slotted casing should be installed into the holes to guard against further collapse. Should it not be possible to rehabilitate the hole then the drilling of a replacement hole in the same area should be undertaken.

The Master Plan proposes to increase the groundwater abstraction from under Damascus. The extra abstraction will be introduced progressively, during this period it is imperative that the behavior of the groundwaters are studied to ascertain whether the extra pumping exceeds the capacity of the aquifer. This knowledge will be used in the of later stages of the Master Plan.

(b) Hydrological and hydrogeological study and modeling of the city

The objective of this study should be a better understanding of the water fluxes within the City, the relationship between surface water and groundwater, the relationship between waste water, surface and groundwater. This understanding is important in the formulation of plans for the use of the City groundwaters and to establish the likely influence of the future waste water schemes. The changes in flow along the many surface canals should be investigated from El Hame to the eastern boundary of the City urban area. The understanding of the hydraulic systems may be assisted by the construction of a mathematical model of the groundwater system. Such a model is a useful way of focusing on difficult areas that deserve further investigations. The final model can become a powerful predictive and managerial instrument that would enable the determination of future response of the aquifer system to different pumping scenarios.

(c) Water resources information and analysis systems

The data collected by DAWSSA from its various monitoring networks and on the operational details of the sources is stored on the main establishment technical computer system. Although a useful tool for the day to day management of water extraction and supply it is less adaptable to the diverse requirements and analytical capabilities needed for water resources studies. The data that may be called upon for water resources work is various and will include meteorological, hydrological, geological, hydrogeological sources. A more flexible approach is desirable to cope with data on time scales from minute to minute during aquifer testing to decades when looking for long term groundwater and meteorological trends. The capacity of the system to be able to represent information graphically and cartographically would be employed extensively in water resources studies.

Information and analytical systems are widely available for the disciplines that constitute water resources. Most of such software is directed towards the personal computer or network of personal computers, either working under DOS or a Windows environment. Systems may be either standard packages, or customized versions. A need is perceived for software systems to cover the following areas, Pumping Test Analysis, Hydrological / Hydrogeological Database, and, Groundwater Modeling.

Work undertaken on water resources in the preparation of the master plan used '*Ground Water for Windows*' (GWW) for storage and reporting purposes. The inventory of almost a thousand wells from DAWSSA, the Municipality and the Ministry of Irrigation has been collated. A copy of the files has been provided to the Water Resources Directorate.

(d) Long term study of Barada spring behavior

Apart from Figeh the sources in the Zabadani Valley represent the largest resource that DAWSSA uses. The understanding of the behavior of the spring-aquifer system to pumping is critical in the future planning of possible schemes. It is opportune to gather data that will help with the through study of the source. Currently one on site observation well is monitored every two weeks and the Barada River at Tekieh is flow gauged. It is proposed that this monitoring is intensified and broadened. The level in the lake and the observation well should both be monitored on a continuous basis with autographic float recorders. The water level in the aquifer at a distance could be monitored in the three wellfields that belong to DAWSSA. The measurement of the actual discharge from the lake should be given the highest priority. Until such time as a proper rated channel section is available at Ramleh attempts should be made to measure the flow over the penstock and into the irrigation channels.

5.5.2 Alternative Future Water Sources for DAWSSA

(1) Water resources available to DAWSSA

The water resources that are available for use in the vicinity of Damascus are already almost fully committed to water supply and irrigation uses. In the preparation of the Master Plan the maximum utilization of the existing sources is proposed together with limited development of new sources. The rough estimate of the resources is given in the following table.

Source	Total Replenished Resource with acceptable water Quality (MCM/y)	Estimated Resource available to DAWSSA (MCM/y)
Figeh Source	220	220
Barada Source	100	34
Sergaya Area	9	3
Deir al Ashayer Area	7	3
Damascus Quaternary	50	50

At present about 130 to 185 MCM/y are used from Figeh Source and up to 35 MCM/y from Damascus. The unused portion of the Figeh source over flows into the Barada River during the flood season when the quantity of water from this single spring exceeds the requirement of Damascus. The natural flow of the Barada is about 100 MCM/y, however not all of this is available for use. The flow has reduced to about 70 MCM/y, the water probably being intercepted by irrigation wells before reaching the spring. The MOI has allocated a 34 MCM tranche for use by DAWSSA. The estimates of the resources in the Jurassic aquifer east of Sergaya and the Cretaceous around Deir al Ashayer is based upon water balances for the aquifer units. The water in these two areas is already used for local water supply and irrigation the amount that may be taken is therefore limited. The source of Wadi Marwan is the Cretaceous aquifer block that also supplies Figeh spring. It is anticipated that the use of Wadi Marwan will not create any new resources but will share those that naturally discharge from Figeh. For that reason it is not included in the list of water resources.

The groundwater resources under Damascus are not clearly quantified. Broadly, the resources in the mountainous areas comprise the rainfall less evapotranspiration. Whereas on the plains and foothills the quantification of resources is more complicated. The rainfall less evapotranspiration is much less or negative, and the water resources are those that enter the area either by groundwater flow, surface water streams or conveyed by public water supply distribution systems. The water balance of the whole catchment has been estimated for natural conditions and for the mid 1980's. This balance has been updated with data as is available for the mid 1990's. The zone where the water balance is most different to those pertaining to natural conditions is the city of Damascus and the Ghouta. It is this region where large and un-measured fluxes occur. The groundwater resources usable by DAWSSA have been set at 50 MCM/y that would be derived from groundwater flow into the area from the Cretaceous, less through-flow of groundwater towards the Ghouta. To this should be added a very small contribution from infiltrated winter rainfall, and then a significant quantity due to leakage from the distribution system, canals, river bed, and, waste water systems. From the groundwater DAWSSA has taken 35 MCM/y and other abstractors an unknown amount. The maximum exploitable quantity is higher than that used at the present. The value of 50 MCM is approximately half the estimated storage in the Pebble Beds, this is assumed to be the safe limit.

Within the duration of the Master Plan schemes will be implemented may reduce recharge to the aquifer. Firstly the leakage from the distribution system is to be reduced especially in the informal areas of the city. Secondly connection to the sewerage system will become more wide spread. This will reduce seepage from soak-aways and for those settlements upstream of Damascus reduce the flow in the river and irrigation canals through the city. If these schemes are successful and there is an overall reduction in absolute amounts of water losses, groundwater recharge quantity will reduce even though the quality will be safe-guarded.

(2) Current water sources capacity

The current water resources available to DAWSSA to serve the population in Damascus are summarized below, the details of individual sources are provided in Table 5.5.1.

Source Name and Type	Source Capacity				Seasonal Capacity (MCM)
	Installed (l/s)	Minimum (l/s)	Average (l/s)	Average (m^3/d)	
Damascus Wellfields	3,073	1,585	1,900	164,020	41.47
Figeh Sources					
Average Year	12,400	-	5,800	507,000	185.00
Dry Year	-	2,880	3,870	334,000	122.00
Barada Spring	1,100	1,100	1,100	95,000	23.27
TOTAL					
Average Year	16,573	-	8,860	771,220	249.74
Dry Year	-	5,565	6,930	598,220	186.74

(3) Existing schemes in progress

(a) Figeh Side Spring

The water intake structure at Figeh side spring consists of a sump about 8 m deep. It is equipped with 13 pumps with a theoretical total capacity of 3.25 m^3/s, however during operation they produce from a peak of 1.8 to a minimum of 1 m^3/s. A scheme to replace the existing water intake structure for Side Spring is under construction. A planned total of 20 new wells each 50 m deep and 762 mm (30") diameter are to be built. The new structure will be able to create a larger drawdown in the wells and it is anticipated that a larger yield will be available. It is anticipated by DAWSSA that a further 500 l/s could be added to the site capacity.

(b) Ain Haroush.

The existing wells at this site are to be replaced by new deeper wells. The additional yield that will be available is expected to be about 800 l/s (69,000 m^3/d), or 13.8 MCM over a 200 day pumping period. Two wells have been drilled, each 800 mm internal diameter and 40 m deep, a third well is due to be constructed. The new wells are awaiting testing to evaluate their performance before the installation of pumps and commissioning the source. For the Master Plan there is assumed to be no increase in yield from Figeh from the work in Side Spring or in Ain Haroush.

(c) Barada Group 1, 2 & 3 Wellfields

There are three wellfields north of Barada Spring that were drilled in the 1980's by the Ministry of Irrigation. They are referred to as Groups 1, 2 and 3, and are separate to Barada Spring Wellfield. The right to use these sources has been given to DAWSSA and they are in the process of commissioning the wellfields. The wells that have been designated for inclusion in the new wellfields are itemized in Table 5.5.2. The design capacities are 230, 150 and 70 l/s for the three groups with an achievable average seasonal production for the groups used for the Master Plan are 185, 120 and 60 l/s respectively.

(d) Wellfield at Takadom

The wellfield lies in the South of the City and was drilled in 1989. The wells were performance tested with step tests and the aquifer was tested with a constant rate test. A summary of the step test results is provided in Table 5.5.3. The wells divide into two groups one with small drawdown that are suitable for use as production wells (1, 4, 6, 7, 9, 12 & 13) and the remainder that have high well losses, large drawdowns and a rapid increase in drawdown at high pumping rates (5, 8, 10, 11). It is planned by DAWSSA to install 10 pumps, 3 with 120 m^3/hr capacity and 7 with 100 m^3/h capacity at this site. For the Master Plan the wellfield has been rated at an average capacity of 140 l/s or 2.96 MCM in 8 months.

(e) Wellfield at Kadam Store

The wellfield lies in the southern area of the City about 500 m to the North West of the Kadam Railway wellfield. The wells in this wellfield are closer together than on other wellfields in Damascus. As a consequence the interference drawdowns can be more significant here than on the other wellfields. Three of the holes are in use and it is planned by DAWSSA to equip all the remaining holes on the site with pumps with a 30 m head and

100 m^3/hr capacity. An estimate of the anticipated drawdowns is provided for each well in Table 5.5.4. For the Master Plan the output from the site is estimated as an average of 170 l/s for 8 months.

(f) Wellfield in Wadi Marwan

DAWSSA is working on the commissioning of a wellfield, pipeline and associated works to provide a water supply to the new development area of Kudsaya. The wellfield is located approximately 19 km west of the center of the City. The wellfield comprises 16 wells, three drilled by the Ministry of Irrigation in the 1980's and 13 constructed between May 1990 and September 1992. The wells are all about 300 m deep with 9" or wider casing with a rest water level about 180 m below the surface. The capacity of each hole is in excess 15 l/s and quite possibly as much as 30 l/s could be pumped from each hole. This would give an overall wellfield capacity of 450 l/s or 14.2 MCM over a full year. DAWSSA plans to install 13 pumps each with a capacity of 18 l/s, however for the Master Plan the achievable quantity is taken to be 185 l/s or 5.84 MCM over a full year if pumping.

(g) New Wellfield at Kaboon

A scheme for increasing the abstraction from the area of the existing wellfield is due to start in 1996. In the first phase two deep wells will be drilled, subject to these being successful in obtaining an acceptable yield a further 8 holes are planned for a second phase. For the purpose of the Master Plan it has been assumed that the wells will all be constructed and have an overall yield of 120 l/s, or 2.54 MCM in 8 months.

(h) Wellfield at Dummar

The wellfield at Dummar has not been used since 1991. The wells are due to be re-commissioned to supply the local area. Five pumps with a capacity of 30 l/s are to be installed into the wells. For the Master Plan these wells are assumed to operate throughout the year at a rate of 100 l/s, 3.14 MCM/y.

(4) Future water sources for DAWSSA

(a) Options

The future water sources that may be used by DAWSSA are located on Figure 5.5.1. The anticipated capacities are summarized in Table 5.5.5.

(i) Option 1

The first option proposed comprises developing sources to which DAWSSA has been assigned Water Rights. The Rights exist for all the groundwater sources within the Municipality plus Figeh Spring, Wadi Marwan, Deir al Ashayer, Rimeh and the Al Sahl wellfields near Barada Spring. The quantity that may be taken from Damascus wellfields and from Figeh is limited only by the physical availability of water. Whereas at Barada Spring the Prime Minister has granted a Right to abstract up to 34 MCM per year from the combined wellfields. The MOI has reported on the available water and assigned quantities of 4.1 MCM at Deir al Ashayer and 4.5 MCM at Rimeh for use by DAWSSA.

The schemes that are included in option 1 are; new, equipped and upgraded wellfields in Damascus, a completion of the ongoing schemes near Barada Spring, Wadi Marwan, Figeh and Damascus, and, the development of the Deir al Ashayer wellfield. The use of Rimeh is excluded on economic and financial grounds from the first option.

(ii) Option 2

This option includes all the schemes that are in option 1 plus the promotion of schemes in areas for which DAWSSA has not been assigned Water Rights. These areas are the springs on the Awaj River at Beit Jenn and Tabibiyeh, and also the Rimeh wellfield, all which lies south west of Damascus. In the option is also the use of new wellfields at Sergaya and El Irk north east of Zabadani.

(iii) Option 3

Like option 2 this option envisages the use of all the schemes proposed in option 1. In addition a greater exploitation of the Barada Wellfields in excess of the assigned water Right of 34 MCM. An extension of the wellfield around Barada Lake and Spring is considered the best means to increase the abstraction.

(iv) Option 4

The fourth option comprises the combination of all the is the previous options and involves the development of all the water resources identified.

(b) Selection of the most desirable option

The choice of an option of use in the Master Plan is a balance between what will provide sufficient water to the city and yet will not adversely affect the environment, the economic livelihoods of the local population and be a politically acceptable solution. The selection must also be economically and financially attractive to both DAWSSA and to lending agencies. All the schemes proposed are thought to be technically feasible so this is not a consideration for the screening process.

At the time of the Master Plan formulation only option 1 is politically acceptable. The other options have to be approved and accepted by government, something that can not be guaranteed and used for planning purposes. The economic analysis has shown that the scheme at Rimeh has a very low viability and therefore has been excluded from any option. All the options will affect the local availability of water for other uses.

In option 1 this will be confined to the farmers in the Deir al Ashayer area who use groundwater for irrigation. Water levels will be lowered by the proposed wellfield and some of the irrigation wells will be de-watered while in others the pumps will need to be lowered. The scheme at Sergaya and El Irk will intercept water that otherwise would discharge through springs from where it is channeled and used in irrigation. The use of water by EDWSSR from the adjacent areas has already had this effect. The farmers have started to look for other means to irrigate their lands, the drilling of private wells seams to be the most common solution.

The social effect of the Hermon area schemes is likely to be large furthermore there will be an environmental impact on the upper reaches of the Janani River. The spring water is now used in flood irrigation of the land. If all this water is piped to Damascus there will be no viable source of irrigation water in some areas. Within the Awaj basin there is a switch to groundwater for irrigation, this is not always technically feasible for all farmers.

Option 3, the further exploitation of the Barada Spring source, will have an effect upon farming in the Zabadani Valley. The Barada River, whose headwaters are Barada Spring, is used as a source of irrigation water, albeit illegally. The existing quantity taken from Zabadani Valley wellfields reduces the stream flow, as also do private irrigation wells within the spring catchment. The further development of DAWSSA's water use will need to take these factors into account. The substitution of the river as a source of irrigation with another source is one possible solution, but this lies outside the jurisdiction of DAWSSA.

The use of options 2, 3 and also 4 are ruled out on socio-economic and/or political grounds, even though they may be able to satisfy the demand in the year 2015. The choice of option 1 permits the reduction and at times elimination of the seasonal deficit of water currently suffered by the inhabitants of Damascus. The option will achieve these improvements up to the year 2005, by which time all the schemes will have been commissioned and there is a forecast deficit that grows to 46.7 MCM by the year 2015. The deficit in option 2 is 20.8 MCM and for option 3 it is 16.9 MCM at the end of the Master Plan period. Option 4 removes the deficit completely. For the Master Plan, option 1 is the most desirable option and so it is adopted for use. The water production plan and the water sources development plan are base upon this option.

(5) Water sources development plan (Option 1)

The plan is able to increase the capacity of sources from Damascus and Deir al Ashayer to meet the anticipated requirements until the year 2005. The schemes that are quick and will give a proven source of water will be implemented first while the more costly and longer term schemes are programmed to start later. The year when each source will be finished and the extra capacity available is listed below.

Source	Year	Source	Year
Wadi Marwan	1997	Kafar Souseh	2000
Barada Spring Group 2	1997	Tishreen & Kywan Phase II	2000
Kadam Store	1997	Deir al Ashayer	2000
New Kaboon Phase I	1998	Barada Group 3	2001
Takadom	1998	Shokry al Qouwatly	2001
Tishreen & Kywan Phase I	1998	Ibn Assaker	2002
Dummar	1999	Fringe Wells	2002
Jaramana	1999	Tishreen & Kywan Phase III	2002
Barada Group 1	2000	Kanawat Gardens	2003
New Kaboon Phase II	2000	Kadam Railway	2003

The water resources projects can be divided into four types;

- Equipping existing, tested, but unused wellfields. This comprises the installation of pumps, well headworks, reservoir, chlorination and control equipment and site pipeworks. The wellfields to be equipped are at Takadom, Tishreen, Jaramana, Kadam Store, Wadi Marwan, Dummar, Barada Group 1,2 & 3.
- Re-equipping existing wells to increase their production. At these sites the wells are able to produce more water the limiting factor is the capacity of the submersible pumps or the booster pumps. The schemes are at Ibn Assaker, Kadam Railway and the Fringe Wells
- Construction of new wellfields in Damascus. Three of these are at totally new sites, Kafar Souseh, Shokry al Qouwatly and Kanawat Gardens, the third, Kaboon, involves the drilling of more holes at an existing wellfield.
- Construction of new wellfields outside the city. The wellfield at Deir al Ashayer is proposed to use some existing Ministry of Irrigation some new holes.

(6) Water production plan (Option 1)

The key objectives in water production planning for DAWSSA are firstly to be able to satisfy a demand that peaks in August while the sources have their maximum capacity in March-April, and secondly, to meet the demands when the principle source is very variable year to year. To meet these two objectives production plans must be constructed on a monthly basis and also for various hydro-meteorological conditions. A schedule of production is devised for each source for each year of the Master Plan for three hydro-meteorological scenarios. For these three conditions a month by month plan is produced for the years 2000, 2005, 2010 and 2015. See Tables 5.5.6 to 8 for the annual production program. The information for both annual and monthly plans is summarized pictorially in Figures 5.5.2 to 4.

To represent different hydro-meteorological conditions three reference years have been chosen for comparison. These reference years represent average wet and dry conditions. The average conditions are conveniently similar to those experienced in 1995. Dry conditions in 1990 (water year 1989-90) produced a total flow of 141 MCM a flow that is exceeded 90% of years. For the wet conditions the year 1992 is selected (water year 1991-92) during which an annual flow of 334 MCM occurred, an event that is exceeded less than 5% of years. The reference years were selected to be in the recent past when the measurements are the most reliable and the source was modified by pumping. The total flow from Figeh in future years, is taken to be the same as the total flow in the comparison year, either that by gravity discharge or by pumping. The ongoing schemes at Figeh are assumed for the purpose of the plan to have no effect upon the discharge regime. This is a worst case scenario, since the effect can only be to increase the low flows and reduce the flood of the spring. Making this assumption is therefore a conservative measure, the actual situation achievable being possibly slightly better than that assumed in the production plan. The monthly production from Figeh is either all the flow or that part of the flow that is needed to satisfy the requirements of Damascus.

The total flow from Figeh under the three scenarios does not change for the duration of the Master Plan. It may however be noted that it becomes possible to take a larger proportion of the flow each year in the wet and average scenarios. This is not due to any increase in resources, but a result of higher demand during the flood period when more of the flow can be used. The ceiling on the capacity is however reached in the low rainfall scenario when all the water from Figeh is required to meet the demand and there is no overflow to the river even in a normal year.

At certain times during the Master Plan period there is surplus capacity. When this has arisen preference is made to use Jurassic and Cretaceous sources to permit the groundwater under Damascus to recover. The use of the Quaternary aquifer under Damascus is limited by the area that has acceptable water quality and by the anticipated total resource assessment of 50 MCM/y. The plan anticipates being able to exceed this amount due to the additional, but un-quantifiable recharge from leaking distribution system, waste water system and canals. At the end of the period during an average year 69 MCM are abstracted from Damascus. However during a dry year water use is much more intensive with wellfields operated for 11 months. Storage in the aquifer will be heavily drawn upon during these years that should be offset against years with lower abstraction when recharge will replace the used resource. It is stressed that the volume of storage of good water in the aquifer is comparatively small. The ability of the aquifer to buffer a long period of abstraction with low recharge is small. Thus, with the build-up of abstraction in the lifetime of the plan studies are recommended to monitor the groundwater and hydrological conditions.

Water quality is generally good under the city, however there is a slug of poor water quality that lies roughly north west of the Mezze autostrada. The known poor water quality at the University wellfield has led to its planned abandonment.

5.5.3 Outline of Most Promising Schemes for New Water Resources

(1) New groundwater resources schemes outside Damascus

(a) Cretaceous aquifer at Deir al Ashayer

Deir al Ashayer lies within an intermontain valley about 25 km west of Damascus and 7 km south west of Tekieh, immediately west of Jabel Mazar and adjacent to the Lebanese border, Figure 5.5.5. To the South east of Mazraat Deir al Ashayer, and just over the border in Lebanon lies a dried lake bed covering almost 2 km^2. The lake bed and the bottoms of the valleys are intensively used for irrigated agriculture.

The geology of the area comprises limestones of Cretaceous and Jurassic age. The wells penetrate a north-south trough of Cretaceous limestone that lies between higher mountains of Jurassic limestone to the West and east. The eastern side of the Cretaceous is faulted against the Jurassic. The Cretaceous is hydrogeologically isolated from the Jurassic to the West and east with a high permeability zone only about 1 km wide running south to north. The aquifer productive zone is only about 60 to 70 m thick at a depth of between 75 and 135 m below ground surface.

Regionally groundwater flow is from west to east in the Jurassic and Cretaceous strata, but in the Deir al Ashayer area groundwater in the Cretaceous flows to the North towards Wadi Barada. Although the water levels in the Jurassic to west and east are respectively higher and lower than the Cretaceous, the faulted zones act as low permeability barriers. It is considered (by MOI) that very little groundwater flows between the Cretaceous and the Jurassic.

The aquifer properties are quite variable as is illustrated by the range of specific capacities in the tested wells. The transmissivity of well 308K is reported to be 5800 m^2/d from a 26 hour airlift pumping test (MOI 1986). A group pumping test was undertaken to assess the hydrogeological conditions in the Dier al Ashayer area. The test used three wells, numbers 844, 846 and 854, pumping at a combined rate of 165.5 l/s for a 44 day period starting in August 1990. Analysis of the testing indicated a transmissivity for the area of 620 to 1000 m^2/d and a storativity of between 0.007 and 0.04. These figures together with the geometry of the aquifer and positioning of the wellfield were used to calculate the theoretical drawdowns in a wellfield pumped at a higher rate and for a longer period of time than the group pumping test.

The scheme proposed for the Master Plan is a modified and version of the earlier MOI design. The total scheme operational quantity is revised downwards from 255 to 200 l/s on the basis of use for 6 months in the year. The recharge into the aquifer, rather than well hydraulics, is the limiting factor on water resource utilisation in this area. The yield is based on assessment of the aquifer block in which the long term recharge may be only 7 MCM/y.

Construction of a large scale wellfield with a large pumping capacity would be possible, but, after the initial use of aquifer storage, would not be able to be used at an annual rate greater than the recharge. To abstract the water three of the existing MOI wells are proposed plus a further purpose drilled well. The drilling of a further production well to make a wellfield of four holes is recommended, for a number of reasons; Firstly it would enable the wells to be operated at or near to the rates that are known to have been achieved during the group pumping test, secondly, high capacity operation at 80 l/s is ruled out since this would require a pump larger than can be fitted into the casing, and thirdly the overall drawdowns in each well are reduced.

The location for the new well is about 200 m north east of the existing well number 854. This would place it along a track at an elevation of about 1180 masl. The depth of 150 m is chosen to fully penetrate the productive zone of the Cretaceous limestone between 70 and 135 m depth. The hole when drilled may prove to have a low yield, in such a case it another hole should be drilled. The proposed design for the new well is a 150 m deep hole drilled at 12.25" diameter incorporating 70 m of plain and 80 m of perforated 9" casing. The conductor pipe of 13" casing should be 20 m long for a good sanitary seal.

The drawdowns have been calculated based upon the hydraulic properties of the region determined by the group pumping test. The values were used in a well interference calculation. The transmissivity was taken to be uniform and 960 m^2/d while a value of 0.03 was used for storativity. To represent the elongate aquifer block image wells pumping were used. They were placed so as to create a 1 km wide high productive aquifer strip, with the pumped wells centrally located. The proposed pumping equipment for the wellfield is listed in Table 5.5.9.

(2) Groundwater schemes in Damascus, existing wellfields

(a) Wellfield at Jaramana.

The wellfield consists of one observation and 10 production wells. The holes were mainly drilled in 1990 but were not equipped. The testing shows that the aquifer is highly productive in this area, with a transmissivity of 3800 m^2/d causing individual well drawdowns of about 1 m at the tested pumping rate of 30 l/s. The well performance equations determined from the step tests are summarized in the Table 5.5.10. It is proposed that 9 of the wells be installed with pumps with a 40 l/s capacity and all the associated equipment for a pumping station. The site will have peak site capacity of 360 l/s, if an allowance is made for one of the wells to be undergoing maintenance over a 245 day pumping season a yield of 290 l/s or 6.12 MCM is available.

The water quality is typical of the Damascus wellfields. In operation the wellfield may tap poorer water that lies to the East, it is therefore possible that in the medium to long term water quality of the site will deteriorate. To continue using the site it may be necessary to blend water from Figeh to obtain a satisfactory water quality for consumers.

The rest water level at the beginning of the pumping season in May is about 12 m below ground. By November the level will be around 24 m below ground, the drawdown caused by 1.4 m in the well plus 7.6 m of interference effects plus about 3 m of regional recession.

(b) Wellfield in Tishreen and Kywan

This wellfield lies to the West of the current operational source at Oumawiyin. It comprises two parts, Kywan lies to the South of the road to Dummar and beside the course of the Barada River, and the second part lies within Tishreen on higher ground north of the road, Figure 5.5.6.

The five wells in Kywan were drilled in 1989 and tested in April 1990. The tests mainly comprised a 3 day constant rate test and a one hour period of pumping at a similar rate. The results are not amenable to conventional pumping test analysis, however radial flow modeling of wells 2 and 3 can give transmissivities of 3900 and 2300 m^2/d respectively. These hydraulic properties would indicate that high yields might be obtainable from the area. However the wells have high drawdowns due to head losses in the immediate vicinity of the hole, thereby reducing the quantities of water that may be produced from the wellfield, Table 5.5.11. Only wells numbers 2 and 3 are really suitable for use as production wells, the remaining holes have very low yields. The two holes can each reliably produce 30 l/s without excessive drawdowns.

The Tishreen part of the wellfield consists of ten wells drilled in 1993 but as yet they also have not been equipped. Only three of the holes at the site are hydraulically efficient and possibly suitable for use as production holes, (nos 3, 4 & 8). Both well losses and aquifer losses are high in the other wells.

To use the wellfield it is proposed that a phased approach be adopted. Initially the best wells should be equipped secondly the lower capacity wells may be used and lastly two new wells may be constructed. The production from the wellfield should be piped to Oumawiyin pumping station for chlorination and addition to the distribution system. The planned capacity of the wells to be equipped in the first phase is 135 l/s, Table 5.5.12. If used operationally for 80% of the time during an 8 month season the production would be 110 l/s and 2.33 MCM. In the second phase smaller capacity and higher head pumps are to be installed. The extra capacity is 120 l/s or an average of a further 100 l/s and 2.03 MCM. The final phase the capacity could be increased by the addition of two wells that could produce a total of 50 l/s. The final potential total installed capacity would be 260 l/s from 16 wells, an average of 210 l/s or 4.44 MCM in an 8 month year.

(c) Fringe Wells

There are 23 Fringe Wells operate by DAWSSA on the perimeter of the city. The wells are equipped with pumps with 50 m^3/h capacity. The wells are used at a typical total output of 9,000 m^3/d in the winter months and 12,500 m^3/d in the summer. This equates to an average use of 8 and 11 hours per day for each well in the winter and summer respectively. Certain of the wells could produce more water by equipping them with more powerful pumps and possibly increasing the capacity of the network in the vicinity of the source. Wells that have a specific yield of greater than 2 l/s/m and do not have records of high nitrates or total dissolved solids are selected for re-equipping. The wells with the revised capacities are listed in Table 5.5.13. An interference plus seasonal regional recession of groundwater levels is assumed to be 5 m.

The estimated net effect of the change would be an overall increase in production of 1.76 MCM in a year. The estimate is based on the newly equipped sources operating 18 hours per day for a six month period each year. During the rest of the year when demand is lower they will operate for fewer hours to produce a similar amount to that produced in the other wells. The unchanged fringe wells are assumed to operate at the existing rates.

(d) Increased abstraction from the existing wellfields

The capacity of the existing wellfields is limited by the storage in the aquifer, the ability of the water to move towards the well and the hydraulic properties of the well. It is considered by DAWSSA that there is still available capacity in the aquifer that may be abstracted by the wellfields and that the limiting factor is the ability of the wells to remove the water from the ground. The wells can be used to pump water from the aquifer so long as the water level within the structure does not fall too far. For the purposes of the evaluation it is considered that the water level should not decline below 25 % of the perforated length of the casing. Using step test data and records from the observation wells the pumping rates that will produce the maximum acceptable drawdown were calculated. The current water levels and the future proposed water levels are listed in Table 5.5.14, together with the data used in the determination.

At Mazraa there is scope to increase the pumping by a small quantity from this site up to about 31,700 m^3/d (367 l/s). This could be achieved by increasing the existing overall pumping capacity by 10%. The most favorable wells for the use of larger capacity pumps are operational numbers 8, 10, 12, 13 and 15. Increase in available resources of 33.3 l/s or 0.58 MCM/y. Due to the turbidity known at this wellfield an increase in pumping is not recommended.

The abstraction at Ibn Assaker may be increased to 40,000 m^3/d. The lift pumps in the reservoir may be have an increased capacity so as to enable the well pumps to be utilized more efficiently. The wells on the site are used typically only 65 % of the time, by increasing this utilization to about 90% the site can increase the output by 10,000 m^3/d.

The hydraulics of Kaboon do not permit the abstraction of a greater quality from the five existing wells that are currently used. On the contrary it would appear that the water level in the wells may be lowered by more than 25 % of the screen length in some instances.

Kadam Railway could yield more water, though there may be long term water quality problems in this area. It is proposed to increase the average capacity of the pumps from 100 to 135 m^3/hr. With the current utilization rate this would result in an increase of about 115 l/s.

The capacity of the Oumawiyin pumping station will be increased with the supply from Tishreen and Kywan wellfields amounting to sum 5 to 7 wells with a combined output of up to 195 l/s. It is not proposed to further increase the abstraction from the aquifer in this wellfield.

The University wellfield lies on the interface between good water quality that is actively recharged from the Barada and a poor water area lying to the West towards Mezze. As a consequence the wells on the West of the site have elevated chlorides, sulfates, lead and another determinands compared to the East side of the site. In view of the water quality constraints at this site and the laudable desire from DAWSSA to not induce the migration of poor water quality from the East the site should be considered the last to be utilized. No change to the capacity of the site is recommended. The production plan does not use output from this site.

The well hydraulics of Jobar indicate that no more may be taken from this site without de-watering the aquifer.

(3) Groundwater schemes in Damascus, new wellfields

(a) Shoukry al Qouwatly Street

The proposed location is within the parks adjacent to the Barada River opposite the International Fair and the National Museum, see Figure 5.5.7. There are existing wells along the river bank that are used by the Municipality for garden irrigation and fountains.

The zone along the river is anticipated to have hydraulic properties suitable for the construction of high yield wells for a wellfield. In this area the pebble beds are better developed than the rest of Damascus being over 40 m thick. A transmissivity of over 1000 m^2/d can be expected in this area, and individual well drawdowns may be less than 5 m at a pumping rate of 100 m^3/hr. In addition the water chemical quality is likely to be good with the total dissolved solid less than 400 mg/l. The rest water level is likely to be about 10 m lower in elevation than at Oumawiyin in May or June, that is an absolute elevation of 685 m in 1994 or about 5 m below ground level.

The natural groundwater flow direction is from the north west, whereas the Barada is aligned east to west. The abstracted water will be derived from a radius around the wellfield and may in addition induce leakage from the Barada River. River water quality is an important consideration in the viability of this scheme. However, the effective 'filtering' of river water through the aquifer will improve some of the river water chemical characteristics. The fountains in the Barada are supplied by wells adjacent to the river, a sample of this water has an electrical conductivity of 620 μS/cm and does not have any problems with the major ions chemistry.

To utilize the groundwater at the site an exportation cum observation well and five high yield wells are proposed. It is anticipated that the holes will need to be 75 to 80 m deep to fully penetrate the highly productive sediments. The first hole should be tested to check the aquifer properties and water quality prior to the establishment committing it's self to the location. Subject to the exploration hole having a transmissivity of greater than 1500 m^2/d and producing water of a drinking water standard the five production wells may be drilled. The productions holes will be drilled at a diameter of 20" to permit the installation of 17" casing and slotted casing. A large diameter is recommended to enable the well to have a specific yield of more than 10 l/s/m, this could permit each hole to abstract 150 m^3/h with a drawdown of less than 4.3 m. An additional drawdown of 7 m can be anticipated from other wellfields plus an interference between the wells of up to 17 m through a typical pumping season from May to the beginning of the natural recharge in November or December. A pumped water level of up to 33 m below ground level is expected here.

(b) Kanawat Gardens wellfield

The proposed location for a new wellfield is within the triangle of land at the junction between Abu Baker as Swddik Street and 17th April Street, see Figure 5.5.8. The land is now used for small farms in the center of the plot, but the wellfield is planned to be constructed on the perimeter of the area to minimize the effects on the existing land users. The site is chosen to be in an area where the aquifer is good, the highly productive pebble beds are about 30 m thick under the site and the rest water level about 10 m below the surface. The location is also a balance between poor water quality to the West in Mezze with elevated sulfates and chlorides and higher nitrate water towards Kadam.

The proposed wellfield will have 5 production and one observation hole. Each will be 70 m deep to fully penetrate the aquifer. The design should allow for 20 m of plain and 50 m of perforated 9" diameter casing to be installed into a 12.25" hole, and 10 to 20 m of 13" casing for the conductor pipe. The anticipated capacity of the wells will permit the installation of a 25 l/s pump, giving an average site production of 80 l/s or 1.69 MCM over an eight month period.

(c) Kafar Souseh wellfield

The wellfield, proposed by DAWSSA is of a very similar type to the Kanawat Gardens wells. The location is beside the Municipality offices, Figure 5.5.9. The wellfield is to the South east of the proposed Kanawat Gardens wellfield, as such the hydrogeology and the hydrochemistry is expected to be similar. The well design and capacity are the same as the Kanawat Gardens site for the planning in the Master Plan.

5.6 Comparison and Selection of Master Plan Projects

5.6.1 Approach

Several projects have been proposed to improve existing water supply conditions and meet future water demands. In order to assess if a project will be included in the master plan, it is evaluated and compared to other alternative projects using technical, economic and environmental criteria. The principal approach used for comparing the various candidate projects is described as follows:

i) Countermeasures for unaccounted-for water (UFW) are generally the least costly way of increasing water available for consumption since they defer the need for expensive water resources development schemes. Therefore these projects are preferred for immediate implementation.

ii) Improving water supply conditions in the informal areas has been identified as a priority by municipal authorities. Projects to extend the distribution network and provide proper service connections are selected for the master plan except where DAWSSA has already initiated a feasibility study.

iii) Water supply projects required for new development areas identified in the Municipal Master Plan are selected if they needed before the target year of 2015 identified in the Water Supply Master Plan.

iv) Water resources development projects are screened on the basis of availability of water

All the projects identified as candidates for the master plan are listed in Table 5.6.1 and described in detail in the sections that follow. The projects are classified into one of the following three groups:

i) Rehabilitation and Supply Improvements: Schemes in this group include rehabilitation projects to reduce system losses and unaccounted for water, and improvements in water quality testing.

ii) Ongoing and Planned Water Supply Improvements: Schemes in this group have already been identified by DAWSSA and are either under construction or in the planning stage. Projects in this group include supply improvements for informal areas.

iii) Proposed Water Supply Schemes: Schemes in this group are proposed by the JICA-DAWSSA study team based on the proposed Damascus City Master Plan (2020), results of water resources study by Ministry of Irrigation, and a hydrogeological assessment carried out by JICA-DAWSSA study team.

5.6.2 Rehabilitation and Supply Improvement Schemes

(1) Water main replacement

The total length of distribution mains in 1996 is about 1,000 km. A variety of materials have been used over the years. In general the older mains are cast iron pipe and the younger mains are ductile iron pipe, and steel pipe (see Chapter 4.5).

The cast iron pipes, most of which are 80 years old, inferior lead joints which are susceptible to high leakage rates. Leakage is also high at connection points and valves in comparison to other pipe materials Therefore, the replacement of cast iron pipes is one of the measures proposed to effectively reduce water losses in the distribution system. The total length of cast iron pipe is about 124 km. Only 22 % of the cast iron pipes were installed in the 1970's. These are considered to have some useful life remaining and do not need to be replaced. The balance of the cast iron pipes, approximately 98 km (78%), were installed before the 1970s, and should be replaced ductile pipes. The implementation schedule for water main replacement program is shown in Table 4.5.2.

(2) Water meter replacement

There is a huge backlog of defective or unreadable meters waiting to be repaired (more than 86,000 or 30% of house connection) and a substantial amount of revenue is being lost to malfunctioning meters. The most common domestic consumption meter in use is the Syrian made Doris multi-jet meter. Testing revealed that as many as 22.73 % of these meters fail to record at minimum flow levels although they perform very well under specified maximum and normal flow conditions. In addition to above, the multi-jet design requires that the meter be installed in a horizontal plane to prevent distorted readings.

There are two meter replacement options that are considered. One option is to retain the existing Syrian made meter and increase the level of replacement and repairs. The second option is to import foreign made rotary piston type meters which have a high degree of accuracy at minimum flow of +/- 1.5%. The rotary piston meter facilitates installation in the horizontal or vertical plane which is seen as an advantage. Based on technical and economic evaluation it is recommended that existing Doris meters be replaced with a more reliable and accurate rotary piston type meter.

(3) Improvement in meter testing and repairing

Currently, DAWSSA has only one meter repair facility which is staffed with only one meter repair man. There is a large backlog in meters waiting for repair. This backlog will likely increase since meter failure rates appear to be holding steady at 30% and the number of service connections is increasing. Replacement of Syrian made meters with imported meters will require the installation of new test bench. More staff will likely be required regardless of which option is selected however, selecting imported meters will require a separate specially trained repair team until the old meters are phased out.

(4) District Meter Area

The implementation of District Meter Areas (DMA) is an essential requirement for an effective leakage control strategy as mentioned in Chapter 4.5. Without any information on district flows, it is impossible to determine accurate leakage levels or pin-point where maintenance and leakage should focus their efforts. The DMA system is required to reach the targets identified for reduction of system leakage.

(5) Leakage survey (Active leakage detection program)

The leak detection section currently has three teams who are systematically working their way through Damascus looking for leaks. It is important that when leaks are found they be repaired in as short a time as possible. It is proposed that staffing in the leakage detection section be increased from three teams to four teams by the year 1998. Combined with the implementation of the DMA system, proposed staffing levels will enable full coverage of Damascus. The section will need to be further expanded by the year 2010 to cope with expansion and an aging system.

(6) Pressure control

The effectiveness of leakage control efforts can be greatly enhanced by controlling system pressure. Pressure control is critical since it significantly reduces leakage rates and therefore the quantity of water lost when a leak develops. Where possible, advantage of the latest pressure control pressure control valve technology should be used to automatically regulate pressures in response to varying water demand patterns. Reducing the pressure will not only reduce the level of leakage, but will also reduce the quantity of water used in what can be described as open tap use (widespread in Damascus). Pressure reduction will also reduce the frequency of pressure related mains breaks.

(7) Improvements in master metering

The recording of water flow from reservoirs and pumps, daily and hourly water supply amounts, is helpful to identify yearly, seasonal and hourly trends in water production and water use. Master metering is essential for optimizing system operation and providing the information required by management to formulate future operational plans. In the present condition, only 28% of the total requirement for water flow measurement at service reservoirs and booster pump stations is adequately covered. Another 24% of the requirement is covered by non-functional meters and the balance of 48 % has no provision for metering. A total of 59 master meters are required including the replacement of 20 non-functional meters as listed in Table 5.6.2.

There are four types of flow meters available: (i) turbine, (ii) a venturi tube, (iii) a electromagnetic and (iv) a ultrasonic. The electromagnetic flow meter offers the most advantages in terms of accuracy, ease and flexibility of installation, and minimal maintenance requirements. The ultrasonic flow meter is the second best choice. It is therefore recommended that electromagnetic flow meters be used for applications on pump discharge piping and the ultrasonic flow meter be used in gravity flow applications from service reservoirs.

(8) Water quality testing improvement

The quality of the water supplied by DAWSSA, discussed in section 3.4, is less than ideal in the dry season. Parameters of concern include high levels of nitrate and hardness. Surface water in Damascus is already heavily contaminated, and may deteriorate the groundwater quality in the future. In spite of these alarming facts and potential problems, potable water in Damascus is being consumed virtually untested. DAWSSA's water quality testing laboratory has a limited capacity and can only analyze 30 samples/day for general water quality analysis. The lab does not analyze for pesticides, disinfection by-products, and pathogens. Many of the analytical instruments are old, and unreliable, and in general, repair services and replacement parts are unavailable.

It is an essential requirement for every water supply authority to ensure public health and safety. The laboratory must be upgraded in order to provide regular and comprehensive water quality testing. Under the proposed project, the capacity of the laboratory will be increased by 3 to 5 times. Programs to test for toxic organic chemicals, heavy metals, and pathogens are also included in the project. Achieving these improvements will require a corresponding reinforcement in human resources, training, space, and equipment.

(9) Water quality control in South Damascus

In South Damascus, the levels of nitrate and hardness in groundwater are as high as the allowable maximum specified by the Syrian Drinking Water Standard (section 3.4). The water quality in this area may even worsen in the future. This pollution related water quality problem appears to be widespread on a regional scale. There appears to be no effective measure that DAWSSA can take to stop the pollution of groundwater. If the water quality becomes unacceptable, the pumping from this region will have to be stopped. This event would have a serious impact on the water supply condition since well fields in South Damascus contribute a significant amount of water which is strategic to meeting growing demands. The economic and technical feasibility of treating this water to bring it back to acceptable standards would then have to be re-assessed in light of other available options.

Taking Kadam Railway well field as a model case, five different approaches were considered to make maximum use of low quality water resources in South Damascus. They are based on : blending (mixing of low quality south Damascus water with high quality Figeh water), water treatment (softening and nitrate removal), and suppression of pumping from contaminated wells.

(10) Reinforcement of existing water resources

The sources at Figeh; Side Spring and Ain Haroush are both under re-development. New wells have been drilled near to the existing sources that allow for much greater drawdowns than are currently achievable. The up-graded sources are hoped to increase the total Figeh output during peak demand months. There are no changes planned for the Main spring and the Deir Moukaren wellfield.

Barada wellfields groups 1, 2 and 3 are ongoing projects, the group 2 wellfield is nearing completion, the other groups have yet to be developed. The sources together have a capacity of 450 l/s which will be pumped via a pipeline to Damascus via Figeh. The Jurassic that feeds Barada Spring is estimated to have a long term natural recharge of about 100 MCM/y. DAWSSA has been allocated 34 MCM/y. It is considered that with careful management an additional 20 MCM/y may be available from the aquifer for use in Damascus without deleterious effects on local water users and the Barada River.

The study of the sources operated by DAWSSA has shown that there are three wellfields that have undeveloped potential for further water abstraction, (Ibn Assaker, Kadam Railway and the Fringe Wells). Ibn Assaker wellfield is under utilized, and an additional 120 l/s may be pumped from the wells. The limiting factor constraining usage is the ability of the reservoir pumps to get the water into the distribution system. By up-grading the capacities of these pumps the quantity that may be produced from the site as a whole can be increased. Kadam Railway may also produced more, the limiting factor being the capacity of the submersible pumps. By upgrading these it should be possible to obtain an average of 115 l/s extra from the whole site.

The other existing wellfields in the City; Mazraa, Jobar, Kaboon, Oumawiyin are used at near optimal rates, no changes in the operation of these sites are made in the Master Plan. The University wellfield is on the interface between good and poor water quality. The continued operation of the site is liable to result in the water quality not meeting the Syrian drinking water standards. It is therefore proposed that this site is not used in the future. Kadam Store wellfield is to be fully equipped with submersible pumps, this will add water to the distribution network in south Damascus.

An existing wellfield at Dummar is to be re-equipped after period of idleness while new reservoirs and pumping station were built. It is intended that the water will be used for the local distribution network in Dummar, releasing the supply that currently comes from Figeh to other parts of the network. The fringe wells have different specific capacities, however they are all equipped with the same pumps. Those wells that are in higher yielding parts of the aquifer could be used at a higher rate. The re-equipping of just 8 sites could give an extra 1.76 MCM in a typical year. The emergency wells continue to be a back-up source for DAWSSA in times of unprecedented water shortage if the main sources can not be used. No change in the use of these sources are planned.

5.6.3 On going and Planned Water Supply Improvements

The following projects are identified in DAWSA's five year plan for the 1996-2000 period:

(1) Distribution schemes for informal areas (Formalizing informal areas)

There are currently 14 informally populated sites in and around Damascus and these sites are a major contributing factor to unacceptably high levels of unaccounted for water. There is an estimated population of 407,000 persons with a daily water consumption of 78,580 m^3/d. Besides the fact that no revenue is generated from this informal water consumption, there are also substantial losses through leaks at informal connection points. Clearly, there are many benefits to be gained by providing properly connected and metered services in these areas. The location of the informal connection areas is illustrated in Figure 5.2.1. The status and progress of on going projects to provide proper service connections is summarized as follows:

1) Esh - Al Warwar informal area:

Location : in the north part of Berze district
Implementation Schedule : completed at the end of 1997
Area to be improved: 31.9 ha
Estimated Population : 15,180
Water Demand : 3,036 m^3/d estimated
Construction cost for distribution : US$ million 0.443 approximately
Work Items : 7,300 m main pipe length of 80 mm to 150 mm diameter
1,845 m service pipe
Remarks : The scheme is under construction by DAWSSA

2) Kassioun Mountains Foot informal area:

Location : spread over both Mouhajreen and Ruku Aldyn districts
Implementation Schedule : completed at the end of 2004
Area to be improved: 30.9 ha
Estimated Population : 33,977
Water Demand : 6,562 m^3/d estimated
Construction cost for distribution : US$ million 0.806 approximately
Work Items : 3,550 m main pipe length, service pipe and 5,660 meters
Remarks : Informal dwelling are scattered randomly throughout the area among formal residences.

3) Tishreen informal area

Location : in Kaboon district
Implementation Schedule : completed at the end of 2002
Area to be improved: 36.2 ha
Estimated Population : 33,977

Water Demand : 15,488 m^3/d estimated

Construction cost for distribution : US$ million 1.117 approximately

Work Items : 3,550 m main pipe length and 2,580 meters, service pipe

4) Jobar Surrounding - Al Aksab Mosque area

Location : in Jobar district

Implementation Schedule : completed at the end of 2001

Area to be improved: 63.7 ha

Estimated Population : 25,704

Water Demand : 4,964 m^3/d estimated

Construction cost for distribution : US$ million 1.944 approximately

Work Items : 3,550 m main pipe length and 4,280 meters, service pipe

5) East - West Tabbaleh area

Location : in Shaghour district and outside of the city

Implementation Schedule : completed at the end of 2005 for out of city

Area to be improved: 135.2 ha (remaining area is 40.6 ha)

Estimated Population : 12,669

Water Demand : 2,447 m^3/d estimated

Construction cost for distribution : US$ million 1.024 approximately

Work Items : 8,330 m main pipe length, service pipe and 630 meters

Remarks : about 70 % of the informal area in Shagour has been improved, and the remaining area is out of the City.

6) Mokhayam Al Yarmouk (Tadamun & Zahera) area:

Location : in Yarmouk district and outside of the city

Implementation Schedule : completed at the end of 2003 for outside of city

Area to be improved: 118.0 ha

Estimated Population : 86,068

Water Demand : 16,621 m^3/d estimated

Construction cost for distribution : US$ million 1.279 approximately

Work Items : 7,260 m main pipe length, service pipe and 14,340 meters

Remarks : Tadamun area has been improved by DAWSSA. the improvement works at Zahera area are planned to start within 1996. Yarmouk are is required to be improved.

7) Naher - Eshah - Dahhadil & Asalie Kadam area

Location : in Kadam district

Implementation Schedule : completed at the end of 1999

Area to be improved: 170.4 ha

Estimated Population : 37,005

Water Demand : 7,146 m^3/d estimated

Construction cost for distribution : US$ million 4.656 approximately

Work Items : 7,260 m main pipe length and 6,170 meters, service pipe

Remarks : The improvement scheme is proposed to start at the same time as Zahera within 1996.

8) Al Qazzaz & Shagour Bassateen area

Location : in Shagour district and outside of the city

Implementation Schedule : completed at the end of 2001 for outside of city

Area to be improved: 64.2 ha (remaining area is 44.9 ha)

Estimated Population : 10,692

Water Demand : 2,065 m^3/d estimated

Construction cost for distribution : US$ million 1.698 approximately

Work Items : 7,260 m main pipe length and 1,250 meters, service pipe

Remarks : About 30 % of the informal area in Shagour has been improved, and the remaining area is out of the City.

9) Mezze - Razy & Kafar Souseh - Lawan area

Location : in Kafar Souseh district

Implementation Schedule : completed at the end of 2000

Area to be improved: 170.3 ha

Estimated Population : 46,786

Water Demand : 6,322 m^3/d estimated

Construction cost for distribution : US$ million 4.656 approximately

Work Items : 7,260 m main pipe length and 7,800 meters, service pipe

Remarks : this is one of the areas with the largest leakage losses.

10) Mezze # 86 area

Location : in the north part of Mezze district

Implementation Schedule : completed at the end of 1997

Area to be improved: 95.7 ha

Estimated Population : 46,390

Water Demand : 9,278 m^3/d estimated

Construction cost for distribution : US$ million 0.681 approximately

Work Items : 20,250 m main pipe length of 80 mm to 400 mm diameter, Elevated service reservoir with capacity of 500 m^3

Remarks : The scheme is now under construction by DAWSSA

11) Somareyeh area

Location : along the Konaytera Road in the southern east of Mezze district

Implementation Schedule : completed at the end of 2004

Area to be improved: 37.6 ha

Estimated Population : 45,90

Water Demand : 918 m^3/d estimated

Construction cost for distribution : US$ million 0.877 approximately

Work Items : 6,950 m main pipe length and 770 meters, service pipe

12) Dummar - Wadi Al Mashare area

Location : in the south part of Dummar district

Implementation Schedule : completed at the end of 1999

Area to be improved: 41.9 ha

Estimated Population : 14,841

Water Demand : 2,866 m^3/d estimated

Construction cost for distribution : US$ million 1.242 approximately

Work Items : 6,950 m main pipe length and 2,470 meters, service pipe

13) Takadom area

Location : outside of the city in the south of Yarmouk district

Implementation Schedule : completed at the end of 1998

Area to be improved: 54.5 ha

Estimated Population : 36,750

Water Demand : 7,350 m^3/d estimated

Construction cost for distribution : US$ million 0.738 approximately

Work Items : 6,950 m main pipe length and 2,470 meters, service pipe

Remarks : about 25 % of the area surrounding Takadom well field has already been improved by DAWSSA.

14) Kudsaya area

Location : in the southern part of Kudsaya village

Implementation Schedule : completed at the end of 2005

Area to be improved: 50.0 ha

Estimated Population : 20,800

Water Demand : 4,017 m^3/d estimated

Construction cost for distribution : US$ million 1.536 approximately
Work Items : 6,950 m main pipe length and 3,470 meters, service pipe

(2) New well centers for the informal area

New wellfield sites are identified in DAWSSA's plan to supply existing informal areas. The capacity of the existing Kaboon wellfield will be increased with, new and deeper wells. In the first phase two are planned, if they prove to be successful than another eight will be constructed. Jaramana wellfield is located in a highly productive area. This wellfield will be equipped to serve the distribution network in the area of South Damascus. Water supply in the informal area of Takadom will be enhanced by the Takadom wellfield. The site has 10 production wells that were drilled in 1989 but were not immediately equipped for production. DAWSSA plans the commission the wellfield in the next couple of years.

(3) New well centers for formal area

DAWSSA's development plan identifies several projects to increase the capacity of water sources supplying the City. A new wellfield is planned for Kafar Souseh, this will be a small source with approximately 5 wells. The wellfield at the Faculty of Agriculture between Mazraa and Kaboon is not viable since DAWSSA can not been able to find any suitable land for locating the wells. Tishreen and Kywan wellfields have been drilled but not equipped with pumps. It is planned to develop this source is a phased sequence by firstly equipping the high yield wells, followed by the low yield wells and finally by drilling another pair of wells. The wellfield will be controlled from the existing Oumawiyin center located close by.

(4) New water resources schemes in the Hermon area

DAWSSA's five year plan identifies a number of potential water resources development schemes described as follows:

A wellfield near Rimeh in the southern part of the Hermon area consists of existing wells drilled by the MOI during hydrogeological investigations. The limited capacity of the source (285 l/s for 6 months of the year) and the distance to Damascus have made scheme economically unattractive.

The Kudsaya residential development north west of Damascus will be supplied by a wellfield in Wadi Marwan. The wellfield, pipeline and associated works are designed for a capacity of 20,000 m^3/d.

An existing wellfield in the Cretaceous limestone at the north end Hermon near the village of Deir al Ashayer is identified as a potential new water source. Three existing MOI wells and a fourth to be drilled by DAWSSA, make up a small wellfield. The water would be supplied to Damascus via a new pipeline to Huseiniyeh, where it would join other existing pipelines.

(5) Water supply distribution schemes for new development areas inside Damascus city.

The need to extend the distribution of water supply into new development areas of Kudsaya New Suburb, Dummar is identified in the DAWSSA's plan. The system in Kudsaya is currently under construction. A project is also planned to install more transmission line with capacity of 500 m^3/d for the Special Area Zone (residential area for State Factory). The location of each distribution scheme is shown in Figure 5.2.2. The various distribution schemes are outlined as follows:

a) Kudsaya New Suburb
Location : in the east to Kudsaya village
Implementation Schedule : completed the settlement in the year 2010
Total Area : 400 ha (Net area for residential & commercial : 300 ha)
Population Projection : 52,000 persons in 2010 (density : 130 persons/ha)
Water Supply: 20,000 m^3/day from Well Field (13 wells) at Wadi Marwan
Water Demand : 12,000 m^3/day in 2010
Distribution : work on installation of distribution mains is in progress

b) Dummar Extension Area (1st Phase)
Location : in the east to Dummar New Town
Implementation Schedule : completed the settlement in the year 2000
Total Area : 124 ha (Net area for residential & commercial : 100 ha)
Population Projection : 6,000 persons in 2000 (density : 60 persons/ha)
Water Supply :planned to supply through Kudsaya New Suburb from Wadi Marwan and new Dummar Well Field
Water Demand : 7,600 m^3d in 2000
Distribution : Distribution main is under construction

c) Special Area Zone (residential area for State Factory)
Location : in the north to Hame village
Implementation Schedule : completed the new transmission pipe in the year 2000
Total Area : 25 ha for residential area
Population Projection : 3,500 persons in 2000 (density : 140 persons/ha)
Water Supply : planned to install one more pipeline along the existing pipe
Bulk water (Net) : 500 m^3/d in 2000 from 100 m^3/d at present
Distribution : Distribution system is existing

5.6.4 Proposed Water Supply Schemes

The following schemes are proposed by the DAWSSA-JICA study team to develop water resources required for population growth and new residential areas identified in the municipal master plan.

(1) Rural areas

According to the City Master Plan for the year 2020, the existing Maraba village and Assad Suburbs will be annexed to the Damascus City by 2020. Maraba village is supplied by the Establishment of Drinking Water and Sewerage in the Rural Province of Damascus from the 2 wells with capacity of 35 m^3/hr. Assad suburb has its own water resource of well field located in rural area. It is proposed that these existing water supply systems be incorporated into DAWSSA's system after the year 2010. Location of each system is shown in Figure 5.2.2. These systems are outlined as follows;

a) Maraba water supply system

Location : near the planned Kassioun New Town in the north of the Kassioun Mountain

Exiting population : 4,680 in 1995 based on the 1994 Census

Area : 75 ha

Water Supply : supplied by the Establishment of Drinking Water and Sewerage in the Rural Province of Damascus

Water Demand : 840 m^3/d (per capita water demand is estimated as 180 lpcd)

Distribution : Distribution system is existing

b) Assad Suburb

Location : along Homes Road in the east of the City

Exiting population : 7,800 in 1995 estimated based on the 1994 Census

Area : 40 ha for 1st Phase, 193 ha for 2nd Phase and 298 ha for Extension area

Water Supply : supplied by itself with Wells located at rural area (no detail information)

Water Demand : 2,220 m^3/d estimated as 285 lpcd

Distribution : Distribution system is existing

Implementation Schedule: under construction for 1st Phase

: no information for 2nd Phase and Extension area

(2) Distribution schemes for new development areas

As described Section 3.2, Damascus Municipality proposes in it's master plan to extend the administrative boundary of Damascus City and develop new residential suburbs to accommodate population growth. DAWSSA's existing water rights of 296.9 MCM/year will be insufficient to meet the estimated water demands in the year 2005 even if system losses are reduced significantly. Distribution schemes required for the proposed extension of Damascus city are summarized below. To provide water for the new development areas, reallocation of water from other resources, for example those used for irrigation will be required in the future.

a) Proposed Kudsaya New Suburb
Location : in the east of Kudsaya New Suburb
Implementation Schedule : development completely populated after 2015
Development Area : 200 ha for residential & commercial
Population Projection : 25,000 in 2020 with proposed unit consumption
Water Demand : 10,000 m^3/d estimated
Construction cost for distribution : US$ million 3.4 approximately

b) Dummar Extension Area (2nd Phase)
Location : in the east of Dummar Extension Area (1st Phase)
Implementation Schedule : development completely populated in 2015
Development Area : 216 ha for residential & commercial
Population Projection : 25,000 in 2015
Water Demand : 8,000 m^3/d estimated with proposed unit consumption
Construction cost for distribution : US$ million 3.6 approximately

c) Kassioun New Town
Location : in the north of the Kassioun Mountain
Implementation Schedule : development completely populated after 2015
Development Area : 650 ha for residential, commercial, Industrial, etc.
Population Projection : 12,000 in 2020
Water Demand : 4,800 m^3/d estimated with proposed unit consumption
Construction cost for distribution : US$ million 10.9 approximately

d) Assad Suburb (2nd Phase & Extension Area)
Location : along Homes Road in the east of the City
Implementation Schedule : development completely populated after 2015
Development Area : 193 ha for 2nd Phase and 298 ha for Extension area

Population Projection : 25,000 for 2nd Phase in 2010
: 14,000 for Extension area in 2015

Water Demand : 4,800 m^3/d estimated with proposed unit consumption

Construction cost for distribution : US$ million 3.2 (2nd Phase) and 5.0 (Extension Area) approximately

e) Kaboon Green Area : reserved area for greenery with area of 530 ha

f) Assad City & Proposed Assad City Extension Area No.1, 2, 3

Location : along Quneita Road in the southern west of the City

Implementation Schedule : development completely populated after 2015

Development Area : 655 ha for Assad City, 200 ha for No.1, 124 ha for No.2
575 ha for No.3

Population Projection : 25,000 for Assad City in 2015
: 12,000 for Proposed Assad City Extension Area No.1 in 2020
No.2 & 3 are no information

Water Demand : 9,950 m^3/d for Assad City in 2015 and 4,800 m^3/d for Proposed Assad City Extension Area No.1 estimated with proposed unit consumption

Construction cost for distribution : US$ million 11.0 (Assad City), 3.4 (No.1), 2.1 (No.2) & 9.7 (No.3) approximately

(3) Water resources schemes in Damascus (new stations)

Three new wellfields are proposed; one in the center of the city on Shokry al Qouwatly street, another in Kanawat Gardens and a final one in Kafar Souseh. A wellfield is planned to be located in gardens along Shokry al Qouwatly street and opposite the National Museum. The water quality and yields from the ground are both anticipated to be good in this part of the City. A potential water source that is not put forward for the Master Plan is the area north of Al Shouhada Square near the Yalbuga Center. The groundwater is known to be shallow depth and the pebble beds known to be highly productive. Although for quality reasons it may not be suitable as potable water, it may be a substitute source for the Municipality.

A third phase of the development of the Tishreen wellfield comprises the construction of two new wells in that part of the site where existing holes have already demonstrated the potential for high well yields. The Kanawat Gardens wellfield is planned for an area of small market gardens between Kanawat and Kafar Souseh. The area was selected to be distant from existing wellfields yet still have reasonable well yields and good water quality. A small wellfield of 5 holes is anticipated for this site.

(4) Water resources schemes in Hermon and Zabadani area

Three sources in the Hermon area would all require long pipelines if the water where allocated for use in Damascus. In the Awaj basin a spring source at Beit Jenn and Tabibiyeh could provide a seasonally variable supply. The Jurassic aquifer east of Sergaya and north east of Zabadani has only limited recharge. It has some development potential, but is economically unattractive. A pair of wellfields at Ain el Irk and Sergaya could have a potential yield of about 3 MCM/y.

5.6.5 Cost Estimates

This section describes how the project cost estimates are developed. These cost estimates are used to evaluate the economic viability of each project which is one of the screening criteria used to select the master plan projects. Costs estimates include the direct construction costs and the operation & maintenance costs for each project alternative described in Section 5.6.2, 5.6.3 and 5.6.4. Estimated costs for each project are shown in Table 5.6.3. The following assumptions are applied to the cost estimate:

i) Cost for transmission main and distribution network are estimated based on work quantities calculated for each project and corresponding unit prices,

ii) Costs for reservoirs are estimated by applying a unit rate of SL 6,300/m^3 based on Barada collecting reservoir,

iii) Costs for building are estimated by applying a unit rate of SL7,600/m^2 based on the Kadam store training center,

iv) Estimated costs for annual operation of pumps is based on operating hours and annual electricity consumption calculated for respective pumping station and a unit rate of SL 0.75/kWH, and

v) Annual maintenance costs for pumps and distribution network is 3.0 % and 0.3 % of the direct construction cost for economic evaluation.

5.6.6 Economic Evaluation

One of the criteria used to screen proposed master plan projects was economic evaluation. The Economic Internal Rate of Return (EIRR) for each project was calculated on the basis of the estimated economic benefits and economic costs. Details of the economic evaluation are provided in Appendix J of the supporting report.

The main benefit is the incremental water delivered to the consumer generated by each candidate project. The benefit is evaluated by taking the difference between the "with" and "without" project case. Many of the candidate projects contribute to the general well being of the public, however, health benefits, and other social benefits from improved services are not considered in the economic evaluation since only increased water sales are quantifiable.

The estimated construction costs for each candidate project are converted to the economic costs by applying the shadow exchange rate of SL 50 = US$ 1 to the local cost components. Economic costs include engineering, administration and contingency allowances. Incremental operation and maintenance costs were also estimated on the "with" and "without" project basis and added to the investment cost to obtain the cost stream of each candidate project over it's expected economic life.

Each candidate project is evaluated by calculating the internal rate of return based on the discounted cash flows produced from the estimated economic costs and incremental water sales. The various components of the leakage control program such as district metering, pressure control and master metering were grouped together and evaluated as a whole.

In general, the economic life for most of the candidate projects is assumed to be 25 years. Replacement of pumps and rehabilitation of conveyance components is assumed to occur after 15 years. The three Hermon Spring scenarios include significant conveyance elements and therefore are assumed to have a longer economic life of 35 years. Economic assessment of the cast iron pipe replacement program assumes a 75 year economic life based on the longevity of ductile iron mains.

In general, projects with a rate of return higher than 10% (assumed opportunity cost of capital in Syria) are deemed economically viable. Candidate projects are ranked according to their EIRR as summarized in Table 5.6.4. A sensitivity analysis indicates that estimated EIRR's are robust to variations in costs, benefits and delays in implementation.

5.6.7 Environmental Evaluations

(1) Objectives

The projects proposed in this chapter are expected to bring positive environmental impacts (e.g., improved public health condition through safe drinking water supply) to Damascus. However, they may also bring negative environmental impacts. Therefore, master plan level environmental impact assessment (Initial Environmental Examination, IEE) was conducted as a part of comprehensive project evaluation of proposed projects. The objectives of IEE are :

i) assessment of environmental impacts by the proposed projects

ii) environmental screening of the proposed projects

(2) IEE

The criteria for IEE were selected based on the Syrian EIA guideline, JICA Environmental Consideration guideline, and characteristics of the area. The following 5 aspects of environmental impacts were considered important.

Criteria	Examples of environmental impacts considered
1. Natural Environment	water : exhaustive exploitation of water resources other : destruction of local vegetation and wild life
2. Public Health and Pollution	construction : noise, vibration, increase in traffic, dust operation : quality of supplied water, increase in hygiene, health standard, subsidence
3. Waste	disposal of various waste produced by the project, increase in waste water
4. Social Environment	water right, change in life style, local economy, and other factors
5. Cultural Asset	damage to historical and cultural asset
Overall Assessment	overall environmental impact

The results of the assessment is given in Table 5.6.5 . In general, the environmental impacts by the proposed projects seem to be small, and the proposed projects have significantly large positive environmental impact on public health. Among the most important environmental factors are water quality of supplied water and environmentally irresponsible exploitation of water resources.

(3) Projects with high environmental impacts

- Water Quality Control in South Damascus, option 2 : This option considers the blending of water from Kadam Railway at Eastern Reservoir. Any project that involves transport of contaminant is considered undesirable. In addition, this scheme has the risk of contaminating the entire water supply system of Eastern Reservoir.

- Reinforcement of Existing Water Resources, Damascus Well, Kadam Railway : Water from Kadam Railway contains elevated level of hardness and nitrate. If the water quality becomes unacceptable, countermeasures suggested in 1.9 Water Quality Control in South Damascus have to be considered.

- Reinforcement of Existing Water Resources, Damascus Well, Oumawiyin : There is a potential of pesticide pollution in Oumawiyin. Further investigation is strongly recommended.

- Reinforcement of Existing Water Resources, Damascus Well, University : Water from University well field contains high level of hardness and sulfate. Increased production from this side will decrease the overall water quality of supplied water.

- Reinforcement of Existing Water Resources, Damascus Wells, Dummar : Water from Dummar contains high levels of hardness and sulfate. Increased production from Dummar will decrease the overall water quality of supplied water.

Table 5.2.1 Implementation Schedule of New Development Schemes (Tentative)

No.	Name of Area	Total Area (ha)	2000 (1997)	2005	2010	2015	2020
	Proposed New Development Area						
1	Kudsaya New Suburb	300		300			
2	Proposed Kudsaya New Suburb	200		P	D/D		200
3	Dummar Extension Area (1st phase)	124	124				
4	Dummar Extension Area (2nd phase)	216	P		D/D	216	
5	Kassioun New Town (Total area : 650 ha)	340	P			D/D	340
6	Assad Suburb (1st phase)	40		D/D	40.0		
7	Assad Suburb (2nd phase)	193	P	D/D	193		
8	Assad Suburb Extension Area	298		P		D/D 298	
9	Kaboon Green Area	530			530		
10	Assad City	655	P		D/D	655	
11	Proposed Assad City Extension Area (1)	200		P		D/D	200
12	Proposed Assad City Extension Area (2)	124				D/D	124
13	Proposed Assad City Extension Area (3)	575					D/D 575
14	Special Area Zone (State Factory)	25	25				
	Total (ha)	2,540	149	300	763	1,169	1,439

(Remarks)

- Planning (P) / Detail Design (D/D)
- Land Acquisition
- Construction
- Approval of The Damascus City Master Plan by The Government in 1997

Table 5.2.2 List of Informal Connection Areas

No.	Name of Area	Population 1995	Area (ha)	Existing Conditions: Distribution Main & Water Meter	Existing Conditions: Remarks
1	Esh - Al Warwar	15,180	31.9	under construction (Kaboon Wells) used Booster Pump	1845 Connections, 1 Reservoir 7300 m (D80-150) pipe length
2	Kassioun Mountains Foot (Akrad) (Mouhajreen)	33,977	10.8 20.1	partially installed, no meter (KH & K2)	
3	Tichreen	15,448	36.2	partially installed No meter	(planning)
4	Jobar Surounding - Al Aksab Mosque	25,704	63.7	partially installed	(planning)
5	East - West Tabbaleh (map)	12,669	135.2	partially installed	
6	Mokhayam Al Yarmouk (Tadamon & Zahera)	86,068	118.0	partially used Private Wells	(planning) project is on starting by the end of 1996
7	Naher Eshah - Dahhadil & Asalie Kadam Al Kadam A Al Kadam B Al Kadam C	37,005	 60.5 31.5 78.4	partially installed	(planning) project is on starting by the end of 1996
8	Kafar Souseh Organisation	Non	Non	Re-developping Area under construction by Damascus Municipality (not informal area)	
9	Al Qazzaz & Shagour Bassateen	10,692	24.9 39.3	partially installed Partially used Private Wells	
10	Mezze - Razy Kafar Souseh - Lawan	32,786 14,000	110.5 59.8	partially installed	
11	Mezze # 86 (map)	46,390	95.7	under construction (M1 & M2) used Booster Pump	constructed Elevated Tank:500 m3
12	Somareya (map)	4,590	37.6	partially installed used Booster Pump at each bilding	(Military Housing Area)
13	Dummar - Wadi Al Mashare (map)	14,841	41.9	Non	(planning) caonstructed 5 wells & installed 3 pumps
14	Takadom	36,750	54.5	partially installed (Takadom Well Field)	(planning)
15	Kudsaya	20,800	50.0	Non	
	Total	407,000	1,050.5		

(Source : JICA & DAWSSA)

Table 5.2.3 Service Area and Population (1995 to 2015)

Name of Area	1995			2000			2005			2010			2015		
	Population (***)	Area (ha)	Density	Population (***)	Area (ha)	Density	Served Population	Area (ha)	Density	Served Population	Area (ha)	Density	Served Population	Area (ha)	Density
Villages*															
Figeh	3,975	44	90	4,389	44	99	4,845	44	109	4,968	44	112	5,093	44	115
Al Khadra	2,231	12	191	2,463	12	211	2,719	12	232	2,788	12	238	2,858	12	244
Bassime	468	18	27	517	18	30	570	18	33	585	18	33	600	18	34
Ashrafye Wadi	3,311	27	123	3,656	27	136	4,037	27	150	4,138	27	154	4,243	27	158
Judayde	4,464	53	84	4,928	53	93	5,441	53	102	5,579	53	105	5,719	53	108
Hame	21,570	56	384	23,815	56	424	26,291	56	468	26,958	56	480	27,638	56	492
Jemarya	2,034	5	384	2,246	5	424	2,479	5	468	2,542	5	480	2,606	5	492
Kudsaya	43,398	158	275	46,134	158	293	49,109	158	311	55,951	158	355	63,412	158	402
Takadom	36,750	55	674	40,575	55	744	44,798	55	822	49,461	55	908	54,609	55	1,002
Military Area 4 (Residential)	14,040	85	165	14,040	85	165	14,040	85	165	14,040	85	165	14,040	85	165
Maaraba															
Sub-total	132,241	512	258	142,763	512	279	154,332	512	301	167,010	512	326	180,818	512	353
Proposed New Development Area															
Kudsaya New Suburb							30,000	300	100	48,315	300	161	53,344	300	178
Proposed Kudsaya New Suburb															
Dummar Extension Area (1st phase)				20,500	124	165	26,793	124	216	35,017	124	282	38,662	124	312
Dummar Extension Area (2nd phase)													25,000	216	116
Kassioun New Town (650 ha)															
Assad Suburb (1st phase)										11,849	40	296	13,082	40	327
Assad Suburb (2nd phase)										25,000	193	130	33,456	193	174
Assad Suburb Extension Area													14,000	298	47
Kaboon Green Area											530	0		530	0
Assad City													25,000	655	38
Proposed Assad City Extension Area (1)															
Proposed Assad City Extension Area (2)															
Proposed Assad City Extension Area (3)															
Special Area Zone (State Factory) **	3,500	25	140	3,500	25	140	4,000	25	160	4,204	25	168	4,418	25	177
Others (not classified)															
Sub-total	3,500	25	140	24,000	149	161	60,793	449	135	124,385	1,212	103	206,962	2,380	87
Existing Damascus City															
Ruku Aldyn	166,768	437	382	184,125	437	421	203,289	437	465	224,448	437	513	247,808	437	567
Mouhajreen	77,461	363	213	85,523	363	235	94,424	363	260	104,252	363	287	115,103	363	317
Mezze	110,002	1,328	83	121,451	1,328	91	134,092	1,328	101	148,048	1,328	111	163,457	1,328	123
Kafar Souseh	96,021	1,200	80	106,015	1,200	88	117,049	1,200	98	129,231	1,200	108	142,682	1,200	119
Kanawat	66,761	269	248	73,710	269	274	81,381	269	302	89,852	269	334	99,203	269	368
Kadam	64,175	300	214	70,855	300	236	78,229	300	261	86,372	300	288	95,351	300	318
Midan	143,579	296	485	158,523	296	536	175,022	296	591	193,239	296	653	213,351	296	721
Old City	18,493	145	128	20,417	145	141	22,542	145	155	24,889	145	172	27,479	145	190
Shaghour	65,631	470	140	72,462	470	154	80,004	470	170	88,331	470	188	97,524	470	207
Sarouja	117,617	349	337	129,859	349	373	143,375	349	411	158,297	349	454	174,773	349	502
Yarmouk	214,669	227	948	237,034	227	1,047	261,704	227	1,155	288,943	227	1,276	319,016	227	1,408
Jobar	104,106	642	162	114,942	642	179	126,905	642	198	140,113	642	218	154,696	642	241
Berze	75,899	673	113	83,799	673	125	92,521	673	137	102,150	673	152	112,782	673	168
Kaboon	51,592	497	104	56,961	497	115	62,890	497	127	69,436	497	140	76,662	497	154
Dummar	49,415	473	104	54,558	473	115	60,237	473	127	66,506	473	141	73,428	473	155
Kassioun Mountain		2,956			2,956			2,956			2,956			2,956	
Sub-total	1,422,209	10,624	134	1,570,234	10,624	148	1,733,664	10,624	163	1,914,107	10,624	180	2,113,325	10,624	199
Total	1,557,950	11,162	140	1,736,997	11,286	154	1,948,789	11,586	168	2,205,502	12,349	179	2,501,105	13,517	185

(Source : Damascus Governate, DAWSSA and the Study Team)

(Remarks) * : Area of Villages is water served area.

** : It is a bulk water system to supply water from DAWSSA.

*** : Service level to the total population is estimated 74 % in 1995 and 90 % in 2000.

Table 5.4.1 Annual Water Consumption of Past 5 Years and The 8th 5 Years Plans for Water Supply by DAWSSA

	Item	Unit	1990	The 7th 5 Years					The 8th 5 Years Plan				
				1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1.	Un-billed (Free)	MCM/year	62.520	65.165	84.792	89.000	87.168	102.965	102.785	106.752	110.720	114.687	118.655
	(Percentage)		54%	50%	56%	56%	56%	62%	62%	62%	62%	61%	61%
1.1	Water Right Obligations		14.020	15.750	15.154	15.750	15.028	14.859	15.500	15.500	15.500	15.500	15.500
	(Percentage)	%	12%	12%	10%	10%	10%	9%	9%	9%	9%	8%	8%
1.2	Public & Religious Use		48.500	49.415	69.638	73.250	72.140	88.106	87.285	91.252	95.220	99.187	103.155
	(Percentage)	%	42%	38%	46%	46%	46%	53%	53%	53%	53%	53%	53%
a)	Mosque & Church*												
b)	Public fountains & Tap*												
2	Billed	MCM/year	53.280	64.515	66.328	70.000	69.582	62.218	62.215	65.748	69.280	72.813	76.345
	(Percentage)		46%	50%	44%	44%	44%	38%	38%	38%	38%	39%	39%
2.1	Domestic Use		36.524	44.225	45.468	47.985	47.698	45.454	44.708	47.247	49.785	52.323	54.862
	(Percentage)	%	32%	34%	30%	30%	30%	28%	27%	27%	28%	28%	28%
2.2	Governmental Use (Public Use)		12.025	14.561	14.970	15.799	15.705	13.418	13.096	13.846	14.590	15.335	16.078
	(Percentage)	%	10%	11%	10%	10%	10%	8%	8%	8%	8%	8%	8%
a)	Office & Public Facilities*												
b)	Schools*												
c)	Hospitals*												
d)	Special & Airport Use*												
2.4	Commercial, Tourism &		4.731	5.729	5.890	6.216	6.179	3.346	4.411	4.655	4.905	5.155	5.405
	Industrial Use (Percenatge)	%	4%	4%	4%	4%	4%	2%	3%	3%	3%	3%	3%
a)	Commercial*												
b)	Hotels*												
c)	Industrial*												
3.	Counted Water Consumption without Leakage	MCM/year	115.800	129.680	151.120	159.000	156.750	165.183	165.000	172.500	180.000	187.500	195.000

(Source : DAWSSA)

Remark * : Data is not available

Table 5.4.2 (1/2) Summary of Seasonal Water Consumption from Bill in 1995

	Unit	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average	Total	Percentage
		1st Quarter			2nd Quarter			3rd Quarter			4th Quarter				MCM/y	(%)
1 Billed Consumption	MCM/m															
Domestic		4.127	4.127	4.127	4.127	4.127	4.127	3.542	3.542	3.542	3.356	3.356	3.356	3.788	45.454	73
without Water Rights		1.976	1.976	1.975	1.976	1.976	1.976	1.582	1.582	1.582	1.681	1.681	1.681	1.804	21.642	35
with Water Rights		2.151	2.151	2.151	2.151	2.151	2.151	1.960	1.960	1.960	1.675	1.675	1.675	1.984	23.812	38
Commercial		0.251	0.251	0.251	0.251	0.251	0.251	0.225	0.225	0.225	0.203	0.203	0.203	0.233	2.792	4
Industrial		0.051	0.051	0.051	0.051	0.051	0.051	0.042	0.042	0.042	0.041	0.041	0.041	0.046	0.554	1
Government		1.093	1.093	1.093	1.093	1.093	1.093	1.109	1.109	1.109	1.178	1.178	1.178	1.118	13.418	22
Sub-total		5.521	5.521	5.521	5.521	5.521	5.521	4.917	4.917	4.917	4.779	4.779	4.779	5.185	62.218	100
2 Number of Connections	x 1000															
Domestic		180.158	180.158	180.158	180.158	180.158	180.158	194.842	194.842	194.842	198.912	198.912	198.912	188.518		84
without Water Rights		101.893	101.893	101.893	101.893	101.893	101.893	102.575	102.575	102.575	103.940	103.940	103.940	102.575		46
with Water Rights		78.265	78.265	78.265	78.265	78.265	78.265	92.267	92.267	92.267	94.972	94.972	94.972	85.942		38
Commercial		29.046	29.046	29.046	29.046	29.046	29.046	30.539	30.539	30.539	33.525	33.525	33.525	30.539		14
Industrial		2.310	2.310	2.310	2.310	2.310	2.310	2.310	2.310	2.310	2.306	2.306	2.306	2.309		1
Government		3.019	3.019	3.019	3.019	3.019	3.019	3.065	3.065	3.065	3.065	3.065	3.065	3.042		1
Sub-total		214.533	214.533	214.533	214.533	214.533	214.533	230.756	230.756	230.756	237.808	237.808	237.808	224.408		100
3 Unit Consumption per Connection	m3/d															
Domestic		0.764	0.764	0.764	0.764	0.764	0.764	0.606	0.606	0.606	0.562	0.562	0.562	0.674		
without Water Rights		0.646	0.646	0.646	0.646	0.646	0.646	0.514	0.514	0.514	0.539	0.539	0.539	0.586		
with Water Rights		0.916	0.916	0.916	0.916	0.916	0.916	0.708	0.708	0.708	0.588	0.588	0.588	0.782		
Commercial		0.288	0.288	0.288	0.288	0.288	0.288	0.245	0.245	0.245	0.202	0.202	0.202	0.256		
Industrial		0.730	0.730	0.730	0.730	0.730	0.730	0.605	0.605	0.605	0.598	0.598	0.598	0.666		
Government		12.064	12.064	12.064	12.064	12.064	12.064	12.059	12.059	12.059	12.816	12.816	12.816	12.251		
4 Population Served (6 persons per Domestic Connection)	x 1000	1.081	1.081	1.081	1.081	1.081	1.081	1.169	1.169	1.169	1.193	1.193	1.193	1.131		
5 Population in Damascus City (from Census)	x 1000													1.422		
6 Percentage of Population Sreved (without Informal residents)	%	76	76	76	76	76	76	82	82	82	84	84	84	80		
7 Water Consumption per capita (1/5)	lcd	129	129	129	129	129	129	115	115	115	112	112	112	122		

Table 5.4.2 (2/2) Summary of Seasonal Water Consumption from Bill in 1995

	Unit	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average	Total	Percentage
		1st Quarter			2nd Quarter			3rd Quarter			4th Quarter				MCM/y	(%)
8 Percentage of Meter Malfunction*	%															
Domestic		35	35	35	35	35	35	38	38	38	34	34	34	35.597		
without Water Rights		36	36	36	36	36	36	45	45	45	38	38	38	38.683		
with Water Rights		34	34	34	34	34	34	30	30	30	30	30	30	32.118		
Commercial		57	57	57	57	57	57	63	63	63	54	54	54	57.645		
Industrial		47	47	47	47	47	47	48	48	48	50	50	50	48.171		
Government		26	26	26	26	26	26	40	40	40	28	28	28	29.859		
Average		38	38	38	38	38	38	42	42	42	37	37	37	38.641		
9 Unit Consumption per Connection (without Inefficient WAter Meter)	m3/d															
Domestic		1.175	1.175	1.175	1.175	1.175	1.175	0.979	0.979	0.979	0.855	0.855	0.855	1.046		
without Water Rights		1.005	1.005	1.005	1.005	1.005	1.005	0.938	0.938	0.938	0.871	0.871	0.871	0.955		
with Water Rights		1.391	1.391	1.391	1.391	1.391	1.391	1.015	1.015	1.015	0.840	0.840	0.840	1.159		
Commercial		0.666	0.666	0.666	0.666	0.666	0.666	0.663	0.663	0.663	0.440	0.440	0.440	0.609		
Industrial		1.386	1.386	1.386	1.386	1.386	1.386	1.166	1.166	1.166	1.195	1.195	1.195	1.284		
Government		16.245	16.245	16.245	16.245	16.245	16.245	20.012	20.012	20.012	17.855	17.855	17.855	17.589		
10 Domestic per Served Population (without Inefficient WAter Meter)																
Domestic Consumption	lcd	191	191	191	191	191	191	159	159	159	140	140	140	170		
without Water Rights	lcd	164	164	164	164	164	164	153	153	153	142	142	142	156		
with Water Rights	lcd	227	227	227	227	227	227	166	166	166	137	137	137	189		
11 Sesonal Load Factor	%															
Domestic		109	109	109	109	109	109	94	94	94	89	89	89	100.000		
without Water Rights		110	110	110	110	110	110	88	88	88	93	93	93	100.000		
with Water Rights		108	108	108	108	108	108	99	99	99	84	84	84	100.000		
Commercial		108	108	108	108	108	108	97	97	97	87	87	87	100.000		
Industrial		110	110	110	110	110	110	91	91	91	90	90	90	100.000		
Government		98	98	98	98	98	98	99	99	99	105	105	105	100.000		
Average		106	106	106	106	106	106	95	95	95	92	92	92	100.000		

(Source : DAWSSA) Remark * : Meter Malfunction includs number of meter under estimation and no meter reading.

Table 5.4.3 Suspension of The Water Supply (1991 - 1995)

(Unit : hours / month)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1991	0	0	0	0	0	0	240	240	240	240	240	240	120
1992	240	200	0	0	0	0	0	0	80	180	210	240	96
1993	0	0	0	0	0	0	0	70	150	180	180	210	66
1994	60	0	0	0	0	0	0	0	80	200	200	210	63
1995	100	60	0	0	0	0	150	150	150	180	225	250	105
Average	80	52	0	0	0	0	78	92	140	196	211	230	90
Day	3.33	2.17	0.00	0.00	0.00	0.00	3.25	3.83	5.83	8.17	8.79	9.58	3.75

(Source : DAWSSA)

Table 5.4.4 Unit Water Consumption by DAWSSA's Classification

Classification	Unit	Unit Water Consumption (Damascus)*	(Japan)	(Recommendation)
1 Domestic Use	lpcd	(170)**		
High Income		212 -236	160 - 250	250
Middle Income		163 - 191		200 / 210 / 220
Low Income		120 - 184		170 / 180 / 190
2 Governmental Use		(18)**		
Government Offices & Facilities	m3/d/connection	51		51
	l/d/worker	266	100 - 200	
School	m3/d/connection	14		24
	l/d/student	26	40 - 50	
University	m3/d/connection	254		500
	l/d/student	53	100 - 200	
Hospital	m3/d/connection	370		800
	l/d/bed	340	1,000	
Sport Facilities	m3/d/connection	176	Required	176
	l/d/worker	486	survey	
3 Commercial Use	m3/d/connection	(0.609)**		
Hotel		148		148
	l/d/bed	371	250 - 300	
General Commercial User	m3/d/connection		Required	15
- Large Commercial User		10	survey	14
- Others		1		1
Theater	m3/d/connection	44	Required survey	44
3 Industrial Use	m3/d/connection	(1.3)**		
Factories	m3/d/connection		Required	128
- Large		287.5	survey	
- Medium		84.4		
- Small		12.6		
Manufacturing	m3/d/connection	0.603		0.600
11 Religious & Public Facilities				
Um-Ayad Mosque	m3/d/connection	44		44
Other Mosques & Church	m3/d/connection	4		4
Public Tap/Fountain	m3/d/connection	72		72

(Remark)

* Unit water consumption in Damascus are data from the results of the Interview survey and the water meter reading survey.

** Average unit water consumption based on the billed consumption in 1995.

Table 5.4.5 Basic Factor of Water Use Classification

Factor for Basic Frame (Year)	Unit	1995 (0)	2000 (5)	2005 (10)	2010 (15)	2015 (20)
1 **Income Classification (Domestic)**						
1) High	%	16.7	17.5	18.4	19.2	20.0
Medium	%	18.0	23.5	29.0	34.5	40.0
Low	%	39.5	49.0	52.7	46.3	40.0
Informal	%	26.0	10.0	0.0		
2) Average Domestic Demand per capita (3)	lpcd	170.0	180.0	193.0	204.0	214.0
2 **Connection of Main Water Users**	Number	37,475	37,895	38,912	41,494	45,453
1) Governmental Users	Number	991	1,002	1,029	1,097	1,202
Government Offices & Facilities		650	657	675	720	788
Schools		235	238	244	260	285
Universities		42	42	44	47	51
Hospitals		46	47	48	51	56
Sport Facilities		18	18	19	20	22
2) Industrial Users	Number	2,310	2,336	2,399	2,558	2,802
Factories		38	38	39	42	46
Manufacturing		2,272	2,297	2,359	2,516	2,756
3) Commercial Users	Number	33,525	33,901	34,810	37,121	40,662
Hotels		89	90	92	99	108
Large Commercial Users		659	666	684	730	799
Other Commercial Users		32,722	33,089	33,977	36,232	39,688
Restraints		41	41	43	45	50
Theaters		14	14	15	16	17
4) Public Use (Un-billed)	Number	649	656	674	719	787
Mosques & Church		534	540	554	591	648
Public Taps/Fountains		115	116	119	127	139

Table 5.4.6 Water Demand Forecast by Water Use Classified Analysis (Alternative 1)

Year / Factor for Basic Frame	Unit	1995 0	2000 5	2005 10	2010 15	2015 20
1 Area (km2)	km2	111.62	112.86	115.86	123.49	135.17
1.1 Existing City		106.25	106.25	106.25	106.25	106.25
1.2 Villages & New Developed Area		5.37	6.61	9.61	17.24	28.92
2 Population	1000 persons	1,554	1,737	1,949	2,205	2,501
2.1 City		1,422	1,570	1,734	1,914	2,113
2.2 Villages & New Development Area		132	167	215	291	388
3 (Billed) Population Served	1000 persons	1,150	1,563	1,949	2,205	2,501
4 Percentage of Population Served (3/2)	%	74	90	100	100	100
5 Daily Average Water Demand	m3/d	**310,600**	**448,200**	**555,100**	**618,000**	**694,500**
5.1 Water Deficits*	m3/d	86,500				
5.2 (Billed Consumption)	m3/d	224,100				
1) Domestic	m3/d	126,300	266,600	369,700	423,100	485,200
2) Governmental Use	m3/d	37,300	98,800	101,400	108,200	118,500
Government Offices & Facilities	m3/d		33,209	34,100	36,363	39,832
Schools	m3/d		1,010	1,037	1,106	1,211
Universities	m3/d		21,038	21,602	23,036	25,233
Hospitals	m3/d		36,866	37,855	40,367	44,218
Sport Facilities	m3/d		6,672	6,851	7,306	8,003
3) Commercial Use	m3/d	7,800	23,700	24,400	26,000	28,400
Hotels	m3/d		13,196	13,550	14,449	15,827
Commercial Users	m3/d		9,903	10,168	10,843	11,878
Theaters	m3/d		617	634	676	740
4) Industrial Use	m3/d	1,500	6,100	6,300	6,700	7,300
Factories	m3/d		4,720	4,847	5,169	5,662
Manufacturing	m3/d		1,372	1,409	1,503	1,646
5) Water Right Obligations	m3/d	40,700	42,500	42,500	42,500	42,500
(Un-billed Consumption)						
6) Religious & Public Use	m3/d	10,500	10,500	10,800	11,500	12,600
Mosques & Churches (500 m2)	m3/d	2,176	2,180	2,237	2,383	2,607
Public Taps/Special Area	m3/d	8,280	8,295	8,517	9,083	9,949
6 Uncounted for Water						
6.1 (% of Production Water Required)	%	**37**	**61**	**69**	**72**	**75**
6.2 % of UFW	%	62.7	39	31	28	25
1) Meter Malfunction	%	14.4	3	0	0	0
2) Informal Use	%	13.6	4	1	0	0
3) System Losses	%	34.7	32	30	28	25
7 Daily Average Water Requirement**	m3/d	**678,000**	**739,600**	**801,000**	**861,900**	**926,000**
7.1 Average Flow	(l/s)	7,800	8,600	9,300	10,000	10,700
7.2 Yearly Water Requirement	MCM/y	247.5	270.0	292.4	314.6	338.0
7.3 Yearly Water Production Amount	MCM/y	218.3				
8 Saving Water	m3/d		**462,000**	**115,000**	**29,900**	**42,600**
Losses in case of the former % of UFW	m3/d		1,201,609	916,007	891,775	968,619
9 Daily Maximum Water Requirement (Load Factor : 1.14)	m3/d	**668,800**	**843,100**	**913,100**	**982,600**	**1,055,600**
10 Unit Domestic Demand per capita	lpcd	110	171	190	192	194
11 Unit Water Demand per capita	lpcd	270	287	285	280	278

(Remark) * : Estimated on the assumption of the water consumption per capita with 185 lpcd.

** : Effective water Requirement based on data of production on April.

: UFW in 1995 is estimated from water production amount (598,100 m3/d)

Table 5.4.7 Water Demand Forecast by Water Use Classified Analysis (Alternative 2)

Year / Factor for Basic Frame	Unit	1995 / 0	2000 / 5	2005 / 10	2010 / 15	2015 / 20
1 **Area (km2)**	km2	111.62	112.86	115.86	123.49	135.17
1.1 Existing City		106.25	106.25	106.25	106.25	106.25
1.2 Villages & New Developed Area		5.37	6.61	9.61	17.24	28.92
2 **Population**	1000 persons	1,554	1,737	1,949	2,205	2,501
2.1 City		1,422	1,570	1,734	1,914	2,113
2.2 Villages		132	167	215	291	388
3 **(Billed) Population Served**	1000 persons	1,150	1,563	1,949	2,205	2,501
4 **Percentage of Population Served (3/2)**	%	74	90	100	100	100
5 **Daily Average Water Demand**	m3/d	322,100	476,400	594,100	662,100	744,500
5.1 **Water Deficits***	m3/d	98,000				
5.2 **(Billed Consumption)**	m3/d	224,100				
1) Domestic	m3/d	126,300	294,800	408,700	467,200	535,200
2) Governmental Use	m3/d	37,300	98,800	101,400	108,200	118,500
Government Offices & Facilities	m3/d		33,209	34,100	36,363	39,832
Schools	m3/d		1,010	1,037	1,106	1,211
Universities	m3/d		21,038	21,602	23,036	25,233
Hospitals	m3/d		36,866	37,855	40,367	44,218
Sport Facilities	m3/d		6,672	6,851	7,306	8,003
3) Commercial Use	m3/d	7,800	23,700	24,400	26,000	28,400
Hotels	m3/d		13,196	13,550	14,449	15,827
Commercial Users	m3/d		9,903	10,168	10,843	11,878
Theaters	m3/d		617	634	676	740
4) Industrial Use	m3/d	1,500	6,100	6,300	6,700	7,300
Factories	m3/d		4,720	4,847	5,169	5,662
Manufacturing	m3/d		1,372	1,409	1,503	1,646
5) Water Right Obligations	m3/d	40,700	42,500	42,500	42,500	42,500
(Un-billed Consumption)						
6) Religious & Public Use	m3/d	10,500	10,500	10,800	11,500	12,600
Mosques & Churches (500 m2)	m3/d	2,176	2,180	2,237	2,383	2,607
Public Taps/Special Area	m3/d	8,280	8,295	8,517	9,083	9,949
6 **Uncounted for Water**						
6.1 (% of Production Water Required)	%	37	61	69	72	75
6.2 % of UFW	%	62.7	39	31	28	25
1) Meter Malfunction	%	14.4	3	0	0	0
2) Informal Use	%	13.6	4	1	0	0
3) System Losses	%	34.7	32	30	28	25
7 **Daily Average Water Requirement****	m3/d	678,000	786,100	857,300	923,400	992,700
7.1 Average Flow	(l/s)	7,800	9,100	9,900	10,700	11,500
7.2 Yearly Water Requirement	MCM/y	247.5	286.9	312.9	337.0	362.3
7.3 **Yearly Production Amount**	MCM/y	218.3				
8 **Saving Water**	m3/d		491,100	123,100	32,000	45,700
Losses in case of the former % of UFW	m3/d		1,277,212	980,363	955,411	1,038,354
9 **Daily Maximum Water Requirement** **(Load Factor : 1.14)**	m3/d	668,800	896,200	977,300	1,052,700	1,131,700
10 **Unit Domestic Demand per capita**	lpcd	110	190	210	212	214
11 **Unit Water Demand per capita**	lpcd	280	305	305	300	298

(Remark) * : Estimated on the assumption of the water consumption per capita with 195 lpcd.

** : Effective water Requirement based on data of production on April

: UFW in 1995 is estimated from water production amount (598,100 m3/d)

Table 5.4.8 Water Demand Forecast by Water Use Classified Analysis (Alternative 3)

Year Factor for Basic Frame	Unit	1995 0	2000 5	2005 10	2010 15	2015 20
1 **Area (km2)**	km2	111.62	112.86	115.86	123.49	135.17
1.1 Existing City		106.25	106.25	106.25	106.25	106.25
1.2 Villages & New Developed Area		5.37	6.61	9.61	17.24	28.92
2 **Population**	1000 persons	1,554	1,737	1,949	2,205	2,501
2.1 City		1,422	1,570	1,734	1,914	2,113
2.2 Villages		132	167	215	291	388
3 **(Billed) Population Served**	1000 persons	1,150	1,563	1,949	2,205	2,501
4 **Percentage of Population Served (3/2)**	%	74	90	100	100	100
5 **Daily Average Water Demand**	m3/d	327,900	453,700	562,300	644,300	744,500
5.1 **Water Deficits***	m3/d	103,800				
5.2 **(Billed Consumption)**	m3/d	224,100				
1) Domestic	m3/d	126,300	272,100	376,900	449,400	535,200
2) Governmental Use	m3/d	37,300	98,800	101,400	108,200	118,500
Government Offices & Facilities	m3/d		33,209	34,100	36,363	39,832
Schools	m3/d		1,010	1,037	1,106	1,211
Universities	m3/d		21,038	21,602	23,036	25,233
Hospitals	m3/d		36,866	37,855	40,367	44,218
Sport Facilities	m3/d		6,672	6,851	7,306	8,003
3) Commercial Use	m3/d	7,800	23,700	24,400	26,000	28,400
Hotels	m3/d		13,196	13,550	14,449	15,827
Commercial Users	m3/d		9,903	10,168	10,843	11,878
Theaters	m3/d		617	634	676	740
4) Industrial Use	m3/d	1,500	6,100	6,300	6,700	7,300
Factories	m3/d		4,720	4,847	5,169	5,662
Manufacturing	m3/d		1,372	1,409	1,503	1,646
5) Water Right Obligations	m3/d	40,700	42,500	42,500	42,500	42,500
(Un-billed Consumption)						
6) Religious & Public Use	m3/d	10,500	10,500	10,800	11,500	12,600
Mosques & Churches (500 m2)	m3/d	2,176	2,180	2,237	2,383	2,607
Public Taps/Special Area	m3/d	8,280	8,295	8,517	9,083	9,949
6 **Uncounted for Water**						
6.1 (% of Production Water Required)	%	37	61	69	72	75
6.2 % of UFW	%	62.7	39	31	28	25
1) Meter Malfunction	%	14.4	3	0	0	0
2) Informal Use	%	13.6	4	1	0	0
3) System Losses	%	34.7	32	30	28	25
7 **Daily Average Water Requirement****	m3/d	678,000	748,700	811,400	898,600	992,700
7.1 Average Flow	(l/s)	7,800	8,700	9,400	10,400	11,500
7.2 Yearly Water Requirement	MCM/y	247.5	273.3	296.2	328.0	362.3
7.3 **Yearly WAter Production Amount**	MCM/y	218.3				
8 **Saving Water**	m3/d		467,700	116,500	31,100	45,700
Losses in case of the former % of UFW	m3/d		1,216,354	927,888	929,726	1,038,354
9 **Daily Maximum Water Requirement (Load Factor : 1.14)**	m3/d	759,400	853,500	925,000	1,024,400	1,131,700
10 **Unit Domestic Demand per capita**	lpcd	110	180	193	204	214
11 **Unit Water Demand per capita**	lpcd	285	290	289	292	298

(Remark) * : Estimated on the assumption of the potential water consumption per capita with 200 lpcd.

** : Effective water Requirement based on data of production on April

: UFW in 1995 is estimated from water production amount (598,100 m3/d)

Table 5.4.9 Monthly Water Requirement (Alternative 3)

(Unit : MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
2000	21	21	21	22	23	23	25	26	24	23	23	22	274.0
2005	23	23	23	24	25	25	27	28	26	25	24	24	296.9
2010	25	25	25	26	27	28	30	31	29	28	27	26	328.6
2015	28	28	28	29	30	31	33	34	32	30	30	29	363.1
Factor	0.92	0.92	0.93	0.97	1.00	1.03	1.10	1.14	1.05	1.01	0.99	0.97	12.00

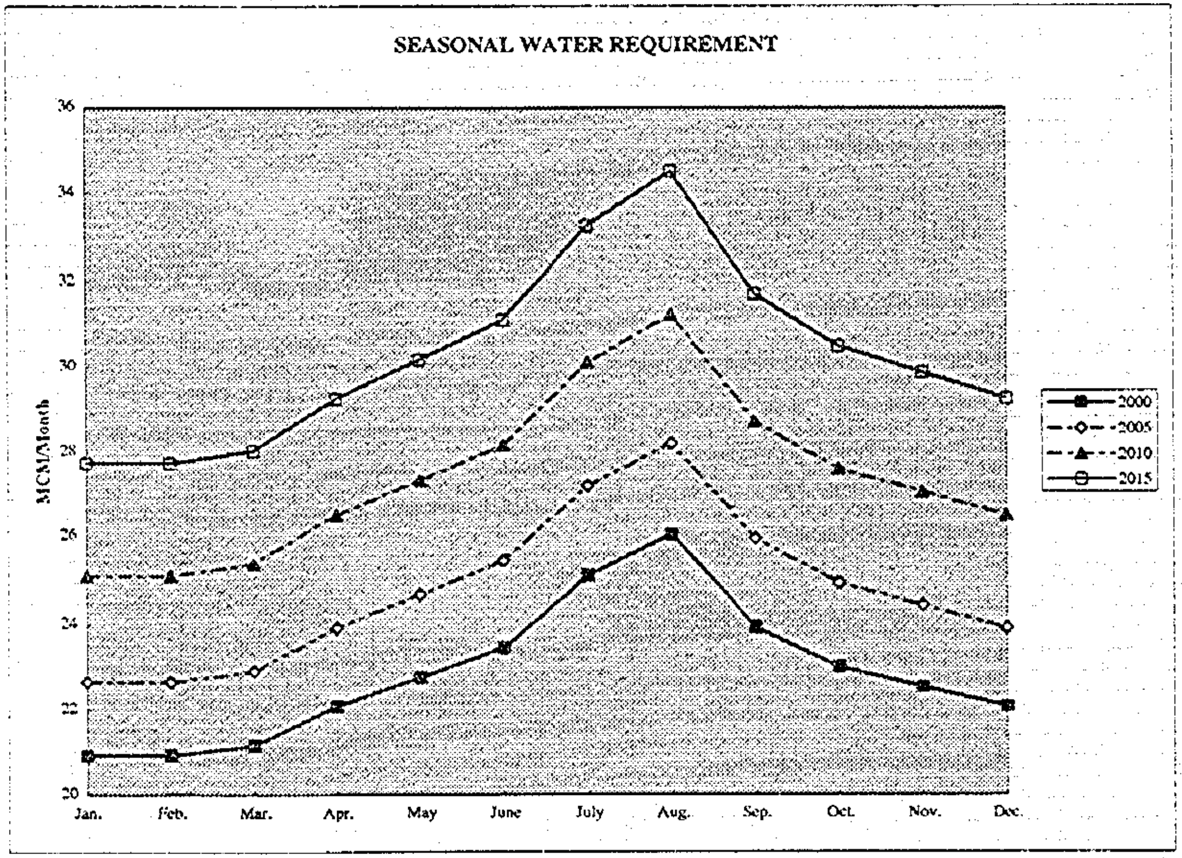

Table 5.4.10 Water Demand Forecast at Each Area (2000 to 2015)

Name of Area	2000					2005					2010					2015				
	Population	Area (ha)	Density	Water Requirement (m3/d)		Population	Area (ha)	Density	Water Requirement (m3/d)		Served Population	Area (ha)	Density	Water Requirement (m3/d)		Served Population	Area (ha)	Density	Water Requirement (m3/d)	
				Average	Maximum				Average	Maximum				Average	Maximum				Average	Maximum
Villages*																				
Figeh	4,389	44	99	1,700	2,000	4,845	44	109	1,700	1,938	4,968	44	112	1,772	2,020	5,093	44	115	1,808	2,061
Al Khadra	2,463	12	211	900	1,100	2,719	12	232	1,000	1,140	2,788	12	238	994	1,134	2,858	12	244	1,005	1,146
Bassime	517	18	30	200	300	570	18	33	200	228	585	18	33	209	238	600	18	34	195	222
Ashrafye Wadi	3,656	27	136	1,400	1,600	4,037	27	150	1,400	1,596	4,138	27	154	1,476	1,683	4,243	27	158	1,503	1,713
Judayde	4,928	53	93	1,900	2,200	5,441	53	102	2,000	2,280	5,579	53	105	1,990	2,269	5,719	53	108	2,033	2,317
Hame	23,815	56	424	9,100	10,400	26,294	56	468	9,900	11,286	26,958	56	480	9,859	11,239	27,638	56	492	10,123	11,541
Jemarya	2,246	5	424	900	1,100	2,479	5	468	900	1,026	2,542	5	480	926	1,055	2,606	5	492	915	1,043
Kudsaya	46,134	158	293	17,300	19,800	49,109	158	311	18,300	20,862	55,951	158	355	20,505	23,375	63,412	158	402	23,091	26,324
Takadom	40,575	55	744	15,000	17,100	44,798	55	822	16,400	18,696	49,461	55	908	17,727	20,209	54,609	55	1,002	19,589	22,331
Military Area 4 (Residential)	14,040	85	165	5,200	6,000	14,040	85	165	5,100	5,814	14,040	85	165	5,008	5,709	14,040	85	165	5,021	5,724
Maaraba									0					0					0	
Sub-total	142,763	512	279	53,600	61,600	154,332	512	301	56,900	64,866	167,010	512	326	60,466	68,931	180,818	512	353	65,283	74,423
Proposed New Development Area																				
Kudsaya New Suburb				0	0	30,000	300	100	11,000	12,540	48,315	300	161	17,234	19,646	53,344	300	178	19,135	21,813
Proposed Kudsaya New Suburb				0	0				0	0				0	0				0	0
Dummar Extension Area (1st phase)	20,500	124	165	7,500	8,600	26,793	124	216	9,800	11,172	35,017	124	282	12,518	14,271	38,662	124	312	13,862	15,803
Dummar Extension Area (2nd phase)				0	0				0	0				0	0	25,000	216	116	8,956	10,210
Kassioun New Town (650 ha)				0	0				0	0				0	0				0	0
Assad Suburb (1st phase)				0	0				0	0	11,849	40	296	4,226	4,818	13,082	40	327	4,677	5,332
Assad Suburb (2nd phase)				0	0				0	0	25,000	193	130	8,917	10,166	33,456	193	174	11,993	13,672
Assad Suburb Extension Area				0	0				0	0				0	0	14,000	298	47	5,006	5,707
Kaboon Green Area				0	0				0	0		530	0	0	0		530	0	0	0
Assad City				0	0				0	0				0	0	25,000	655	38	8,956	10,210
Proposed Assad City Extension Area (1)				0	0				0	0				0	0				0	0
Proposed Assad City Extension Area (2)				0	0				0	0				0	0				0	0
Proposed Assad City Extension Area (3)				0	0				0	0				0	0				0	0
Special Area Zone (State Factory) **	3,500	25	140	667	760	4,000	25	160	667	760	4,204	25	168	667	760	4,418	25	177	667	760
Others (not classified)				0	0				0	0				0	0				0	0
Sub-total	24,000	149	161	8,200	9,400	60,793	449	135	21,467	24,472	124,385	1,212	103	43,562	49,661	206,962	2,380	87	73,253	83,508
Existing Damascus City																				
Ruku Aldyn	184,125	437	421	75,700	86,285	203,289	437	465	81,842	93,299	224,448	437	513	88,165	100,508	247,808	437	567	95,604	108,989
Mouhajreen	85,523	363	235	35,300	40,185	94,424	363	260	37,907	43,214	104,252	363	287	41,588	47,410	115,103	363	317	44,396	50,611
Merze	121,451	1,328	91	64,500	73,485	134,092	1,328	101	67,115	76,511	148,048	1,328	111	72,048	82,135	163,457	1,328	123	77,239	88,053
Kafar Souseh	106,015	1,200	88	44,900	51,185	117,049	1,200	98	48,096	54,830	129,231	1,200	108	52,318	59,642	142,682	1,200	119	56,172	64,036
Kanawat	73,710	269	274	40,700	46,385	81,381	269	302	41,938	47,809	89,852	269	334	45,507	51,878	99,203	269	368	48,249	55,004
Kadam	70,855	300	236	30,100	34,285	78,229	300	261	32,078	36,569	86,372	300	288	35,361	40,312	95,361	300	318	37,535	42,790
Midan	158,523	296	536	66,900	76,185	175,022	296	591	72,017	82,099	193,239	296	653	77,641	88,511	213,351	296	721	84,003	95,763
Old City	20,417	145	141	8,600	9,785	22,542	145	155	8,897	10,143	24,889	145	172	10,835	12,352	27,479	145	190	10,583	12,065
Shaghour	72,462	470	154	30,700	34,985	80,004	470	170	32,811	37,404	88,331	470	188	36,136	41,195	97,524	470	207	38,387	43,761
Sarouja	129,859	349	373	53,400	60,785	143,375	349	411	57,662	65,735	158,297	349	454	62,531	71,285	174,773	349	502	67,421	76,860
Yarmouk	237,034	227	1,047	97,300	110,885	261,704	227	1,155	105,416	120,175	288,943	227	1,276	111,057	126,605	319,016	227	1,408	123,066	140,296
Jobar	114,942	642	179	48,600	55,385	126,905	642	198	52,163	59,466	140,113	642	218	56,623	64,550	154,696	642	241	60,903	69,429
Berze	83,799	673	125	45,500	51,785	92,521	673	137	47,083	53,674	102,150	673	152	50,911	58,038	112,782	673	168	54,147	61,728
Kaboon	56,961	497	115	24,200	27,585	62,890	497	127	25,749	29,354	69,436	497	140	28,661	32,674	76,662	497	154	30,171	34,395
Dummar	54,558	473	115	22,600	25,685	60,237	473	127	24,110	27,485	66,506	473	141	26,961	30,736	73,428	473	155	28,314	32,278
Kassioun Mountain		2,956					2,956					2,956					2,956			
Sub-total	1,570,234	10,624	148	689,000	784,875	1,733,664	10,624	163	734,884	837,768	1,914,107	10,624	180	796,343	907,831	2,113,325	10,624	199	856,190	976,056
Total	1,736,997	11,286	154	750,800	855,900	1,948,789	11,586	168	813,300	927,106	2,205,502	12,349	179	900,400	1,026,423	2,501,105	13,517	185	994,800	1,133,987

(Source : Damascus Governate, DAWSSA & JICA)

(Remarks)

* : Area of Villages is water served area.

** : It is a bulk water system to supply water from DAWSSA.

Table 5.5.1 Existing Resources - Capacities Used for Planning Purposes

Source Name	Capacity				Seasonal
	Installed[2]	Minimum[3]	Average[4]		Capacity[5]
	(l/s)	(l/s)	(l/s)	(m^3/d)	(MCM)
Mazraa Wellfield	665	290	335	28,800	7.06
Jobar Wellfield	390	220	350	30,200	7.40
Kaboon Wellfield	83	est 80	65	5,620	1.38
Ibn Assaker Wellfield	455	280	345	29,800	7.30
Kadam Railway Wellfield	350	200	305	26,500	6.49
Oumawiyin Wellfield	390	175	175	15,000	3.67
University Wellfield	420	est 215	200	17,300	4.24
Fringe Wells	320	125	125	10,800	3.93
Figeh Main Spring					
Average Year (1995)	12,400[1]	-	5,800	507,000	185.00
Dry Year (1990)	-	2,880	3,870	334,000	122.00
Barada Spring Wellfield	1,100	1,100	1,100	95,000	23.27
TOTAL					
Average Year (1995)	16,573	-	8,800	766,020	249.74
Dry Year (1990)	-	5,565	6,870	593,020	186.74

Notes:
1. Capacity limited to that of the supply tunnels during flood period
2. Capacity of well sources is that of the current pumping equipment
3. Minimum capacity is that produced in December 1990, at the lowest capacity of Figeh during a drought year. For sources not commissioned at that time or which have been subsiquently changed an estimate is made based upon December 1995.
4. Average capacity is based upon operating the source at an achievable rate based on conditions in 1996.
5. Seasonal Capacity is the average rate applied for the abstraction season. This is taken as 365 days for Figeh and the Fringe Wells and 245 days (8 months) for other sources.

Table 5.5.2 Barada (Al Sahl) Wellfield Details

Well Number	Design Capacity (l/s)	Q/s (l/s/m)	RWL (mbgl)	Depth (m)	Anticipated Drawdown (m)
Group 1					
21K	60	12.83	3.61	1020	4.7
215K	30	3.13	4.20	250	9.6
243K	60	5.76	2.65	343	10.4
244K	80	22.98	2.77	232	3.5
Group 2					
240K	30	10.60	37.08	220	2.8
20/2	60	18.77	21.10	213	3.2
25/2	60	142.86	21.15	115	0.4
Group 3					
247K	30	7.92	21.30	243	3.8
227K	20	8.31	18.23	250	2.4
23/3	10	-	-	-	-
24/3	10	0.95	21.50	225	10.5

Table 5.5.3 Anticipated Behaviour for Takadom and Kywan Wellfield

Well	A	B	P	Static Water Level (m)	Pumping Water Level (m)	Pump Capacity (m^3/hr)
1	0.0405	3.94×10^{-5}	2	8	23.0	120
4	-	-	-	8	23.2	100
5	0.0126	3.15×10^{-4}	2	8	23.1	100
6	0.0406	4.27×10^{-5}	2	8	23.1	120
7	0.0406	4.27×10^{-5}	2	8	23.8	120
8	0.0330	1.06×10^{-3}	2	8	31.8	100
9	0.0255	2.44×10^{-5}	2	8	18.5	Obs Well
10	0.0552	3.68×10^{-17}	8.7	8	33.2	100
11	-	-	-	8	23.7	100
12	0.0418	4.19×10^{-5}	2	8	23.4	100
13	0.0422	3.83×10^{-5}	2	8	22.7	100

Notes: $s = A \times Q + B \times Q^P$

Where: Q Pumping rate in m3/hr.

s WellDrawdown in m

A,B,P Parameters in table above.

Pump Water level includes interfearance effects plus 3 m or regional recession

Table 5.5.4 Anticipated Behaviour for Kadam Store Wellfield

Well Drilling Number	Q/s (l/s/m)	Static Water Level (m)	Pumping Water Level (m)	Pump Capacity (m^3/hr)
1	8.8	6	21.1	100
2	9.9	6	20.8	100
3	8.9	6	21.1	100
4	8.8	6	21.1	100
5	14.6	6	19.9	100
6	5.8	6	22.8	100
7	6.5	6	22.3	100
8	10.5	6	20.6	100
9	8.5	6	21.3	100
10	26.5	6	19.0	100

Notes: Pumping water level includes for a total of 9 m interfearance effects plus 3 m regional recesssion
Well 5 is operational number 1 and wells 2 and 3 are operational numbers 2 and 3

Table 5.5.5 Capacities of Proposed Water Sources

Source Name	Design Capacity (l/s)	Average Capacity (l/s)	Average Capacity (m^3/d)	Seasonal Capacity (MCM)
Existing Resources				
Average Year (1995)	16,070	8,800	766,020	249.74
Dry Year (1990)	9,830	6,870	593,020	186.74
On going schemes				
1. Wadi Marwan Wellfield	235	185	16,000	* 5.84
2. Barada Group 1 Wellfield	230	185	16,000	3.92
3. Barada Group 2 Wellfield	150	120	10,400	2.55
4. Barada Group 3 Wellfield	70	60	5,200	1.27
5. Takadom Wellfield	295	140	12,100	2.96
6. New Kaboon Wellfield				
Phase I	30	25	2,200	0.54
Phase II	120	95	8,200	2.00
7. Kadam Store Wellfield	275	170	14,700	3.60
8. Dummar Wellfield	125	100	8,600	* 3.14
8. Figeh Side Spring	+ 500[1]	0	0	0
9. Ain Haroush	1500[2]	0	0	0
Master Plan Schemes				
1. Ibn Assaker Wellfield	75	120	10,200	2.50
2. Kadam Railway Wellfield	135	115	9,300	2.28
3. University Wellfield	no change	-200	-17,300	-4.24
4. Fringe Wells	100	110	9,600	1.76
5. Tishreen and Kywan Wf'd				
Phase I	135	110	9,500	2.33
Phase II	130	100	8,600	2.12
Phase III	50	40	3,500	0.85
6. Jaramana Wellfield	360	290	25,000	6.12
7. Kafar Souseh Wellfield	125	80	6,900	1.69
8. Kanawat Gardens Wellfield	125	80	6,900	1.69
9. Shokry al Qouwatly Wf'd	210	170	14,700	3.60
10. Deir al Ashayer	200	200	17,280	** 3.16
Schemes not in the Master Plan				
1. Sergaya and El Irk Wfds	180	140	12,000	2.94
2. Rimeh Wellfield	285	285	24,500	** 4.48
3. Beit Jenn Spring				
Average Year	500	485	42,000	10.30
Dry Year	483	335	29,000	7.09
4. Tabibiyeh Spring				
Average Year	500	440	38,400	9.40
Dry Year	449	225	19,400	4.75
5. Barada Wellfield Reinforcement	1,400	950	81,600	20.00

Notes Season of 245 days assumed unless indicated otherwise
* Season of 365 days operation
** Season of 183 days operation
1 Net increase in capacity for Figeh Side Spring
2 Will replace the existing pumps at Ain Haroush

Table 5.5.6 Summary of Water Production Plan, Average Conditions Option 1

1986–95 Actual, 1996–2015 Forecasted, 1995 Hydro-meteorological conditions. M&E = Mechanical & Electrical Works

		Calendar Year																													
Source	Type	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Ain Figeh Area																															
Figeh Sources	Spring/Wells											215	215	215	215	215	215	215	215	215	215	215	215	215	215	215	215	215	215	215	215
Overflow	Loss to River											31	30	30	30	30	29	28	27	25	24	23	21	20	18	17	15	14	13	11	10
Figeh Total to Supply		129.4	166.3	171.9	131.2	122.2	139.6	186.5	188.5	173.0	177.4	184	185	185	185	185	186	187	188	190	191	192	194	195	197	198	200	201	202	204	205
Barada & Al Sahl																															
Spring Wells	Wellfield	–	–	–	–	–	–	–	–	–	6.8	22.6	22.6	22.6	22.6	22.6	23.3	24.0	24.6	25.3	26.9	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
Group 1	Wellfield	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	3.4	4.4	4.4	4.4	4.4	3.9	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
Group 2	Wellfield	–	–	–	–	–	–	–	–	–	–	M&E	2.8	2.8	2.8	2.8	2.4	2.4	2.3	2.2	2.2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Group 3	Wellfield	–	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sub Total		0	0	0	0	0	0	0	0	0	6.8	22.6	23.4	23.4	23.4	28.8	31.0	31.7	32.3	32.9	33.9	33.8	33.8	33.8	33.8	33.9	33.8	33.8	33.8	33.8	33.9
Damascus (Existing Stations)																															
Mazra	Wellfield	2.12	2.76	5.22	9.30	7.19	7.20	5.86	3.42	8.25	6.55	6.2	6.2	6.2	6.2	6.2	6.4	6.6	6.8	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ibn Asaker	Wellfield	3.33	1.71	2.66	7.30	7.00	6.57	3.57	3.89	4.91	5.64	7.3	7.3	7.3	7.3	7.3	6.3	6.3	6.3	6.3	6.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Ibn Asaker	Re-equiped	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jobar	Wellfield	3.76	1.77	0.95	2.25	3.25	5.16	4.22	3.47	6.37	5.80	7.4	7.4	7.4	7.4	7.4	6.9	6.9	6.9	6.9	6.9	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
Kadam Railway	Wellfield	–	–	–	3.24	3.54	3.75	1.98	3.04	3.71	5.25	6.3	6.3	6.3	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Kadam Railway	Re-equiped	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dumawyn	Wellfield	0.09	0.00	0.00	0.23	1.18	3.94	2.99	3.82	4.14	3.31	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Kaboon	Wellfield	1.00	0.56	0.83	1.96	2.59	2.41	0.86	0.87	1.26	0.86	1.0	1.0	1.0	1.0	1.0	1.2	1.2	1.2	1.2	1.2	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
University	Wellfield	–	–	–	–	–	–	–	0.09	2.49	2.53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kadam Store	Wellfield	–	–	–	–	–	–	–	–	0.82	–	M&E	2.2	2.2	2.2	2.2	2.7	2.7	2.7	2.7	2.7	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Dummar	Wellfield	0.88	0.76	0.50	0.19	0.03	0.17	–	–	–	–	–	–	M&E	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Fringe Wells	23 wells	6.12	5.05	4.98	5.98	5.94	4.90	3.67	3.24	4.32	4.01	4.0	4.0	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Fringe Wells	8 Re-equiped	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Emergency Wells	55 wells	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub Total		17.30	12.61	15.26	30.52	32.71	34.18	23.17	23.86	36.41	34.09	34.9	37.1	37.0	40.2	40.2	39.8	40.0	40.2	40.4	40.4	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
Damascus (New Stations)																															
New Kaboon	2 wells Phase I	–	–	–	–	–	–	–	–	–	–	Drill	M&E	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
New Kaboon	8 wells Phase II	–	–	–	–	–	–	–	–	–	–	–	–	Drill	M&E	1.3	1.4	1.5	1.6	1.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Kafar Souseh	5 wells	–	–	–	–	–	–	–	–	–	–	–	–	Drill	M&E	1.3	1.4	1.3	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Tahreen & Kywan	5 wells Phase I	–	–	–	–	–	–	–	–	–	–	M&E	M&E	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Tahreen & Kywan	9 wells Phase II	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.3	0.3	0.3	0.3	1.4	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Tahreen & Kywan	2 wells Phase III	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.0	0.0	0.0	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Jaramana	9 wells	–	–	–	–	–	–	–	–	–	–	–	–	M&E	4.5	4.6	4.8	5.0	5.5	5.8	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
Takadom	7 wells	–	–	–	–	–	–	–	–	–	–	–	M&E	2.4	1.8	1.6	1.9	2.0	2.1	2.2	2.2	2.4	2.6	2.8	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Sholey al Qouwatly	5 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	Drill	M&E	2.5	2.5	2.6	2.7	2.7	2.8	3.0	3.2	3.5	3.6	3.6	3.6	3.6	3.6	3.6
Yalbuga Centre	10 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Kanawat Gardens	5 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Drill	M&E	0.6	0.8	1.0	1.1	1.1	1.4	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Sub Total		0	0	0	0	0	0	0	0	0	0	0.0	0.0	3.0	9.0	11.8	14.9	15.9	16.9	18.9	20.3	20.8	21.6	22.3	22.9	23.0	23.0	23.0	23.0	23.0	23.0
Hermon & Zabadani Area																															
Beit Jenn	Spring Intake	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tabibiyeh	Spring Intake	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rimeh	8 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Wadi Marwan	13 wells	–	–	–	–	–	–	–	–	–	–	M&E	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Sergaya Wellfield	9 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dier Al Ashayer	4 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.3	0.3	1.5	3.0	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Sub Total		0	0	0	0	0	0	0	0	0	0	0.0	7.3	7.3	7.3	7.8	7.5	8.8	10.3	10.5	10.4	10.5	10.5	10.5	10.5	10.4	10.5	10.5	10.5	10.5	10.4
TOTAL SOURCES (MCM)		146.7	178.9	187.1	161.5	154.9	175.7	209.7	212.3	209.4	218.3	241	254	259	266	274	280	284	288	292	296	301	303	306	308	309	311	312	313	315	316
Water Requirement (MCM)											248	252	257	263	268	274	278	283	288	292	297	303	309	316	322	329	335	342	349	356	363
Deficit (MCM)											29.2	11.0	3.2	3.3	1.5	0.2	0.0	0.0	0.0	-0.0	1.1	1.9	3.8	9.9	14.3	19.2	24.3	30.0	35.3	41.2	46.7

Table 5.5.7 Summary of Water Production Plan, Dry Conditions — Option 1

1986–95 Actual, 1996–2015 Forecasted, 1990 Hydro-meteorological conditions, M&E = Mechanical & Electrical

Source	Type	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Ain Figeh Area																
Figeh Sources	Spring/Wells											132	132	132	132	132
Overflow	Loss to River											1	1	1	1	1
Figeh Total to Supply		129.4	166.3	171.9	131.2	122.2	139.6	186.5	188.5	175.0	177.4	131	131	131	131	131
Barada & Al Sahl																
Spring Wells	Wellfield	–	–	–	–	–	–	–	–	–	6.8	26.7	26.7	26.7	26.7	26.7
Group 1	Wellfield	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	4.4
Group 2	Wellfield	–	–	–	–	–	–	–	–	–	–	M&E	2.8	2.8	2.8	2.8
Group 3	Wellfield	–	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E
Sub Total		0	0	0	0	0	0	0	0	0	6.8	26.7	29.5	29.5	29.5	33.9
Damascus (Existing Stations)																
Mazraa	Wellfield	2.12	2.76	5.22	9.30	7.19	7.20	5.86	5.42	8.25	6.55	9.7	9.7	9.7	9.7	9.7
Ibn Assaker	Wellfield	3.33	1.71	2.66	7.30	7.00	6.57	3.57	3.89	4.91	5.64	10.0	10.0	10.0	10.0	10.0
Ibn Assaker	Re-equiped	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Jobar	Wellfield	3.76	1.77	0.95	2.25	3.23	3.16	4.22	3.47	6.37	5.80	10.1	10.1	10.1	10.1	10.1
Kadam Railway	Wellfield	–	–	–	3.14	3.54	3.75	1.98	3.04	3.71	5.25	8.0	8.0	8.0	8.0	8.0
Kadam Railway	Re-equiped	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Oumawiyin	Wellfield	0.09	0.00	0.00	0.23	1.18	3.94	2.99	3.82	4.14	3.31	5.1	5.1	5.1	5.1	5.1
Kaboon	Wellfield	1.00	0.56	0.83	1.96	2.39	2.41	0.86	0.87	1.26	0.86	1.9	1.9	1.9	1.9	1.9
University	Wellfield	–	–	–	–	–	–	–	0.09	2.49	2.33	0.0	0.0	0.0	0.0	0.0
Kadam Store	Wellfield	–	–	–	–	–	–	–	–	0.82	–	M&E	4.9	4.9	4.9	4.9
Dummar	Wellfield	0.88	0.76	0.30	0.19	0.03	0.17	–	–	–	–	–	–	M&E	3.2	3.2
Fringe Wells	23 wells	6.12	3.03	4.98	3.96	3.94	4.90	3.67	3.24	4.32	4.01	4.0	4.0	3.9	3.9	3.9
Fringe Wells	8 Re-equiped	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Emergency Wells	55 wells	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Sub Total		17.30	12.61	15.26	20.32	32.71	34.18	23.17	23.86	30.41	34.09	48.7	33.7	33.6	36.8	36.8
Damascus (New Stations)																
New Kaboon	2 wells Phase I	–	–	–	–	–	–	–	–	–	–	Drill	M&E	0.7	0.7	0.7
New Kaboon	8 wells Phase II	–	–	–	–	–	–	–	–	–	–	–	–	Drill	M&E	2.8
Kafr Souseh	5 wells	–	–	–	–	–	–	–	–	–	–	–	–	Drill	M&E	2.3
Tahreen & Kywan	5 wells Phase I	–	–	–	–	–	–	–	–	–	–	M&E	M&E	3.2	3.2	3.2
Tahreen & Kywan	9 wells Phase II	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	2.9
Tahreen & Kywan	2 wells Phase III	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Jaramana	9 wells	–	–	–	–	–	–	–	–	–	–	–	–	M&E	8.4	8.4
Takadom	7 wells	–	–	–	–	–	–	–	–	–	–	–	M&E	3.8	3.8	3.8
Shokry al Qouwatly	5 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	Drill	M&E
Yalbuga Centre	10 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Kanawat Gardens	5 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Drill
Sub Total		0	0	0	0	0	0	0	0	0	0	0.0	0.0	7.7	16.0	24.0
Hermon & Zabedani Area																
Beit Jenn	Spring Intake	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tabibiyeh	Spring Intake	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rimeh	8 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Wadi Marwan	13 wells	–	–	–	–	–	–	–	–	–	–	M&E	7.3	7.3	7.3	7.3
Sergaya Wellfield	9 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dier Al Ashayer	4 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	3.8
Sub Total		0	0	0	0	0	0	0	0	0	0	0.0	7.3	7.3	7.3	13.0
TOTAL SOURCES (MCM)		146.7	178.9	187.1	161.3	134.9	173.7	209.7	212.3	209.4	218.3	206	221	229	241	259
Water Requirement (MCM)											248	252	257	263	268	274
Deficit (MCM)											29.2	46.0	36.0	33.6	27.3	15.0

Source	Type	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Ain Figeh Area																
Figeh Sources	Spring/Wells	132	132	132	132	132	132	132	132	132	132	132	132	132	132	132
Overflow	Loss to River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Figeh Total to Supply		132	132	132	132	132	132	132	132	132	132	132	132	132	132	132
Barada & Al Sahl																
Spring Wells	Wellfield	26.9	26.9	26.9	26.9	26.9	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
Group 1	Wellfield	3.9	3.9	3.9	3.9	3.9	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
Group 2	Wellfield	2.2	2.2	2.2	2.2	2.2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Group 3	Wellfield	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sub Total		34.0	34.0	34.0	34.0	34.0	33.8	33.8	33.8	33.8	33.9	33.8	33.8	33.8	33.8	33.9
Damascus (Existing Stations)																
Mazraa	Wellfield	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
Ibn Assaker	Wellfield	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Ibn Assaker	Re-equiped	M&E	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Jobar	Wellfield	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1
Kadam Railway	Wellfield	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	6.0	8.0
Kadam Railway	Re-equiped	–	M&E	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Oumawiyin	Wellfield	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Kaboon	Wellfield	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
University	Wellfield	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kadam Store	Wellfield	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
Dummar	Wellfield	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Fringe Wells	23 wells	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Fringe Wells	8 Re-equiped	M&E	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Emergency Wells	55 wells	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub Total		36.8	63.4	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7
Damascus (New Stations)																
New Kaboon	2 wells Phase I	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
New Kaboon	8 wells Phase II	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Kafr Souseh	5 wells	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Tahreen & Kywan	5 wells Phase I	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Tahreen & Kywan	9 wells Phase II	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Tahreen & Kywan	2 wells Phase III	M&E	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Jaramana	9 wells	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
Takadom	7 wells	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Shokry al Qouwatly	5 wells	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
Yalbuga Centre	10 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Kanawat Gardens	5 wells	M&E	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Sub Total		29.2	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7
Hermon & Zabedani Area																
Beit Jenn	Spring Intake	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tabibiyeh	Spring Intake	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rimeh	8 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Wadi Marwan	13 wells	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Sergaya Wellfield	9 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dier Al Ashayer	4 wells	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
Sub Total		13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6
TOTAL SOURCES (MCM)		265	276	279	279	279	279	279	279	279	279	279	279	279	279	279
Water Requirement (MCM)		278	283	288	292	297	303	309	316	322	329	335	342	349	356	363
Deficit (MCM)		13	7	9	13	18	24	30	37	43	50	56	63	70	77	84

Table 5.5.8 Summary of Water Production Plan, Wet Conditions

Option 1

1986–95 Actual, 1996–2015 Forecasted; 1992 Hydro-meteorological conditions, M&E = Electrical & Mechanical

Source	Type	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		Calendar Year																													
Ain Figeh Area																															
Figeh Sources	Spring/Wells											360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360
Overflow	Loss to River											140	138	136	134	131	129	127	126	124	122	121	118	114	112	111	108	106	103	100	99
Figeh Total to Supply		129.4	166.3	171.9	131.2	122.2	139.6	186.5	188.5	175.0	177.4	220	222	224	226	229	231	233	234	236	238	239	242	246	248	249	252	254	257	260	261
Barada & Al Sahl																															
Spring Wells	Wellfield	–	–	–	–	–	–	–	–	–	6.8	13.8	13.8	13.8	13.8	13.8	16.5	17.1	17.8	18.5	18.5	19.0	20.0	20.0	22.0	22.9	22.9	23.2	23.3	23.4	23.4
Group 1	Wellfield	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	1.5	2.0	2.5	3.0	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Group 2	Wellfield	–	–	–	–	–	–	–	–	–	–	M&E	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6	1.6	1.7	1.9	2.0	2.1	2.2	2.2	2.2	2.2	2.2	2.2
Group 3	Wellfield	–	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.8	0.8	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1
Sub Total		0	0	0	0	0	0	0	0	0	6.8	15.8	17.2	17.2	17.2	18.6	20.8	22.0	23.2	24.3	24.2	25.0	26.2	26.4	28.5	29.6	29.6	29.9	30.0	30.1	30.1
Damascus (Existing Stations)																															
Marran	Wellfield	2.12	2.76	3.22	9.30	7.19	7.20	5.86	5.42	8.25	6.35	2.6	2.6	2.6	2.6	2.6	3.0	3.5	4.0	4.5	5.1	5.5	6.1	6.1	6.1	6.1	6.1	6.1	6.1	7.0	7.0
Ibn Asaker	Wellfield	3.33	1.71	2.66	7.30	7.00	6.57	3.57	3.89	4.91	5.64	4.2	4.2	4.2	4.2	4.2	4.0	3.8	3.7	3.6	3.6	4.0	5.0	6.7	6.7	6.7	6.7	6.8	6.9	7.0	7.5
Ibn Asaker	Re-equiped	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.9
Jobar	Wellfield	3.76	1.77	0.95	2.25	5.23	5.16	4.22	3.47	6.37	5.80	2.8	2.8	2.8	2.8	2.8	3.2	3.2	3.2	3.2	3.2	4.0	4.5	5.0	5.0	5.7	5.7	5.9	6.1	6.5	7.4
Kadam Railway	Wellfield	–	–	–	3.14	3.54	3.75	1.98	3.04	3.71	5.25	0.0	0.0	0.0	0.0	0.0	1.0	2.0	2.4	2.4	2.4	3.5	4.0	4.3	4.5	4.5	6.2	6.2	6.2	6.2	6.2
Kadam Railway	Re-equiped	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.9
Qumawiyn	Wellfield	0.00	0.00	0.00	0.23	1.28	3.94	2.99	3.82	4.14	3.51	0.9	0.9	0.9	0.9	0.9	1.2	1.1	1.0	1.2	1.2	1.3	1.4	1.5	2.3	2.3	2.0	2.1	2.5	2.8	3.5
Kaboon	Wellfield	1.00	0.56	0.83	1.96	2.59	2.41	0.86	0.87	1.26	0.86	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.5	0.8	0.9	1.2	1.2
University	Wellfield	–	–	–	–	–	–	–	0.09	2.49	2.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kadam Store	Wellfield	–	–	–	–	–	–	–	–	0.82	–	M&E	0.6	0.6	0.6	0.6	0.1	0.2	0.4	0.9	0.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Dummar	Wellfield	0.88	0.76	0.50	0.19	0.00	0.17	–	–	–	–	–	–	M&E	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Fringe Wells	23 wells	6.12	3.05	4.98	5.98	5.94	4.90	3.67	3.24	4.32	4.01	4.0	4.0	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Fringe Wells	8 Re-equiped	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.5	0.9	0.9
Emergency Wells	55 wells	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub Total		17.30	12.61	15.26	30.32	32.71	34.18	23.17	23.80	30.41	34.09	14.5	15.1	15.1	18.2	18.2	19.7	21.1	22.2	23.2	23.9	27.5	30.2	32.7	33.7	34.4	36.3	37.2	38.6	41.2	44.1
Damascus (New Stations)																															
New Kaboon	2 wells Phase I	–	–	–	–	–	–	–	–	–	–	Drill	M&E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.4	0.4
New Kaboon	8 wells Phase II	–	–	–	–	–	–	–	–	–	–	–	–	Drill	M&E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.9	1.0	1.5	1.5
Kafr Souseh	5 wells	–	–	–	–	–	–	–	–	–	–	–	–	Drill	M&E	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.4	0.4	0.4	0.5	1.0	1.3	1.3	1.3
Tahreen & Kywan	5 wells Phase I	–	–	–	–	–	–	–	–	–	–	M&E	M&E	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.3	0.4	0.5	0.7	0.9	1.0	1.2	1.3	1.5	2.0
Tahreen & Kywan	9 wells Phase II	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.0	0.4	0.4	0.4	0.4	0.4	0.8	0.8	0.8	0.8	0.8	1.0	1.2	1.4	1.5	1.8
Tahreen & Kywan	2 wells Phase III	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3
Jaramana	9 wells	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.5	2.0	1.5	1.5	2.4	3.0	4.0	4.5	4.9
Takadom	7 wells	–	–	–	–	–	–	–	–	–	–	–	M&E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.4	0.4	0.4	0.5	0.7	1.3	1.3	1.3
Sholry al Qouwatly	5 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	Drill	M&E	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.5	1.8
Yalbuga Centre	10 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Kanawat Gardens	3 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Drill	M&E	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.4	0.6	0.8	0.8	0.8
Sub Total		0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.6	0.6	0.6	1.0	1.0	1.0	1.0	1.1	4.0	4.7	5.4	5.1	5.5	7.6	10.1	12.8	14.6	16.1
Hermon & Zabadani Area																															
Beit Jean	Spring Intake	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tabibyeh	Spring Intake	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rimeh	8 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Wadi Marwan	13 wells	–	–	–	–	–	–	–	–	–	–	M&E	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Sergaya Wellfield	9 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dier Al Ashayer	4 wells	–	–	–	–	–	–	–	–	–	–	–	–	–	M&E	0.0	1.0	2.0	2.5	2.5	2.6	2.7	2.8	2.9	3.0	3.2	3.2	3.2	3.2	3.2	3.2
Sub Total		0	0	0	0	0	0	0	0	0	0	0.0	7.3	7.3	7.3	7.3	8.3	9.3	9.8	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.5	10.5	10.5	10.4
TOTAL SOURCES (MCM)		146.7	178.9	187.1	161.5	154.9	173.7	209.7	212.3	209.4	218.3	230	262	264	269	274	281	286	290	294	297	305	313	321	326	329	336	342	349	356	362
Water Requirement (MCM)											248	252	257	263	268	274	278	283	288	292	297	303	309	316	322	329	335	342	349	356	363
Deficit (MCM)											29.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5

Table 5.5.9 Pumping Details for Deir al Ashayer Wellfield

Well	Static Water Level (mbgl)*	Drawdown (m)**	Dynamic Water Level (mbgl)***	Pump Capacity (l/s)	Installation Depth (m)
844	16	24.2	46.2	50	65
846	15	23.0	44.0	50	65
854	19	24.2	49.2	50	65
new	20	23.0	49.0	50	65

Notes: * Typical level anticipated for beginning of pumping period, using May 1995 as the reference year, Using determined by comparison with well 809.
** After 6 months pumping
*** Lowest expected level based on drawdowns plus 6 m of regional recession from an inial static water level in May

Table 5.5.10 Well Performance Equations for Jaramana Wellfield

Well	A	B	P	Comments
1	0.0092	5.82×10^{-6}	2	-
2	0.0096	2.09×10^{-6}	2	-
3	0.0097	8.48×10^{-6}	2	-
4	0.0238	2.36×10^{-15}	7.6	Breakaway drawdown
5..10	0.0096	2.09×10^{-6}	2	Identical Test Data

Notes: $s = A \times Q + B \times Q^P$
Where: Q Pumping rate in m3/hr.
s Drawdown in m
A,B,P Parameters in table above.

Table 5.5.11 Well Performance Equations for Tishreen and Kywan Wellfield

Well	A	B	P	Q/s (l/s/m)	Comments
Tishreen 1	0.497	4.80×10^{-3}	2	-	-
Tishreen 2	0.581	1.46×10^{-3}	2	-	-
Tishreen 3	0.0198	2.14×10^{-10}	5.2	-	Very high well losses
Tishreen 4	0.0268	1.08×10^{-15}	8.0	-	Very high well losses
Tishreen 5	0.158	8.22×10^{-8}	4.2	-	-
Tishreen 6	-	-	-	-	Very low yield
Tishreen 7	-	-	-	-	Very low yield
Tishreen 8	0.072	1.17×10^{-3}	2	-	-
Tishreen 9	0.126	1.34×10^{-7}	3.9	-	-
Tishreen 10	0.429	1.78×10^{-2}	2	-	-
Kywan 1	-	-	-	0.12	Very large drawdown
Kywan 2	-	-	-	11.57	-
Kywan 3	-	-	-	12.63	-
Kywan 4	-	-	-	0.52	Very large drawdown
Kywan 5	-	-	-	0.32	Very large drawdown

Notes: $s = A \times Q + B \times Q^P$
Where: Q Pumping rate in m3/hr.
s Drawdown in m
A,B,P Parameters in table above.