No.

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR REHABILITATION OF THE WATER TRANSMISSION TUNNELS IN DAMASCUS CITY
IN
THE SYRIAN ARAB REPUBLIC

JUNE 2005

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the Syrian Arab Republic, the Government of Japan decided to conduct a basic design study on the Project for Rehabilitation of the Water Transmission Tunnels in Damascus City and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Syria a study team from 13 November to 26 December, 2004.

The team held discussions with the officials concerned of the Government of Syria, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Syria in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the Project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Syrian Arab Republic for their close cooperation extended to the teams.

June 2005

Seiji Kojima

Vice President

Japan International Cooperation Agency

June 2005

LETTER OF TRANSMITTAL

We are pleased to submit to you the basic design study report on the Project for Rehabilitation of the Water Transmission Tunnels in Damascus City in the Syrian Arab Republic.

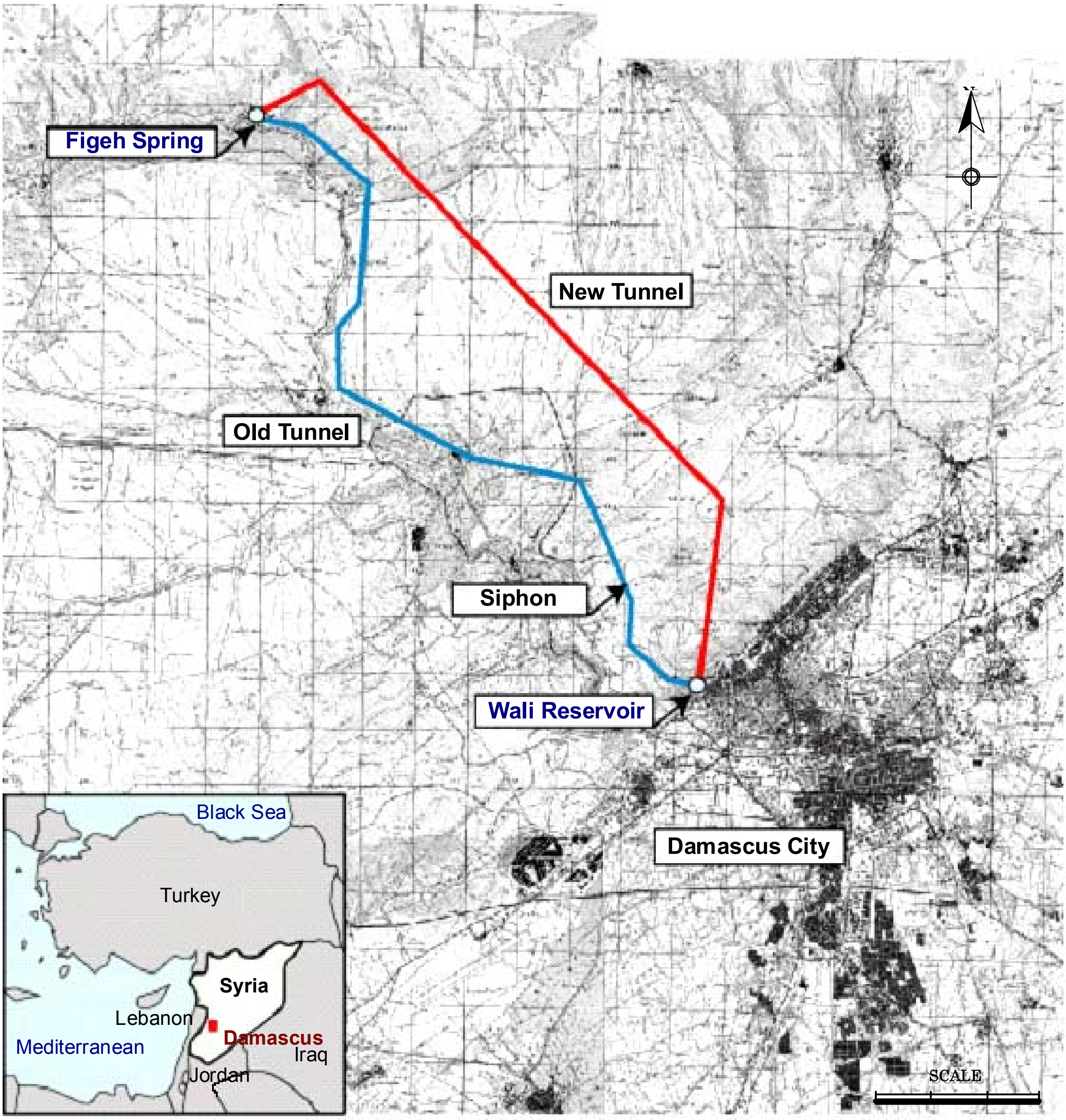
This study was conducted by Nippon Koei Co., Ltd., under a contract to JICA, during the period from November 2004 to June 2005. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Syria and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Shigeru Maruyama

Chief Consultant,

Basic design study team on
The Project for Rehabilitation of
The Water Transmission Tunnels in Damascus City
Nippon Koei Co., Ltd.



Project Location Map

Abbreviations

DAWSSA	Damascus City Water Supply And Sewerage Authority
EL	Elevation
FRP	Fiber Reinforced Plastic
GDP	Gross Domestic Product
GoJ	Government of Japan
GoS	Government of Syria
JICA	Japan International Cooperation Agency
MoHC	Ministry of Housing and Construction
SCADA	Supervisory Control And Data Acquisition
SPC	State Planning Commission
TD	Total Distance
UFW	Unaccounted for Water

(Currencies)

US$	US Dollar
SL or SP	Syrian Pound
¥	Yen

Summary

The capital city of the Syrian Arab Republic, Damascus City, had a population of 1.55 million in 2003, with the metropolitan area having a population of 2.77 million. Water is currently supplied from three sources, namely Figeh Spring (supplying some 73 %), Barada Spring (12 %) and wells within the city (15 %). Figeh Spring, the main source, is located about 15 km north-west of the city.

The water from Barada Spring, located some 15 km west of Figeh Spring, is discharged to Figeh Spring in summer as flow from the latter reduces. Wells are drilled in the city and water is pumped to meet supply demands. Annual rainfall is as low as 100 mm/year in the Damascus low land and 515 mm/year in the catchment basin. The spring discharge at the main water source, Figeh Spring, varies significantly both in magnitude and seasonally. The spring discharge at Figeh Spring reduces to 3 m^3/s below the required consumption discharge of 7 m^3/s after July. Although the Barada Spring and Wells in the city are used to augment spring discharge from Figeh Spring, these sources do not meet overall requirements. This can result in suspension of water supply. Given this situation in the water sector, the Ninth National Development Plan (2001-2005) has established a policy to use water resources more effectively and places a priority on rehabilitation of the existing facilities.

Two tunnels transfer water from Figeh Spring to the Wali Reservoir, where water flow is regulated and distributed to consumers in the service area. The old tunnel, with a length of 16.2 km, was completed in 1930 while the new tunnel, with a length of 14.4 km, was completed in 1980. The tunnels transfer water at a rate of 85 % of the consumption volume in the Damascus area and are therefore a lifeline for the supply. Maintenance and reduction of water leakage of the tunnels are key issues in tackling the water shortage in Damascus.

The old tunnel was rehabilitated in the 1960s by the French. However, given its long service period of 75 years the tunnel has deteriorated and damage will accelerate in the future. The water loss ratio of the old tunnel was measured to be as high as 27 %, and studies revealed that most of this takes place in the upstream section 3 km from the tunnel inlet. Structural cracks some 45 m in length have developed 300 m from the tunnel inlet. These are likely to be caused by landslides. Other defects in the old tunnel include intrusion of tree roots into the tunnel, non-functional gates due to heavy rust, numerous concrete cracks, slaking or peeling of the concrete surface, and exposure of rusting reinforcement bars.

On the other hand, the new tunnel is still sound, with a low water loss rate of 1 % reflecting the short service period of 25 years. However, the concrete lining has deteriorated over a length of 3,170 m from the tunnel inlet, probably due to sulfate attack from groundwater seepage. The deterioration will progress unless countermeasures are implemented.

The Government of Syria submitted an application to the Government of Japan in July 2003, requesting the rehabilitation of the tunnels. The Government of Japan accepted the request and Japan International Cooperation Agency (JICA) dispatched a Preliminary Study Team to Syria from 18 June 2004 to 24 July 2004. The Preliminary Study confirmed the necessity for the rehabilitation. JICA dispatched a Basic Design Study Team (the Study Team) to Syria from 13 November to 27 December 2004. The Study Team produced a basic design draft report after developing a basic design from January to February 2005. The contents of the associated draft report were explained by the Study Team in Syria from 10 to 18 March 2005 at which time they were agreed by the Syrian authorities.

The field investigation identified the deteriorated or damaged sections. It was confirmed that remedying these sections will prolong the life of the tunnels and improve their safety to enable the continued transfer of water to meet supply demands. The Project therefore aims to safely transfer water at a good quality.

Among the alternatives, Fiber Reinforced Plastic (FRP) plates were selected to be installed on the tunnel inner surface with anchors. Voids between the plate and the concrete will be filled with non-shrinkage mortar to stop leakage water and protect deteriorated and damaged sections. The rock bolt method, in which eight steel bolts are to be inserted in a cross section a length of 3 m into the rock

foundation around the tunnel, is proposed to remedy the structural cracks over the 300 m length from the inlet. Aqueduct Bridge No. 3, located 10.7 km from the inlet, was also previously rehabilitated. However, the girder concrete has now peeled off and reinforcement bars are exposed. Since it is dangerous to remedy the girder after removing the deteriorated concrete, carbon sheet will be placed onto the bottom surface of the girder. Steel pipes were previously also installed in the upper part of the hood section in a section of the old tunnel (10 to 13 km) to reinforce tunnel stability. These are now rusted and they will be remedied by the Project by enveloping them with polymer cement.

A gate, which is operational at the tunnel inlet, is the only facility to regulate tunnel flow. The gate will be replaced as it is rusted and cannot stop water effectively. Four back-siphon pipes were embedded chronologically to cross the Dummer Valley on the downstream side of the old tunnel. An asbestos pipe, with a diameter of 1,400 mm, is used to transfer water to the downstream tunnel with the other three pipes not being used. Gates are closed at the inlet and outlet of the three pipes, however, they are not functional due to rusting and deterioration. Accidents and pipe damage occurred in 1963 and 1966, which were caused by landslides and land settlement. The transfer water spouted out from the damaged pipes inundating the area and stopping the water transfer service till their replacement. Two new gates will be installed at the inlet of the tunnel and outlet of the three pipes no longer in use to avoid similar accidents in the future.

The deteriorated concrete over a length of 3,170 m from the new tunnel inlet is caused by sulfate attack. The surface of the deteriorated concrete shall be removed to a depth of 15 cm over a length of 6 m. FRP will be installed on the design section and anti-chemical resin mortar injected to fill the voids between the FRP and concrete.

In the two tunnels, epoxy resin will be injected into concrete cracks more than 0.2 mm wide, while flaked or peeled holes more than 10 cm in size will be filled with polymer cement. Work quantities for the rehabilitation works are listed below.

	Works	Quantity
Old Tunnel	1) FRP lining	1,546 m tunnel length or 5,504 m^2
	2) Rock bolts	45 m tunnel length or 46 sections
	3) Concrete crack repair	566 m
	4) Concrete repair	8,892 places
	5) Repair of reinforcement steel pipe	156 pipes or 43.1 m^2
	6) Carbon textile at aqueduct bridge No.3	28.2 m^2
	7) Replacement of gates	Tunnel inlet: 1 gate
		Siphon: 2 gates
New Tunne	1) Repair of deteriorated concrete	34.6 m^2
	2) Concrete crack repair	13 m
	3) Concrete repair	219 places

The Project will not only rehabilitate the tunnels, but will also establish a system for sustainable tunnel maintenance through manual preparation and training. Furthermore, the Project will provide a monitoring system in the new Wali reservoir for cavern displacement and training for measurement. The Consultant will undertake the tasks during Project implementation under the program of technical assistance (referred to as the soft component).

A Japanese contractor will be selected through a pre-qualification and bidding exercise after a two month detailed design service. The rehabilitation works will be completed in 11 months. Approximate project costs are estimated at 395 million Yen. The Syrian side shall assign the staff required for the implementation of the Project, will provide the required land for the Project and will disseminate the project under Japan's grant aid.

The Ministry of Housing and Construction (MoHC) is a responsible agency in the central government and the Water Supply and Sewerage Authorities are organized regionally under the supervision of MoHC. Damascus City Water Supply and Sewerage Authorities (DAWSSA), which is an executing agency of the Project, is undertaking water supply in Damascus City and neighboring areas. DAWSSA has a total staff of 1,319 (as at November 2003). The Directorate of Studies and Design and Directorate of Construction and Supervision will be responsible for implementation of the Project. After its completion, the Production Department of the Directorate of Exploitation and Maintenance will operate the tunnels and they will be maintained by the Department of Maintenance and Vehicles within the same Directorate. The Directorate of Studies and Design will collaborate with the Directorate of Exploitation and Maintenance to monitor cavern displacement.

The Project is expected to reduce water loss (3.21 million m^3/year) in the old tunnel, corresponding to a 1.6 % saving in the total water supply by DAWSSA. The water saved equals the development of a new water resource for 71,000 persons, assuming a current water consumption of 124 lit./cap./day. Moreover, the Project will have advantageous impacts. Remedying structural cracks in the old tunnel will improve safety, remedying concrete cracks and potholes on the concrete will prolong the life of tunnel, gate replacement at the back-siphon pipes will reduce the potential for damages and the program of technical assistance (soft component) will enhance technology. Therefore, the Project is worthy of implementation under the policy of Japanese grant aid.

The deterioration of the tunnels will progress during its future service. It is strongly recommended that periodic tunnel inspections be undertaken after the Project and damage remedied in the early stages. Since the old tunnel has less earth cover above the tunnel, activities on the ground will have adverse effects. Attention shall be paid not only to the tunnel internally but also its external surface at ground level. The displacement measurement in the Wali reservoir shall be continued for several years at least, and the results monitored carefully.

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR REHABILITATION OF THE WATER TRANSMISSION TUNNELS IN DAMASCUS CITY IN THE SYRIAN ARAB REPUBLIC

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Chapter 1 Background of the Project

1.1 Introduction

The capital city of Syria, Damascus City, which is a center of culture and economics of the country, is a populated and active area. It has a population of 1.546 million, while the capital area has a population of 3.045 million. The city faces a problem of water shortage due to insufficient water resources. The majority of the water supply, more than 85 %, is sourced from Figeh and Barada Springs. Two tunnels, the old tunnel and the new tunnel, transfer water from the springs to the Damascus area and are therefore a lifeline. The old tunnel was rehabilitated in the 1960s, however, it is deteriorating due to a long service period. Damascus City Water Supply and Sewerage Authority (DAWSSA) measured the water leakage ratio of the old tunnel at 40 - 60 %. After the new tunnel commenced service in 1980, precise tunnel inspection by experienced engineers has not been conducted. It is nonetheless important to inspect the tunnels and to maintain them in good condition to satisfy the water supply service.

The Government of Syria (GoS) submitted an application for grant aid to the Government of Japan (GoJ) in July 2003, requesting rehabilitation of the tunnels (Ref. to Appendix 1). The GoJ accepted the application, and Japan International Cooperation Agency (JICA) dispatched the Preliminary Study Team from 18 June 2004 to 24 July 2004 at which time the DAWSSA and Study Team concluded the Minutes of Discussion (Ref. to Appendix 2). The preliminary study revealed the necessity for rehabilitation of the tunnels and JICA dispatched the Basic Design Study Team (called the Study Team hereinafter) from 13 November 2004 to 27 December 2004.

The Study Team subsequently submitted the inception report and explained its contents to DAWSSA. After agreement on the explanation by the Study Team, DAWSSA and the Study Team concluded the Minutes of Discussion (Ref. to Appendix 3).

The tunnel investigation revealed that the new tunnel is generally in good condition with no significant water leakage. Conversely, the old tunnel has deteriorated and significant water leakage occurs. The Study Team identified concrete cracks and concrete peel-off in many sections in the old tunnel. It also measured the water leakage ratio to be 27 % in the old tunnel.

1.2 Water Supply and Consumption

1.2.1 Water Supply

The records of daily water supply from 1999 to 2004 from the three water sources of Figeh Spring, Barada Spring and Wells in the City are presented in Table 1-1. The daily water supply is converted into average monthly water supply as outlined in the table below. The monthly average water supply is shown in Figure 1-1.

(Unit: mil. m^3)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
1999	Figeh	8.79	10.46	14.50	20.59	14.79	9.40	7.75	6.88	6.48	6.11	5.89	5.85	117.51	55.9%
	Barada	3.82	3.86	3.48	0.00	3.54	3.93	3.91	3.56	3.51	3.94	3.89	3.92	41.38	19.7%
	Wells	5.68	5.75	3.92	0.69	1.25	4.97	5.38	5.36	4.96	4.65	4.41	4.24	51.26	24.4%
	Total	18.29	20.07	21.91	21.28	19.58	18.31	17.04	15.80	14.96	14.70	14.20	14.02	210.15	100.0%
2000	Figeh	5.99	7.35	14.40	19.82	18.21	11.21	8.59	7.59	7.11	7.07	7.09	7.04	121.48	63.5%
	Barada	3.95	3.95	2.03	0.00	1.39	2.95	2.95	2.95	2.95	2.95	2.95	2.95	31.94	16.7%
	Wells	4.21	4.09	2.10	0.43	0.72	4.69	4.17	3.84	3.50	3.40	3.28	3.32	37.75	19.7%
	Total	14.16	15.39	18.54	20.25	20.32	18.85	15.71	14.38	13.56	13.41	13.31	13.31	191.18	100.0%
2001	Figeh	7.83	9.21	18.97	19.34	12.72	8.48	7.13	6.77	6.14	5.86	6.19	6.79	115.44	67.8%
	Barada	2.95	2.95	0.48	0.00	0.93	2.95	2.83	2.93	2.95	2.95	2.95	2.95	27.79	16.3%
	Wells	3.27	3.33	0.32	0.00	1.55	2.89	3.09	2.76	2.59	2.51	2.43	2.28	27.03	15.9%
	Total	14.04	15.49	19.77	19.34	15.21	14.31	13.06	12.46	11.68	11.32	11.56	12.02	170.26	100.0%
2002	Figeh	7.23	13.76	19.75	16.38	16.95	11.69	8.37	7.24	7.08	6.69	6.79	9.12	131.05	75.5%
	Barada	2.95	0.97	0.00	0.00	0.19	2.35	2.95	2.95	2.95	2.95	2.95	2.00	23.18	13.4%
	Wells	1.73	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	19.27	11.1%
	Total	11.91	16.33	21.34	17.98	18.74	15.63	12.91	11.78	11.62	11.23	11.33	12.71	173.50	100.0%
2003	Figeh	15.31	16.77	16.98	17.57	18.83	19.25	19.89	19.87	18.11	15.76	14.07	11.97	204.39	88.9%
	Barada	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	2.93	2.85	6.49	2.8%
	Wells	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	19.13	8.3%
	Total	16.90	18.37	18.58	19.17	20.42	20.85	21.48	21.47	19.70	18.07	18.60	16.42	230.01	100.0%
2004	Figeh	13.23	16.01	17.12	17.58	18.12	18.66	17.69	15.07	12.88	11.73	11.11		169.20	83.9%
	Barada	2.35	0.32	0.00	0.00	0.00	0.00	0.38	1.78	2.90	3.79	3.45		14.97	7.4%
	Wells	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59		17.54	8.7%
	Total	17.17	17.93	18.72	19.17	19.72	20.26	19.67	18.44	17.38	17.11	16.15		201.71	100.0%
Total	Figeh	58.38	73.57	101.73	111.29	99.62	78.70	69.42	63.43	57.81	53.22	51.13	40.78	859.08	73.0%
		63.1%	71.0%	85.6%	95.0%	87.4%	72.7%	69.5%	67.2%	65.0%	62.0%	60.1%	59.6%		
	Barada	16.01	12.05	5.99	0.00	6.06	12.17	13.02	14.16	15.25	17.27	19.10	14.66	145.75	12.4%
		17.3%	11.6%	5.0%	0.0%	5.3%	11.3%	13.0%	15.0%	17.2%	20.1%	22.4%	21.4%		
	Wells	18.08	17.96	11.12	5.91	8.30	17.33	17.43	16.74	15.83	15.34	14.90	13.03	171.98	14.6%
		19.6%	17.3%	9.4%	5.0%	7.3%	16.0%	17.5%	17.7%	17.8%	17.9%	17.5%	19.0%		
	Total	92.47	103.58	118.84	117.20	113.98	108.20	99.87	94.33	88.89	85.83	85.14	68.47	1,176.81	100%

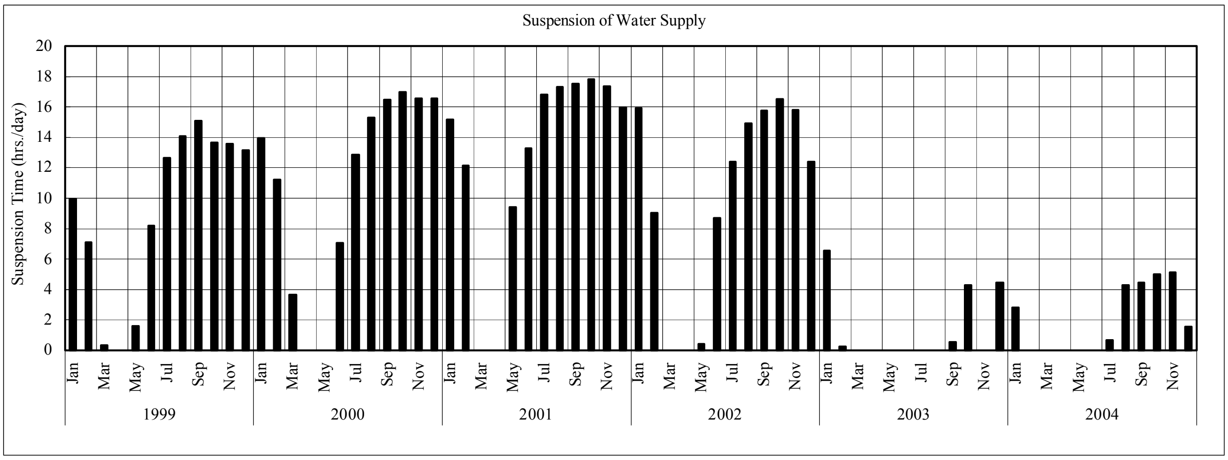
Of the three water sources, Figeh Spring supplies the largest percentage of water (73 %). The Barada Spring and Wells in the City supply water during summer when the spring discharge of the Figeh Spring reduces. The supply ratio is at 12 - 15 %. The Figeh Spring supplies water at a rate of more than 85 % in March and May, increasing to 95 % in April when spring discharges are abundant.

1.2.2 Balance between Supply and Consumption

Damascus area received abundant rainfall in 1993 and DAWSSA could readily meet supply demands. DAWSSA has therefore since referred to the consumption as being the target water supply, as shown in Figure 1-1. Water supply generally meets the required consumption from February to May, when the Figeh Spring discharges sufficient water. The quantity supplied has, however, been significantly below target in January and from June to December, except in 2003. As noted, from October 2002 to May 2003 rainfall was approximately double that which occurs in an average year highlighting why DAWSSA could easily meet demands in 2003. The records of reductions in water supply, defining when water supply quantity is below the target water supply, are shown in Table 1-2. The records of hourly periods of water supply reductions are tabulated and illustrated below on a monthly basis.

	1999			2000			2001			2002			2003			2004			Average	
	Monthly Suspen. (hr)	Daily Suspen. (hr/day)	(days)	Monthly Suspen. (hr)	Daily Suspen. (hr/day)	(days)	Monthly Suspen. (hr)	Daily Suspen. (hr/day)	(days)	Monthly Suspen. (hr)	Daily Suspen. (hr/day)	(days)	Monthly Suspen. (hr)	Daily Suspen. (hr/day)	(days)	Monthly Suspen. (hr)	Daily Suspen. (hr/day)	(days)	Monthly Suspen. (hr)	Daily Suspen. (hr/day)
Jan	308	9.9	31	433	14.0	31	470	15.2	31	493	15.9	31	203	6.5	15	87	2.8	19	332	10.7
Feb	199	7.1	25	325	11.2	28	340	12.1	28	253	9.0	19	6	0.2	1	0	0.0	0	187	6.7
Mar	10	0.3	2	113	3.6	14	0	0.0	3	0	0.0	0	0	0.0	0	0	0.0	0	20	0.7
Apr	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
May	48	1.6	7	0	0.0	0	293	9.4	16	12	0.4	0	0	0.0	0	0	0.0	0	59	1.9
Jun	245	8.2	27	211	7.0	24	398	13.3	30	261	8.7	30	0	0.0	0	0	0.0	0	186	6.2
Jul	391	12.6	31	399	12.9	31	521	16.8	31	385	12.4	31	0	0.0	0	20	0.6	6	286	9.2
Aug	436	14.1	31	474	15.3	31	537	17.3	31	463	14.9	31	0	0.0	0	133	4.3	29	340	11.0
Sep	452	15.1	30	494	16.5	30	525	17.5	30	472	15.7	30	17	0.6	6	134	4.5	27	349	11.6
Oct	423	13.7	31	527	17.0	31	553	17.8	31	512	16.5	31	133	4.3	27	155	5.0	30	384	12.4
Nov	408	13.6	31	497	16.6	30	520	17.3	30	474	15.8	30	0	0.0	0	154	5.1	27	342	11.4
Dec	408	13.2	31	513	16.6	31	496	16.0	31	384	12.4	28	138	4.4	30	48	1.5	9	331	10.7
Total	3,329	9.1	277	3,986	10.9	281	4,650	12.7	292	3,709	10.2	261	496	1.4	79	731	2.0	147	2,817	7.7

Notes: Daily average hour of water supply suspension = Monthly total hour of water supply suspension/ Monthly calendar days
Source: DAWSSA records



Water could be supplied in April without reductions for 6 years from 1999 to 2004. The hourly and daily periods of supply reduction were recorded as more than 300 hours/month in January and from August to December, the equivalent of more than 10 days/month. The periods of reduction in 2003 were, however, significantly lower.

The consumption ratios based on sector use are as follows:

Domestic use:	82 %
Industrial and commercial use:	4 %
Public use:	14 %

Average water supply for the six years from 1999 to 2004 was 196.14 million m^3/year and water for domestic use was 160.83 million m^3/year (= 196.14 x 0.82). The water leakage ratio of the water supply system was recorded at 22 % in 2004. With a population in the service area of DAWSSA of 2,270 thousand people, this equates to a daily consumption rate of 124 l/day/person (= 160.83 x 0.78/ 2.27/ 365). This rate is assessed to be quite low in comparison with a figure of about 300 l/day/person in Japan and 200-250 l/day/person in South-East Asian countries, reflecting the insufficient water resources in the Damascus area.

1.2.3 Daily Balance

Water consumption varies seasonally and weekly (holidays on Friday/Saturday or weekdays). The following dates were selected to scrutinize supply and consumption.

Year	Season	Week day	Dates	Week day	Dates
1998	Rainy	Friday	16 Jan.	Sunday	25 Jan.
	Dry	Friday	07 Aug.	Sunday	16 Aug.
2000	Rainy	Friday	14 Jan.	Sunday	23 Jan.
	Dry	Friday	11 Aug.	Sunday	20 Aug.
2003	Rainy	Friday	10 Jan.	Sunday	12 Jan.
	Dry	Friday	08 Aug.	Sunday	10 Aug.

The hourly records of water balance at Wali Reservoir (tunnel discharge, consumption discharge and reservoir storage) on the selected dates are listed in Table 1-3.

No general rule or tendency can be observed from the Tables.

Year 1998

Tunnel discharges were relatively high at about 7 m^3/s on the selected days above. Hourly consumption volume increased between 10:00 and 21:00, and reservoir storage volume decreased. Hourly consumption volume decreased between 01:00 and 06:00, and reservoir storage volume increased. Reservoir storage volume in the rainy season increased between 22:00 and 24:00. Clear differences between seasons and between week days are not observed.

Year 2000

This was a dry year and water supply was suspended frequently. Tunnel discharges were relatively low at about 5 m^3/s on the selected days. Hourly consumption volume increased between 07:00 and 12:00 when water was supplied, and reservoir storage volume decreased largely between 06:00 and 16:00. The reservoir storage volume returned to levels of previous days between 16:00 and 24:00.

Year 2003

This was a wet year and water supply was seldom interrupted. Water was supplied in the selected days. In the rainy season, consumption volume increased between 01:00 and 06:00 and between 21:00 and 24:00, and reservoir storage volume decreased. Hourly consumption volume stayed at a low rate between 09:00 and 15:00, and reservoir storage volume increased. In the dry season, hourly consumption volume was low between 01:00 and 09:00, and reservoir storage volume reached maximum levels at 09:00. Hourly consumption volume increased between 10:00 and 22:00, and reservoir storage volume decreased.

1.3 Natural Conditions

1.3.1 Hydrology

Syria is located at the eastern end of the Mediterranean Sea and is influenced by a Mediterranean climate. Rain occurs during the cold winters and summers are hot and dry. The rainy season begins in October and ends in May. Rainfall largely depends on ground elevation, with 1,600 mm/year falling at high elevations of more than 2,000 m, while Damascus, in the low lands, receives 100 mm/year. Rainfall also varies annually. Average rainfall for 48 years in the catchment area of the springs is around 515 mm/year. DAWSSA established 8 rainfall stations, but has been recording rainfall data at the following five stations, as shown in Figure 1-2.

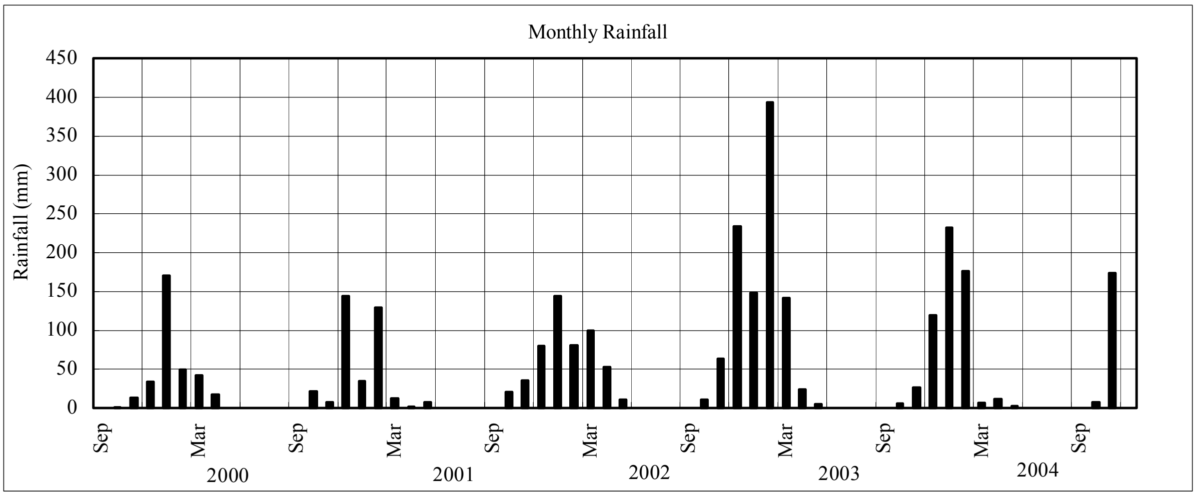
Station Name	Bloudan	Hrerah	Madaya	Syrgaya	Zabdany
North Latitude	33°43'47"	33°40'38"	33°40'52"	33°48'04"	33°44'21"
East Longitude	36º07'37"	36º07'30"	36º04'35"	36º07'22"	36º06'22"

Daily rainfall records are given in Table 1-4, and monthly rainfall is summarized in the following table and figure.

(Unit: mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total in Rainy Season
1999										1.1	13.7	33.8	328.8
2000	170.0	49.8	42.8	17.6	0.0	0.0	0.0	0.0	2.3	21.5	8.0	144.2	360.4
2001	35.1	129.3	13.1	1.2	7.9	0.0	0.0	0.0	0.0	21.1	35.8	79.8	525.2
2002	143.9	80.4	100.3	53.0	10.9	0.0	0.0	0.0	0.0	10.8	63.9	234.3	1,020.1
2003	147.6	393.0	141.2	24.0	5.2	0.0	0.0	0.0	0.0	6.4	26.3	119.9	551.6
2004	232.2	175.5	7.1	11.7	2.2	0.0	0.0	0.0	0.0	8.2	173.1		
Average	145.8	165.6	60.9	21.5	5.2	0.0	0.0	0.0	0.5	11.5	53.5	122.4	557.2

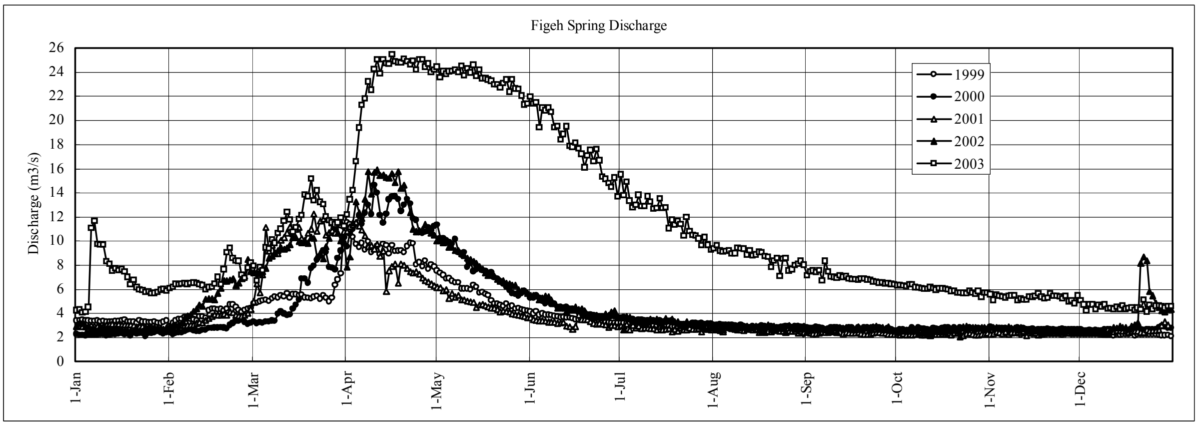
Source: DAWSSA



The rainy seasons from October to May in 1999 and 2000 are classified as low, those in 2001 and 2003 as normal, and the season in 2002 as high.

1.3.2 Springs

Daily spring discharge for 5 years from 1999 to 2003 at the Figeh Spring is listed in Table 1-5 and shown in the Figure below.

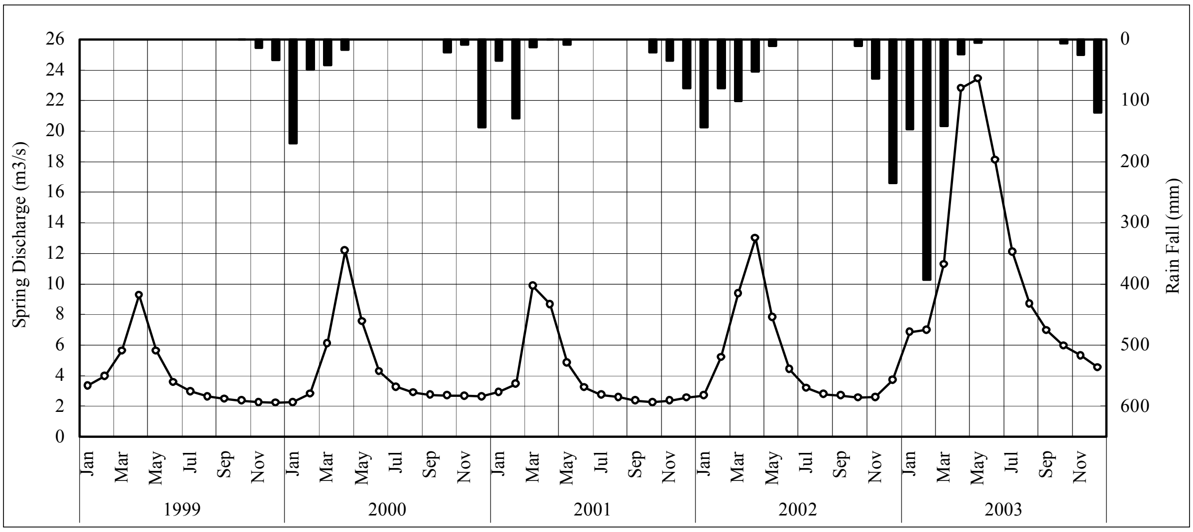


Monthly average spring discharges are tabulated below.

(Unit: m^3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
1999	3.338	3.973	5.628	9.280	5.628	3.592	2.976	2.656	2.507	2.367	2.284	2.252	3.873
2000	2.285	2.816	6.105	12.177	7.552	4.275	3.295	2.921	2.742	2.725	2.698	2.652	4.354
2001	2.944	3.475	9.856	8.680	4.830	3.251	2.750	2.613	2.379	2.274	2.391	2.580	4.002
2002	2.722	5.231	9.377	12.986	7.816	4.448	3.210	2.789	2.731	2.582	2.619	3.733	5.020
2003	6.844	7.015	11.294	22.788	23.413	18.086	12.090	8.698	6.953	5.970	5.330	4.539	11.085
Average	3.627	4.502	8.452	13.182	9.848	6.730	4.864	3.935	3.462	3.184	3.064	3.151	

Monthly rainfall and monthly spring discharge at Figeh are shown in the figure below. Maximum rainfall occurs in February and maximum spring discharge in April. Total rainfall from October 2002 to May 2003 was double that of a normal year, accordingly spring discharges of the Figeh also doubled.



1.3.3 Tunnel Discharge

The old and new tunnels transfer the spring water from Figeh to the consumption area in Damascus. The Figeh Spring receives spring water transferred through steel pipe from the Barada Spring when the spring discharge at the Figeh Spring reduces in summer. Daily flow discharges in the old and new tunnels are listed in Table 1-6. Monthly discharges are summarized in the table below, and are shown in Figure 1.3. The old tunnel transfers water at a discharge of 0.3 - 0.8 m^3/s and the new tunnel at a discharge of 3 - 7 m^3/s. The new tunnel transfers the majority of the supplied water. Discharges in the tunnel increase from March to May when the spring discharges at Figeh increase.

Old Tunnel (Unit: m^3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2000	0.348	0.379	0.597	0.796	0.634	0.325	0.473	0.549	0.556	0.591	0.550	0.542	0.529
2001	0.617	0.690	0.691	0.596	0.581	0.562	0.467	0.396	0.319	0.306	0.310	0.334	0.488
2002	0.346	0.516	0.654	0.588	0.561	0.469	0.488	0.274	0.272	0.321	0.322	0.336	0.428
2003	0.438	0.483	0.475	0.528	0.575	0.504	0.559	0.605	0.507	0.362	0.329	0.302	0.472
2004	0.376	0.382	0.395	0.427	0.519	0.459	0.476	0.424	0.319	0.302	0.270		0.399
Avg	0.425	0.490	0.562	0.587	0.574	0.464	0.493	0.450	0.395	0.377	0.356	0.378	0.463

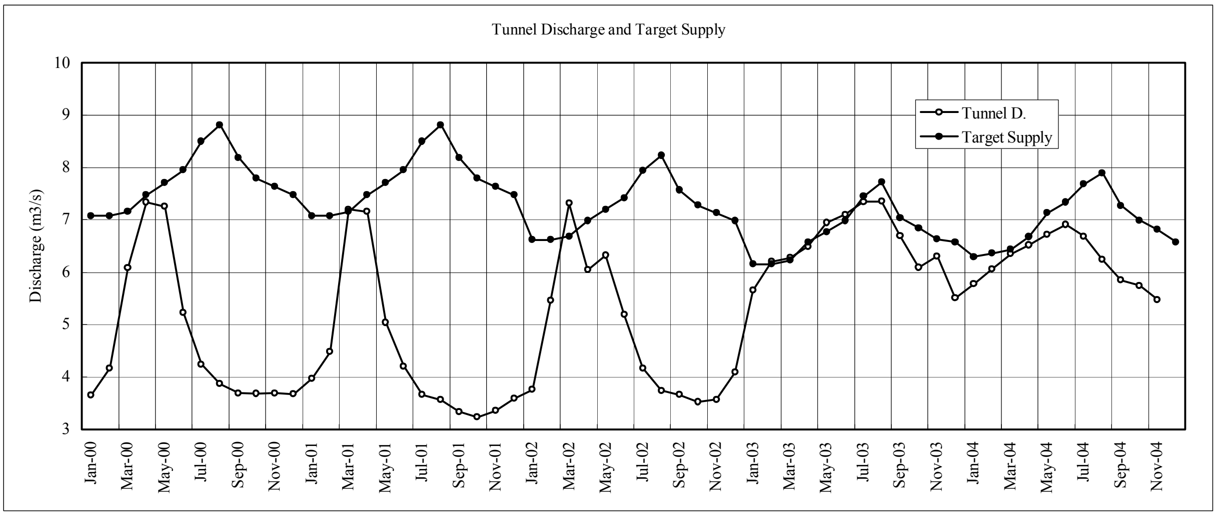
New Tunnel (Unit: m^3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2000	3.305	3.783	5.484	6.543	6.619	4.897	3.767	3.319	3.133	3.084	3.137	3.131	4.183
2001	3.352	3.794	6.511	6.566	4.456	3.643	3.191	3.164	3.015	2.926	3.046	3.252	3.909
2002	3.407	4.940	6.669	5.460	5.765	4.718	3.680	3.458	3.394	3.200	3.246	3.755	4.303
2003	5.216	5.716	5.798	5.959	6.371	6.599	6.790	6.748	6.189	5.733	5.979	5.200	6.026
2004	5.398	5.682	5.957	6.095	6.201	6.453	6.212	5.812	5.526	5.447	5.205		5.835
Avg	4.136	4.783	6.084	6.125	5.882	5.262	4.728	4.500	4.251	4.078	4.123	3.835	4.851

Total (Unit: m^3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2000	3.653	4.162	6.080	7.340	7.253	5.222	4.239	3.868	3.689	3.675	3.687	3.673	4.712
2001	3.969	4.483	7.202	7.161	5.037	4.205	3.658	3.560	3.334	3.232	3.356	3.586	4.397
2002	3.753	5.456	7.323	6.048	6.325	5.187	4.168	3.732	3.665	3.522	3.569	4.091	4.732
2003	5.655	6.199	6.273	6.487	6.945	7.102	7.349	7.352	6.696	6.095	6.307	5.502	6.498
2004	5.774	6.064	6.353	6.522	6.720	6.912	6.688	6.236	5.845	5.749	5.476		6.234
Avg	4.561	5.273	6.646	6.712	6.456	5.725	5.220	4.949	4.646	4.455	4.479	4.213	5.314

The total discharges in the tunnels and the target supply discharges are shown in the figure below. The discharges in the tunnels are quite small in comparison to the target supply discharges from 2000 to 2002. Although the wells in the City were operated to their maximum extent, suspension of water supply was substantial. The very wet rainy season from October 2002, as mentioned previously, allowed that the tunnels could transfer water to meet approximate requirements and the suspension time of water supply was shortened.



1.4 Other Conditions

1.4.1 Water Loss Through Tunnel

Appendix 5.1 discusses the results of flow measurement undertaken by the Study Team.

1) Review of Water Flow Measurement by DAWSSA

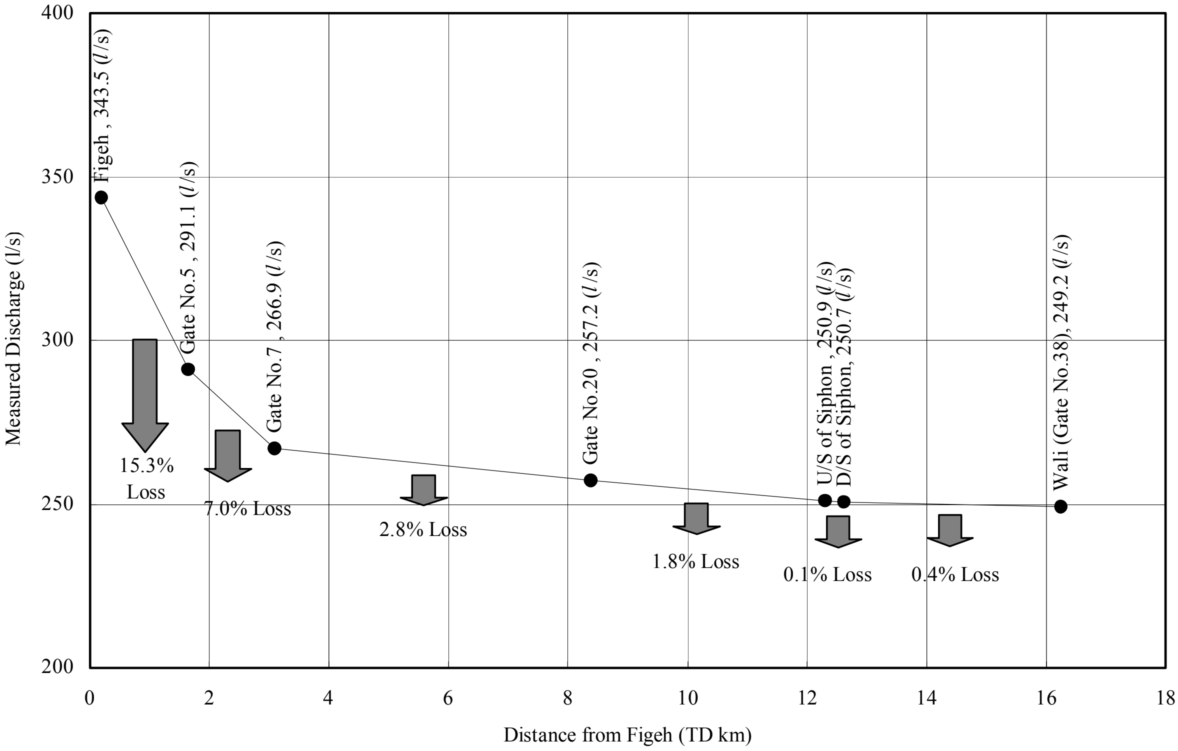
The Study Team obtained the data for water flow measurement by DAWSSA, discussed the methodology for the measurement the Authority, and reviewed the results. DAWSSA reported the water leakage rate as being 46.7 % in September 2002 and 60.3 % in October 2004. DAWSSA also conducted flow discharge measurements in the new tunnel three times in June 2003, indicating water leakage rate in the new tunnel was negligibly small at 0.1 % to 1.5 %. Review results by the Study Team are outlined in the table below. DAWSSA relies on sensor equipment to estimate the flow discharge at the inlet of the old tunnel. The Study Team believes that the established rating curve results in a misleading estimation. DAWSSA also undertook the measurement at the inlet and outlet of the old tunnel and therefore failed to identify the sections where the water leakage occurs.

	Measurement section	Measurement method	Problematic issue
Old Tunnel	Tunnel inlet	i) Water depth was measured by the sensor installed at TD 233. ii) The water depth was converted into flow discharges by a rating curve.	i) The rating curve is established based on an assumed Manning's roughness coefficient. The coefficient seems to be larger than the actual coefficient. ii) Water flow at the section of TD 233 is not stable.
	Tunnel outlet	Increase of storage volume of old reservoir was converted into flow discharge.	Storage volume was measured by water depth of the reservoir, ranging 1 - 4 m to avoid the effects of the distribution pipes, which is acceptable.
	Branch pipes	All branch pipes were closed.	Acceptable.
New Tunnel	Tunnel inlet	i) Water depth was measured by the sensor installed at TD 233. ii) The water depth was converted into flow discharges by a rating curve.	Acceptable.
	Tunnel outlet	Increase of storage volume of new reservoir was converted into flow discharge.	Acceptable.
	Branch pipes	All branch pipes were closed.	Acceptable.

2) Water Flow Measurement in Old Tunnel

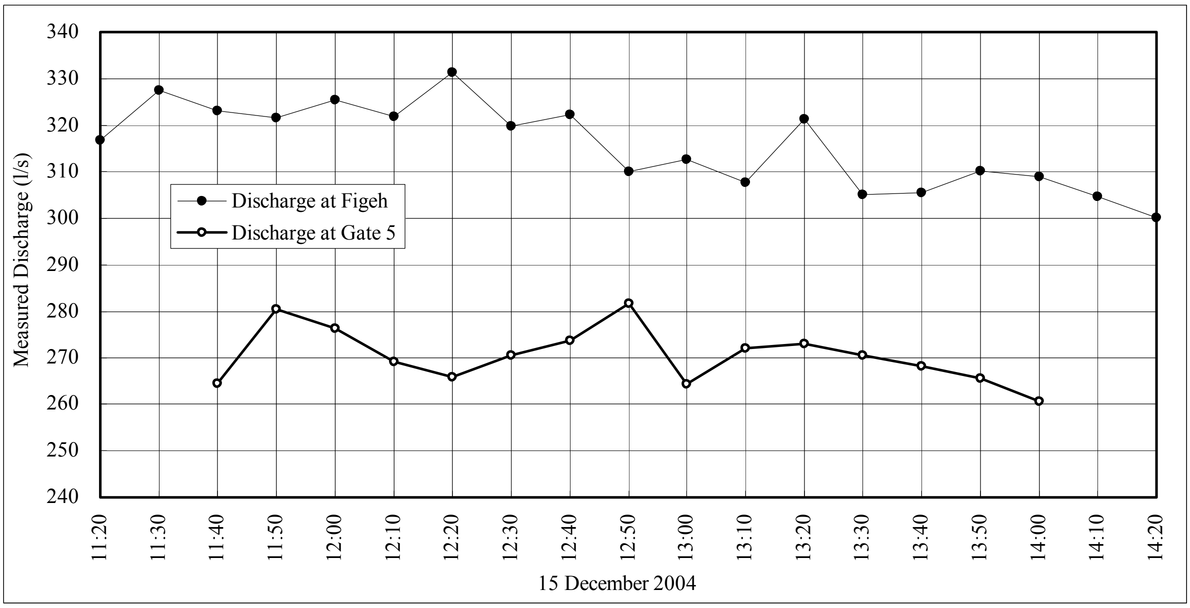
Access entrances at 37 locations were provided to transport the excavated material out of the tunnel and transport concrete into the tunnel during construction. Nine of these locations are used as access inlets. Water depth and flow velocity were measured at seven sections on 13 December 2004. The flow discharges were calculated as shown below.

	Measurement Section	Distance (m)	Discharge (l/s)	Discharge Ratio	Water Loss Ratio
1.	Tunnel Inlet	TD 260	343.5	100.0 %	-
2.	Gate No.5	TD 1,655	291.1	84.7 %	15.3 %
3.	Gate No.7	TD 3,090	266.9	77.7 %	7.0 %
4.	Gate No.20	TD 8,379	257.2	74.9 %	2.8 %
5.	Inlet of Siphon	TD 12,300	250.9	73.0 %	1.8 %
6.	Outlet of Siphon	TD 12,620	250.7	73.0 %	0.1 %
7.	Gate No.38 at Wali	TD 16,254	249.2	72.5 %	0.4 %
	Total				27.5 %



The gate opening at the tunnel inlet at Figeh was kept constant during the flow measurement and all branch pipes were closed. The measurement was carried out from upstream to downstream. The water depth and flow velocity were measured five times at intervals of five minutes. The flow discharges in the table above were calculated based on the average values measured.

The flow measurement was undertaken at the tunnel inlet (Figeh) and Gate No.5 for more than two hours on 15 December 2004 to observe any variations in the flow discharge. The results are shown below.



A loss rate of 15 % was measured, which confirmed the results obtained on 13 December 2004.

3) Water Flow Measurement in New Tunnel

The new tunnel has two access tunnels, Bassima Tunnel (TD 2,490) and Al Alayon Tunnel (TD 9,475). Since the gates equipped at the access tunnels are closed when water are flowing in the tunnel, there is no access point into the tunnel during tunnel operation. Therefore, flow discharge can not be measured along the middle sections of the tunnel. Water depth sensors are installed at TD 81 and TD 86. The water depth is converted into a discharge by use of the established rating curve. The Study Team confirmed the appropriateness of the rating curve. There is only one tunnel opening for discharge measurement, a gate slot opening at the gate chamber of the new Wali Reservoir where the new tunnel ends. The cross section at this location, however, changes abruptly and water surface waves vary radically preventing measurement of water depths. Accordingly, measurement of the water depth in the new reservoir was programmed to estimate the water storage volume of No.3 and No.4 chambers and to examine the balance of water transferred through the tunnel. The flow measurement was undertaken on 7 December 2004.

The branch pipe from the Al Alayon Access Tunnel could not be closed for the continuous supply service. The discharge from the branch pipe was measured and incorporated into the water balance. The results of the flow measurement are presented in the table below. The loss rate is calculated at 1.0 %.

Passing Time	Accumulated Vol. at Figeh (m^3)	Accumulated Vol. at Wali (m^3)	Accumulated Loss (m^3)	Loss Rate
0:00	-	-	-	-
0:10	3,079	3,065	14	0.4%
0:20	6,136	6,150	-14	-0.2%
0:30	9,215	9,177	38	0.4%
0:40	12,294	12,176	119	1.0%

1.4.2 Water Quality

Seasonal variation of water quality was also examined. In the rainy season, groundwater around the tunnel may rise with water seeping into the tunnel. It is questionable, however, whether the seepage water contaminates the water in the tunnel. Detailed discussions are presented in Appendix 5.2.

1) Water Quality Tests

The Study Team sampled the water on 8 December 2004 in the old tunnel and on 9 December 2004 in the new tunnel. The water sample was sent to the DAWSSA Central Laboratory for chemical analysis.

There is a steel pipe at TD 97.5 m in the old tunnel, as shown in the photo, which directs spring water on the ground into the tunnel without sterilization. The discharge was measured at 1.0 l/sec, which is the largest source of water seepage into the tunnel. The pipe should be plugged to stop water inflow.

It was at the beginning of the rainy season in November and December 2004 when the Study Team undertook site investigations. Only limited seepage was observed in the old and new tunnels at that time. Water seepage into the tunnels needs to be investigated at the beginning of dry season when the ground water may rise. However, it is judged that water seepage into the tunnels may be negligible even at the beginning of the dry season when ground water level is probably high, due to the following reasons:

i) The old tunnel is elevated near the ground surface and aligned along the river and will not be affected by groundwater.

ii) The lining concrete of the new tunnel is watertight.

The results of chemical analysis on the sampled water are shown below. No difference is observed in water quality between the inlet and outlet of the tunnels.

No.	Contents	Unit	Syrian Standard	Old Tunnel						New Tunnel	
				Tunnel Inlet	Tunnel Outlet	Siphon Inlet	Siphon Outlet	TD977.5		Tunnel Inlet	Tunnel Outlet
Sampling Date				9 Dec. 2004				11 Dec.	18 Dec.	8 Dec. 2004	
1	Turbidity	NTU	1.0-5.0	0.9	1.0	0.7	0.9	0.9	0.9	0.5	0.5
2	pH	-	6.5-8.5	7.3	7.7	7.7	7.6	7.4	7.3	7.3	7.4
3	Total Hardness "TH"	*mg/l*	≦500	17.2	17.2	17.0	17.0	15.0	15.0	17.0	17.0
4	Chloride "Cl"	*mg/l*	≦250	5.9	6.4	5.9	5.9	5.5	7.0	5.5	5.5
5	Nitrate "NO3"	*mg/l*	≦10	8.5	8.5	8.5	8.5	6.0	6.0	8.5	8.5
6		*mg/l*	≦0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	Total Disolved Solids	*mg/l*	≦1000	193.1	193.1	194.0	195.4	178.0	179.0	191.0	195.0
8		*mg/l*	≦0.5	0.4	0.4	0.4	0.4	0.0	0.0	0.5	0.4
9	Conductivity	*µS/cm*	≦1500	338.0	338.0	340.0	342.0	311.0	314.0	335.0	341.0
10	Calcium "Ca"	*mg/l*	≦50	48.0	48.8	48.0	48.0	48.0	50.0	48.0	48.0
11	Alkali	*mg/l*	≦20	15.4	15.4	15.4	15.4	13.0	12.8	14.8	14.8
12	Bicarbnate "HCO3"	*mg/l*	≦200	188.0	188.0	188.0	188.0	159.0	156.0	180.7	180.7
13	Sulfate "SO4"	*mg/l*	≦250	11.0	12.0	11.0	11.0	9.0	9.0	11.0	12.0
14		*mg/l*	≦0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	Temperature	C^o	5.0-25.0	13.0	14.0	14.0	14.0	13.0	-	13.0	14.0

2) Seasonal Variation of Water Quality

The Study Team obtained water quality data for four years from 2000 to 2003. The results are shown in Figure 1-4. To see the difference in water quality at Figeh (the tunnel inlet) and at Wali (tunnel outlet), the following variation ratio is introduced:

Contents	Change Rate
Turbidity	-4.4%
Conductivity	1.9%
pH	1.0%
Total Hardness	1.0%
Calcium "Ca"	1.4%
Magnesium "Mg"	0.0%
Sodium "Na"	2.6%
Kalium "K"	0.0%
Alkali	1.1%
Bicarbnate "HCO3"	1.1%
Sulfate "SO4"	20.8%
Chloride "Cl"	7.9%
Nitrate "NO3"	1.5%
Total Disolved Solids	3.0%

Variation ratio = $(V_{inlet} - V_{outlet})/ V_{inlet}$

Where,
V_{inlet} = Average value of chemical content at Figeh
V_{outlet} = Average value of chemical content at Wali

The results are shown in the table to the left. The table and Figure 1-4 indicate that the water quality scarcely changes through the tunnels, apart from sulfate level. Although sulfate content is well below the standard content level, the sulfate may be supplied in the tunnel.

Contents	Co-relation factor	Co-relation*
Turbidity	0.62	None
Conductivity	-0.87	Co-relation
pH	0.07	None
Total Hardness	-0.90	Co-relation
Calcium "Ca"	-0.85	Co-relation
Magnesium "Mg"	-0.33	None
Sodium "Na"	-0.80	Co-relation
Kalium "K"	-	-
Alkali	-0.88	Co-relation
Bicarbnate "HCO3"	-0.88	Co-relation
Sulfate "SO4"	-0.68	None
Chloride "Cl"	-0.63	None
Nitrate "NO3"	-0.66	None
Total Disolved Solids	-0.86	Co-relation

*Co-relation with facor of more than 0.7.

Flow Discharges increase in the tunnels in rainy season while spring discharges at Figeh increase. Correlation between the flow discharges in the tunnels and chemical contents are presented in the table to the left. All Correlation coefficients are negative, which indicates that chemical contents do not increase in accordance with spring discharges, but are diluted while spring discharges increase.

3) Other Water Quality

The chemical analysis results of heavy metals are listed below. The contents of all heavy metals are far below the Syrian standard and seasonal variations were not evident.

Constituents	Copper	Manganese	Iron	Cadmium	Chromium	Lead	Zinc	Aluminium	Mercury	Selenium	Arsenic
Symbol	Cu	Mn	Fe	Cd	Cr	Pb	Zn	Al	Hg	Se	As
Unit	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Syrian Standard	≤1,000	≤100	≤300	≤5	≤50	≤10	≤3,000	≤200	≤1	≤10	≤10
Date of Examination											
Mar. 2000	N.D.	0.6	12	0.4	3	4	9	6	N.D.	N.D.	N.D.
Nov. 2000	N.D.	1.0	13	0.5	3	5	11	6	N.D.	N.D.	N.D.
Mar. 2001	N.D.	0.9	17	0.3	3	6	10	4	N.D.	N.D.	N.D.
Nov. 2001	N.D.	0.9	11	0.7	3	5	10	8	N.D.	N.D.	N.D.
Oct. 2002	N.D.	0.9	12	0.3	2	6	10	7	N.D.	N.D.	N.D.
Mar. 2003	N.D.	0.9	18	0.5	4	5	10	8	N.D.	N.D.	N.D.
Nov. 2003	N.D.	1.0	17	0.5	4	5	11	6	N.D.	N.D.	N.D.
Mar. 2004	N.D.	1.0	17	0.7	4	6	12	5	N.D.	N.D.	N.D.
Nov. 2004	N.D.	1.0	15	0.6	3	6	11	6	N.D.	N.D.	N.D.

* N.D.: Not Detected

1.4.3 Tunnel Rehabilitation Sections

A tunnel investigation was undertaken of both old and new tunnels along their entire lengths. The tunnel sections for rehabilitation identified in the Preliminary Study and this Basic Design Study are shown in Figures 1-5 and 1-6.

1.4.4 Cavity Behind Tunnels

Cavities behind tunnels were investigated by use of equipment mounting an electromagnetic wave radar. The investigation results are shown on Figures 1-7 and 1-8. Sections for the investigation and results are listed in the table below.

		Old Tunnel		New Tunnel	
Investigation Section（Length）		TD.300～330 (30m)	TD.15,700～16,150（450m）	TD.20～170 (150m)	TD.3,100～3,200 (100m)
Thickness of Earth above Tunnel		10～12m	3～4m	5～20m	70～80m
Tunnel Situation		This section is located under the residential area. Structural cracks develop.	This section is located under highway road near the Wari reservoir. Crack openings on the cross sections are observed.	This section is located under residential area.	Concrete chemical attack by sulfate is observed on this section.
Observation	Cavity behind concrete	Not continuous but spot cavities are identified.	Continuous cavities from TD.15,700 to 15,995 are observed, but they are minor at depths of 2 - 9 cm.	None	None
	Concrete Thickness（Design Thickness)	15～37 cm（10 cm）	Upper Slab 20～49cm（13 cm at crown）	35～64cm（15 cm）	29～61cm（15 cm）
	Re-bar or Steel Support	Re-bars	Re-bars	Re-bars and Steel support	Steel support, partially

Cavities observed from TD 15,700 m to TD 16,150 m in the old tunnel may be the voids of filled gravel.

1.4.5 Concrete Strength

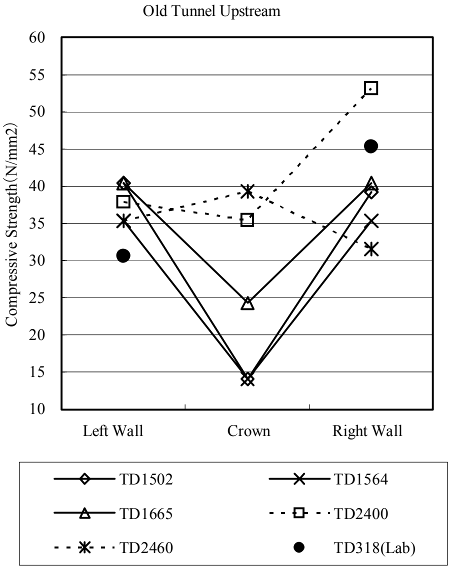
1) Concrete Compressive Strength and Hammer Tests

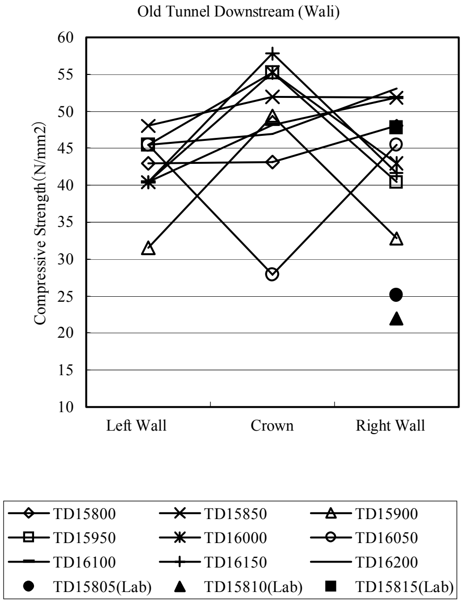
The surface concrete at TD 3,168 m in the new tunnel has deteriorated, probably as a result of chemical attack. Two concrete samples were taken by drill machine. Concrete compressive test results are shown below, while the design strength was set at 28.7 N/mm2. The concrete surface has deteriorated at a depth of 5 - 14 cm and softened. However, the test results revealed that the inner concrete is fresh with good strength.

TD 3,166.2 m (Right wall): 28.7 N/mm^2 (Unit weight: 2.335 t/m^3)

TD 3,171.2 m (Right wall): 28.4 N/mm^2 (Unit weight: 2.339 t/m^3)

Two concrete samples were taken at TD 318 and three samples at TD 15,805, TD 15,810 and TD 15,815 in the old tunnel. Concrete has deteriorated at TD 1,465 - 1,670 (rectangular section) and at TD 15,820 - 16,150 where concrete sampling was difficult due to reinforcement bars installation in the concrete. Instead, concrete hammer tests were undertaken to estimate concrete strength. The results are shown below.

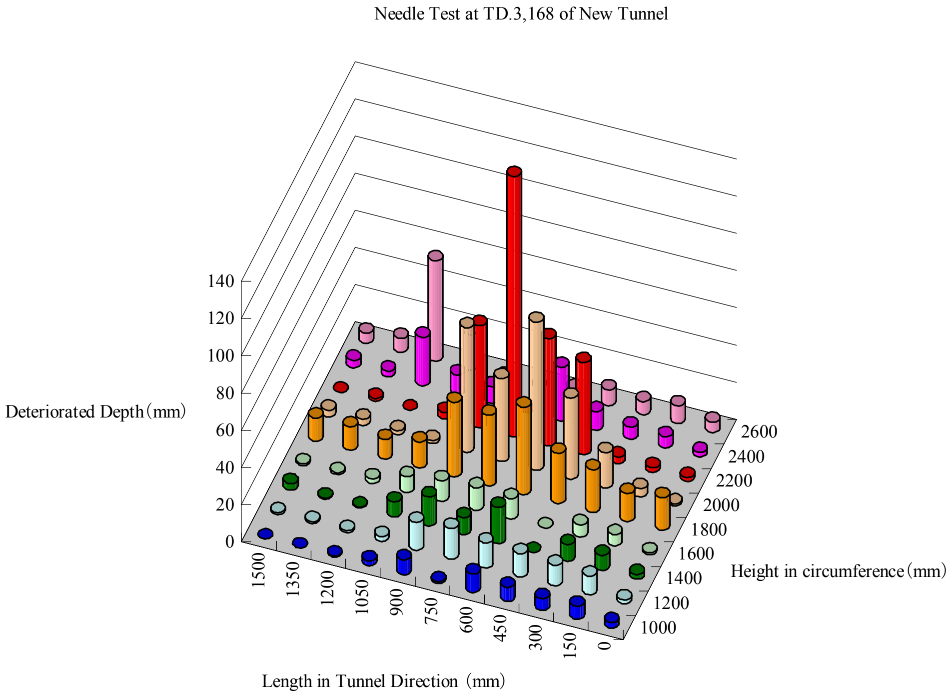




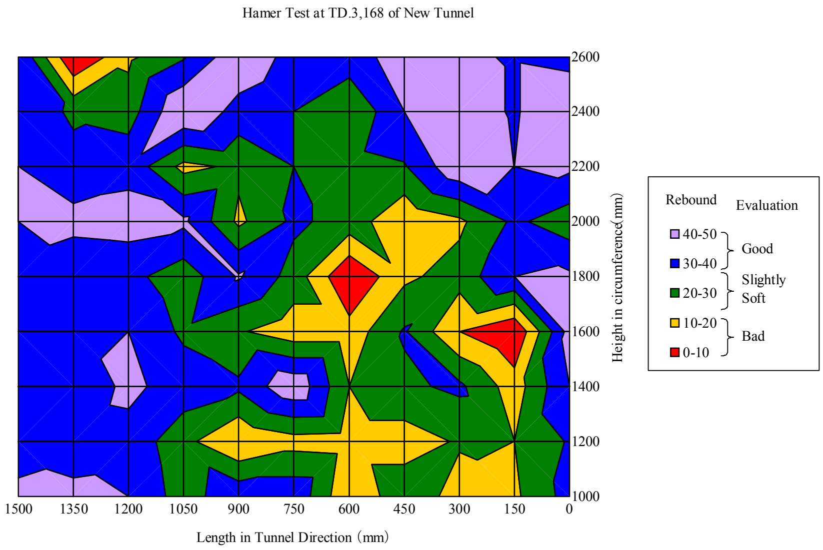
Satisfactorily high concrete strengths were obtained at all except three sections, namely the upper slab at TD 1,502 and TD 1,665 and TD 2,460.

2) Needle Test at TD 3,170 in New Tunnel

Additional tests were undertaken at the deteriorated sections around TD 3,170 m in the new tunnel. Deteriorated depth was measured by use of a hand-held electric drill machine. Based on this test, when the tip of the drill machine hit the hard concrete this was noted by the holder of the drill machine and the depth of deteriorated concrete was measured. The deteriorated area was marked with a 15 cm grid. The needle test was carried out on the grid point, with test results being shown below.



The maximum depth of deteriorated concrete was measured at 14 cm. This compares to a total thickness of concrete of more than 40 cm. Since the thickness of hard concrete is more than the designed thickness, it is judged that the deterioration does not endanger stability at present.



The deteriorated concrete was removed manually by hitting with a chisel. Concrete strength was tested by use of a test hammer. Rebound degree was improved from 10 before removing the deteriorated concrete to 20 after removing the deteriorated concrete. The results suggest that deterioration is limited to the tunnel inner surface only.

The deterioration could be attributed to physical forces such as water flow. However, since the deterioration area is located above the water surface in the tunnel, this is probably not conceivable. It could also be attributed to poor concrete quality or poor concrete placement but as the distribution of deteriorated depth is not uniform but is shaped like a cone, such a reason is also not likely. Geological records at the time of the construction report the existence of gypsum. Therefore deterioration is likely to be attributable to sulfate attack.

1.4.6 Tunnel Inner Dimension

Tunnel inner dimensions were measured by use of laser equipment at the following sections.

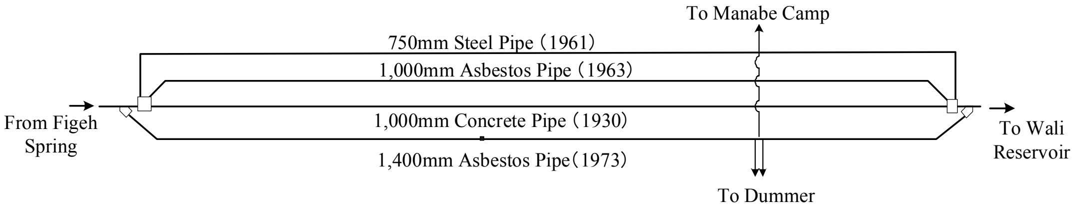
Old Tunnel	New Tunnel
9 sections from TD 310 to TD 340 26 sections from TD 1,450 to TD 1,670 15 sections from TD 2,360 to TD 2,660 11 sections from TD 15,700 to TD 16,100	3 sections from TD 20 to TD 170 1 section at TD 3,170 and at TD 3,185

The survey results are shown in Figures 1-9 and 1-10.

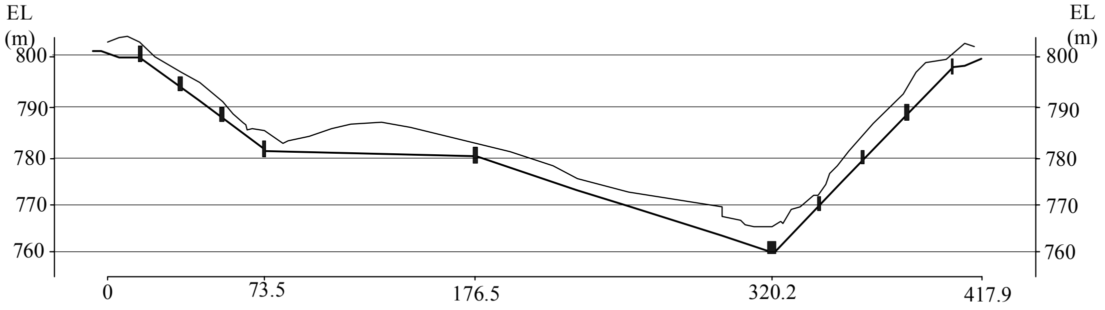
The standard hood-shaped section in the old tunnel has generally maintained its original section dimension. However, the rectangular sections in the old tunnel deviate from the design section. These deviations do not affect discharge capacity and stability. The inner dimensions of the new tunnel are generally comparable to the design section.

1.4.7 Siphon Structure of Old Tunnel

Four siphon pipes have been embedded to cross the Dummer valley along the old tunnel, as shown in the figure below. The asbestos pipe (1,400 mm diameter) embedded in 1973 is currently used for water transfer. The Study Team undertook visual inspection in the pipe after draining of water. The inner surface is in good condition without any surface erosion or exposure of asbestos. No water leakage through pipe joints was observed on the ground. The flow discharge measurement at the inlet and outlet of the pipe, as discussed in Section 1.4.1, also does not indicate water leakage along pipes.



Plan of Siphon Pipe od Old Tunnel



Profile of Siphon Pipe of Old Tunnel

A pipe was damaged in 1963 and 1996 due to land slide and land settlement. The pipes are embedded in the military yard and heavy equipment crosses them so frequently that it is anticipated the pipe damage will reoccur. The asbestos pipe (1,000 mm diameter) was damaged in 1996 due to land settlement. Pipes were imported from Lebanon and replaced. Water in the unused pipe should be drained to avoid inundation at the time of pipe damage.

Chapter 2 Contents of the Project

2.1 Basic Concept of the Project

Damascus City suffers from regular suspension of water supplies in dry and normal years, as discussed in Chapter 1. This is due to significant limitations in available water resources. The 9th National Plan (2001-2005) establishes a policy to use water resources effectively. DAWSSA is therefore taking action to reduce the water leakage ratio. It is reported that the rate of water leakage of the water supply system of the city was 34.7 % in 1997 and the UFW (Unaccounted for Water) was 63 %. It is planned to decrease the rate of UFW to 25% by 2015.

The current study, which is conducted by DAWSSA, is associated with the rehabilitation and expansion of the water supply system, and has a target of reducing UFW to 20 % by the year 2020. The countermeasures to improve water leakage are in operation as a key policy to secure effective utilization of the limited water resources. The National Plan also puts a priority on rehabilitation of the existing facility. DAWSSA has allocated a budget of 1.588 billion Syrian Ponds for rehabilitation works.

The old and new tunnels transfer water some 85 % of the total water consumption of Damascus. The water transmission tunnels in service are therefore one of the most important facilities for water supply of Damascus City. Rehabilitation of damages in the tunnels is therefore proposed to be initiated at an early date to ensure their future utilization, particularly as damage to the tunnels will progress further if left untreated. The rehabilitation ultimately aims at safely supplying good quality water.

The rate of water leakage along the entire length of the old tunnel is measured as 27%, with 22% occurring in the 3 km reach from the tunnel inlet. The remaining leakage, although only 5%, is distributed uniformly along the other 13 km length of the downstream section. There are no significant leakage points in the downstream section, therefore, large-scale leakage prevention work along this section is unadvisable in view of the cost-benefit performance. The Project aims to reduce rate of water leakage from 27 % to 5% by rehabilitation of the upstream section of the old tunnel.

The service period of the new tunnel is 25 years after construction. There are few damaged locations and the rate of water leakage is measured at only 1%. Concrete deterioration was found at TD 3170, which is judged to be due to sulfate attack. Sulfate may be supplied behind the tunnel concrete, having been dissolved in groundwater. The deteriorated concrete will affect the durability of the concrete lining and the Project aims to recover its original durability through rehabilitation.

The project provides technical assistance, the so-called soft component, that aims at improving operation and maintenance of the tunnels after rehabilitation works. Displacement devices to measure the inner dimensions of the Wali reservoir will be installed and technical assistance, the soft component, will provide training to allow DAWSSA to continue observations of the displacement.

2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policy

1) Basic Policy of the Design

The old tunnel has been in service for 75 years and the new tunnel for 25 years. Damage and deterioration of the old tunnel, in particular, have progressed because of its long service period. The extent and methodology of the rehabilitation works were generally defined in the Preliminary Study. In this current study, the extent of the tunnels to be rehabilitated are investigated and again identified based on the results of the Preliminary Study. Both tunnels are generally in good condition and rehabilitation work will further prolong their service lives.

The volume of water transferred by the old tunnel is only some 9 % of the total transferred. Deterioration and damage in the old tunnel have progressed substantially and t he new tunnel now plays a very important role in water transfer. The old tunnel transferred the water to Damascus City and to Dummer area of the outskirts of Damascus City, with water being diverted at the bottom of the siphon pipe. Although the old tunnel transfers water at only 15 % of design discharge, it still plays a very important role as a bypass tunnel in the event of accidents or rehabilitation works in the new tunnel. Maintenance of the tunnels is very important for water supply to Damascus City and the Project will target rehabilitation of both tunnels.

Deterioration and damage were found in the lining concrete where concrete flaking and peeling have taken place. These accelerate the adverse effects such as water leakage, corrosion of reinforcement bars, and widening of cracks due to intrusion of tree roots. The project will remedy those areas with crack widths of more than 0.2 mm and where flaking/peeling exceeds 10 cm. The old tunnel is aligned on the left bank of the Barada river with less earth cover above the tunnel. In particular, the upstream tunnel from the tunnel inlet to Gate No.7 or TD 3,000 m has less cover or has culverts applied with the "cut-and cover" method. Those sections of the old tunnel with thick cover are in good condition with little rehabilitation required. The old tunnel also requires rehabilitation of the deteriorated aqueduct, corroded steel pipes for reinforcement, and corroded gates.

Implementation of the Project will prevent water seepage into the tunnel and fill voids behind the concrete lining. The tunnel investigation by the Study Team found that water seepage is quite small as are the voids, and as such these two components are not included in the Project.

The tunnel will have additional deterioration and damage even after the rehabilitation works, due primarily to changing external conditions. Therefore, periodic inspections and repair when damage is noted are required. The Project will establish the system plan for maintenance. Furthermore, the Project will provide a monitoring system and guideline on measures for safety of the new Wali reservoir.

The optimum rehabilitation method and material will be selected among alternatives from the viewpoint of construction costs, impacts on environment, construction method and period, and durability.

2) Basic Policy towards Natural Conditions

The rehabilitation works are unaffected by the natural conditions including temperature, rainfall and wind, because the works are undertaken inside the tunnels. Flows in the tunnels can be controlled by the gates installed at the tunnel inlets. The old tunnel is affected by external forces on the land and geological conditions because it is elevated near the ground surface. These above conditions are considered in the basic design. There are structural cracks at TD 300 m in the old tunnel, which seem to be induced by landslides above the tunnel. A countermeasure to decelerate progress of the structural cracks is studied.

There are nine accessible gates along the old tunnel, Gate Nos. 4, 5, 7, 11, 20, 24, 32, 33 and 38. Accessibility into the tunnel for the rehabilitation works of the old tunnel is possible through these, if the works do not require large-scale equipment. Ventilation shall be considered at the time of welding with the use of exhaust equipment possibly being required. The rehabilitation works along the entire reach of the new tunnel will be more readily implemented because battery cars, which are on stand by at the inlet and outlet of the tunnel and two audits (Bassime audit and Al Ayoun audit), allow accessibility to the works.

3) Basic Policy towards Social Conditions

Measures are studied in order to minimize the impact on society caused by possible accidents during the operation of the tunnels. Although the back-siphon is located in the military area, houses have recently been illegally constructed in neighboring areas of the siphon. Accidents, in which the siphon pipes were damaged by land slide and ground subsidence, occurred in 1963 and 1996. Since the water that would spill from the siphon pipes would induce further damages, a means of draining off water from the siphon pipes is studied.

Because the tunnels are in service for water supply, their down-time due to the rehabilitation works should be avoided as much as possible. The materials used for rehabilitation works should not affect the water quality in the tunnel, since the water flowing in the tunnel is chlorinated. The materials with quick hardening properties should be chosen for the rehabilitation works of inner surfaces of the tunnel such as injection work, grouting work and coating work. The use of pre-cast members are considered in order to shorten the required work period. It is matter of course to choose the materials that are not toxic and would not dissolve into the water during service.

4) 4Basic Policy towards Local Contractor and Materials

Syrian domestic builders have limited experience in tunnel construction or tunnel rehabilitation works. The rehabilitation works are therefore designed in consideration of the skill of the local contractors. Main works in the Project are not the works that require heavy machinery or advanced technology, but rather the works such as installation of pre-cast materials, filling and injection works. The provision of the rock bolts is the only aspect of the Project requiring advanced technological work. In principle, the materials available in the local market are selected with appropriate materials being assessed on the basis of durability and constraints on construction. The employment of local sub-contractors will be specified in the tender documents.

5) Basic Policy towards Operation and Maintenance Skill of the Executing Organization

No rehabilitation work for the new tunnel has been undertaken to date, and rehabilitation work for the old tunnel was implemented using foreign contractors. DAWSSA aspires to improve inspection and repair skills and request GoJ for implementation of on-the-job training.

Not only the rehabilitation and maintenance of the tunnels but also the maintenance of the underground reservoir cavern is essential. There are cracks on the bottom slab and the wall of the cavern although displacement of the walls or bottoms slab has not yet been observed. The reservoir caverns are an important facility for the water supply system as well as the transmission tunnels.

Issues regarding tunnel inspection and displacement monitoring of the caverns are associated with the soft components of the Project.

2.2.2 Basic Plan

The two tunnels, which convey water from the Figeh spring to Damascus City, are now deteriorated and in a poor state. Associated rehabilitation works of the tunnels will therefore be implemented in the Project. The measures to be implemented at each damaged location are tabulated in the following table while the general concepts of each alternative countermeasure are illustrated in Figure 2-1.

		Study in Basic Design
Requested Remedy in Official Application	1. Prevention of Water Leakage of Old Tunnel	The following alternatives will be studied. Panel Method Panels will be installed on the tunnel inner surface. Panel Material ・FRP (Fiber Reinforced Plastic) ・Steel Plate Bypass Tunnel New bypass tunnel will be replaced with the deteriorated old tunnel. Tunnel route (Vide Fig. 2-1) ・Route 1 ・Route 2 ・Route 3 Open Air Method The deteriorated old tunnel will be rehabilitated by open air method.
	2. Ground Water Seepage into Tunnel	No measure because investigation revealed very few ground water seepage into tunnel.
	3. Repair of Deteriorated Concrete (Cracks, Concrete Flaking, Peeling Off)	To inject epoxy resin into cracks with more than 0.2 mm width. To fill polymer cement mortar where concrete surface is flaked and peeled off. To clean the exposed rusted reinforcement bars and to to fill polymer cement mortar.
	4. Remedy on Rusted Steel Pipes for Reinforcement	To clean the rusted steel pipes and to paint polymer cement.
	5. Filling Voids Behind Tunnel Crown.	No measure because investigation revealed very few voids behind tunnel concrete.
	6. Replacement of gates	Gate Replacement at the tunnel inlet and siphon pipes of the old tunnel.
Additional Remedy Identified	1. Structural Cracks at TD 300-345 in Old Tunnel	The following alternatives will be studied. Steel Support Further deformation will be supported by H-steel. Rock Bolt Further deformation will be supported by rock bolts.
	2. Concrete Deterioration at TD 3,168 - 3,172 m in New Tunnel	To cut out the surface at the depth of 15 cm, to install FRP and to inject resin mortar.

Table 2-1 shows the study results of leakage prevention for the upstream section of the old tunnel. The panel method is superior, attributing to 1) high costs in the new bypass tunnel and 2) with a limited area having the open air method applied. Since periodic painting is required for the steel plate, FRP (Fiber Reinforced Plastic) is preferable. Finally, the lining work in which FRP plate is applied as leakage prevention material was selected through the comparative study. The result of the comparison of countermeasures against structural cracks in the section TD 300-345 m in the old tunnel is tabulated in Table 2-2. Although the costs applying a steel support system are low, rock bolt support has been selected since 1) steel supports reduce the flow area and current flow capacity and 2) rock bolt support has structural superiority against further deformation. The rock bolt method has therefore been selected as the countermeasure.

2.2.3 Basic Design Drawing

The general plan of rehabilitation works is shown in Figure 2-2. The basic design drawings are shown from Figure 2-3 to Figure 2-10.

1) Lining Work for the Old Tunnel (ref. Figure 2-3)

Five standard sections are designed in accordance with the cross section shape of the tunnel and number of wall surfaces to be repaired. The paneling works are to be adapted to those sections suffering from heavy damage such as concrete cracking, flaking and peeling off of the concrete lining, and intrusion of tree roots. Table 2-3 and Figure 2-2 show the sections to be lined with panels.

2) Replacement of the Corroded Gates on the Old Tunnel (ref. Figures 2-5, 2-6, 2-7 and 2-8)

In the old tunnel, gates are installed at the tunnel inlet, siphon structure and aqueduct bridge No. 3. The gates are used rarely, apart from the gate at the tunnel inlet. The tunnel is designed to convey water with no internal water pressure. Therefore, generating pressure due to gate operation in which the tunnel becomes full with water is not allowed. The gate at the tunnel inlet is to be replaced as it is indispensable in controlling tunnel discharges, is in a deteriorated condition and allows water leakage when closed.

Four siphon pipes are embedded at the siphon section and three of the associated pipes are out of service. Gates are installed at all inlets and outlets of the siphon pipes. The gates of the three out-of-service pipes are corroded and non-functioning. In order to prevent pipe accidents, it is preferable to drain off water from the pipes and keep them permanently empty. The three non-operational pipes will be used as bypass channels in case of an unexpected accident in the 1,400 mm diameter asbestos pipe, which is used normally. Additional gates will be designed for the three non-operational pipes to provide the above functions (see Figure 2-7).

Iron steel and stainless steel are conceivable for the gate material. An iron steel gate needs periodic paining to protect it from rusting. Since stainless steel is economically advantageous in view of the cost of painting, this will be adopted.

3) Aqueduct Bridge No.3 (ref. Figure 2-9)

The bridge has been previously reinforced, however, the girder concrete has again been damaged. It would therefore be dangerous to cut the concrete for repairing and carbon textile will be placed on the bottom surface of the girder.

4) Work Quantity

Work quantities for tunnel rehabilitation are listed below.

	Works	Quantity
Old Tunnel	1) FRP lining	1,546 m tunnel length or 5,504 m^2
	2) Rock bolts	45 m tunnel length or 46 sections
	3) Concrete crack repair	566 m
	4) Concrete repair	8,892 places
	5) Repair of reinforcement steel pipe	156 pipes or 43.1 m^2
	6) Carbon textile at aqueduct bridge No.3	28.2 m^2
	7) Replacement of gates	Tunnel inlet: 1 gate
		Siphon: 2 gates
New Tunnel	1) Repair of deteriorated concrete	34.6 m^2
	2) Concrete crack repair	13 m
	3) Concrete repair	219 places

2.2.4 Implementation Plan

2.2.4.1 Implementation Policy

1) Principles for Construction and Procurement

The Project will be implemented under the framework of a Japanese Grant Aid Program. The following policy and conditions will be adopted:

- The executing agency in Syria is DAWSSA.
- Immediately after the issue of the Exchange Note for the Project between the Government of Japan and Syria to conduct the detailed design and to implement the construction works, DAWSSA shall commence preparation including internal procedures.
- The Japanese Consultant will enter into the contract for consulting services with DAWSSA. The Consultant will undertake the tasks of the detailed design and preparation of tender documents. A tender exercise for the civil works will then be executed.
- The Government of Syria will acquire the required land during the detailed design.
- After the pre-qualification exercise for applicants, a Japanese Contractor will be selected on a two-envelope basis through a tender exercise. The Contractor will procure the required material and equipment and will complete the construction works.
- The Consultant will supervise the construction works in collaboration with DAWSSA.
- DAWSSA will maintain the tunnels after the completion of the works and the Contractor shall repair any defective parts during the guarantee periods.

The following subjects will be taken into consideration:

- Local material, manpower and equipment will be utilized to the maximum extent in order to activate the local economy, create employment opportunities and accelerate technical transfer.
- Good communication shall be established between DAWSSA, the Consultant and the Contractor.
- A practical construction program shall be established incorporating a required time for procurement and a practical construction methodology.
- The Japanese Contractor will procure the Project equipment and implement the construction works, in compliance with the contract between DAWSSA and the Contractor.
- The Contractor can build a temporary office and goods storage yard at the area designated by DAWSSA in Figeh and Wali Office.
- DAWSSA will coordinate the stakeholders in collaboration with the Consultant and the Contractor.
- The Contractor shall hand over the completed structure to DAWSSA at the time of completion. DAWSSA shall thereafter maintain the tunnels.
- Rehabilitation works in the tunnels are not affected by rain. The construction schedule can therefore be programmed without disturbance by weather.

2) Construction

Local contractors have less experience in tunneling works, as tunnels have rarely been constructed in Syria. The Japanese Contractor will be directly involved in tunnel rehabilitation works, assigning a Japanese technical site foreman from Japan. The Contractor will guide the local contractor and local staff, also providing technical transfer.

3) Assignment of Japanese Staff of Contractor

Three engineers, the Project Manager, Chief Engineer and Concrete Repair Engineer, will be assigned in consideration of work quantity, work period and work circumstances. Additionally, site technical staff will be assigned.

2.2.4.2 Implementation Conditions

The following conditions shall be noted:

1) Safety

Rehabilitation works in a tunnel will require workers to perform tasks in a narrow and limited space, particularly as the old tunnel has inner dimensions of only 1.8 m height and 1.3 m width. Safety shall be a priority in the limited space. Provision of sufficient ventilation, strict prohibition in the use of gasoline engines, good communication in the tunnels, and ensuring emergency exits must be incorporated in the construction plan.

2) Social Environment

Rehabilitation works in tunnels will seldom have social impacts such as noise, construction powder, vibration by heavy equipment, traffic accidents, and so on.

The rehabilitation work in the tunnels could contaminate the drinking water in the tunnel. Highest priority shall therefore be placed on not contaminating the water during work, with thorough cleaning taking place daily after work. Water quality tests shall be conducted periodically and water quality shall be monitored.

2.2.4.3 Scope of Works

1) Obligations of Japanese Side

- Consulting services of detailed design and preparation of tender document
- Rehabilitation civil works
- Technical transfer of "Tunnel Inspection and Repair" and "Deformation Measurement of Reservoir Cavern"

2) Obligations of Syrian Side

- Acquisition of required land.
- Installation of measurement devices in Wali reservoir.

2.2.4.4 Consultant Supervision

1) Detailed Design and Tender Document

Immediately after issuing the Exchange Note between the Governments of Japan and Syria, the Japanese Consultant shall enter into the contract for consultant services with DAWSSA. The Consultant will commence service including engineering detailed design and tender documents. Main tasks of the Consultant will be as follows:

- Additional survey and investigation
  Confirmation of gate dimensions of tunnel inlet gate and siphon gate
  Confirmation of tunnel situation where rock bolts will be installed
  Investigation for Wali Reservoir

- Detailed design
  Detailed design based on the survey and investigation
  Estimation of project costs based on the detailed design
- Tender documents
  Preparation of detailed drawings for tender
  Preparation of tender documents

2) Tender Exercise and Construction Supervision

After the works for detailed design and tender documents, DAWSSA and the Consultant will commence the tender exercise. The tasks of DAWSSA and the Consultant for construction supervision are as follows:

- Scrutiny and approval of construction plan and drawings
  Scrutiny and approval of construction plan and construction drawings submitted by the Contractor, including work commencement, material sampling, material specification, equipment specification and others

- Supervision of works
  Study and supervision of work progress and work quality, undertaking required tests on the construction methods

- Payment authorization
  Issue of authorization to pay and issue of completion certificate after completion of works

2.2.4.5 Quality Control Plan

Compressive strength tests for mortar will be specified in the contract of civil works, which will be used for concrete repairing. The test would be subcontracted to a laboratory of Damascus University, Ministry of Housing and Construction or Damascus Engineering Syndicate. The Consultant, in collaboration with DAWSSA, will undertake the measurement of flow discharge in the old tunnel to examine the ratio of water loss after the rehabilitation works.

2.2.4.6 Procurement Plan

1) Procurement of Construction Material

Construction activities of big hotels and big structures of elevated traffic crossings are prevailing in Damascus City. Basic construction material such as concrete, reinforcement bars and concrete shuttering forms are available. Agency offices of European material producers are in operation in Damascus City to sell polymer cement, pre-mixed non-shrinkage mortar, and epoxy resin for crack injection, which will be used for the tunnel rehabilitation works.

A cement factory was located in Damascus city but was closed ten years ago to avoid environmental pollution. Another factory is located 30 km away from Damascus City, which has a limited capacity to support construction activities in Damascus City. Most of the cement used in the City is transported from the factory located in Tartus City. The factory has the largest capacity in Syria and produces some 1.3 million ton/year of cement.

The special materials to be used in the tunnel rehabilitation works, such as FRP (Fiber Reinforced Plastic), rock bolts and carbon textile sheet (for bridge girder repair), are scarcely available in Damascus City. They will be imported from Japan or third countries.

Steel gates could be procured in Syria. However, design requirements for stainless steel gates and the four-face water proof function are of a high standard. It is therefore preferable to import gates from Japan.

Goods from Japan will be transported from Yokohama port, for unloading at Tartus port and then transported to Damascus City. A good highway with 2 - 3 lanes on one side is in service from Tartus port to Damascus City over the distance of 260 km.

2) Procurement of Construction Equipment

General heavy equipment including bulldozers, back hoes, truck cars, crane cars, and others are available in the local construction market on a rental basis. Other equipment required for the works such as engine generators, air compressors, breaking machines, and grout equipment is also available in the construction market.

Rental prices are set out on the following conditions:

- The prices are for equipment only. Operator cost will be charged additionally.
- The lender is responsible for maintenance during rental period.
- The lender will transport the equipment to the site and the transportation cost is included in rental charge.
- Rental charge covers the duration of the days of equipment transportation.

2.2.4.7 Technical Assistance (or Soft Component)

1) Background

Tunnel Inspection and Repair

There are very few tunnel structures in Syria. As a result, technology for tunnel inspection and repair is not developed. DAWSSA has undertaken tunnel inspections four times since 2002. Inspection records, however, are not sufficient since a manual or guideline is not issued. Only visual inspection is carried out with no quantified records kept. An inspection system is therefore required. Nonetheless, even after finding the concrete cracks and concrete damages, DAWSSA remains unfamiliar with repair procedures.

Deformation Measurement of Reservoir Cavern

Wali Reservoir functions to regulate the discharge of the new tunnel to meet the variable demand. The underground cavern, which forms the reservoir at the end of the new tunnel, has a total capacity 61,400 m^3 (= 4 x 15,350 m^3) and comprises four cavern units (12 m width, 12 m height, 160 m length). Concrete cracks are developed on the bottom slab and vertical walls. DAWSSA is concerned at development of cavern deformation and therefore installed 70 pieces of glass at the cracked lines in 1999 to monitor their movement. The pieces of glass were found to be broken during the inspection in 2002. The number of broken glass pieces was not defined and records of width of crack, movement of crack width, and movement of deformation of the inner dimension of the caverns are not available. Stability safety can not be assessed without such information and countermeasures can not be established.

2) Goals

Tunnel Inspection and Repair

The damaged and degraded concrete accelerates degradation of concrete quality.

Without repair, this would deteriorate further. It is economic to repair damaged concrete an early stage after regular inspections. DAWSSA will undertake regular tunnel inspections and will be able to carry out simple repairs for concrete cracks and concrete surface deterioration.

Deformation Measurement of Reservoir Cavern

The reservoir is a very important facility for water supply. If instability of the cavern is found, remedial works shall be undertaken immediately so that the costs can be minimized and water supply services can be continued. The Project will install measurement devices in Wali cavern to monitor displacement and DAWSSA will undertake measurement works for several years. A manual will be prepared by the Consultant to guide the required actions by DAWSSA according to the measurement results.

3) Effects

Tunnel Inspection and Repair

- Manual will be issued.
- Routine inspection system will be established.
- DAWSSA will learn the use of tools for inspection.
- DAWSSA will be able to undertake simple repairs.

Deformation Measurement of Reservoir Cavern

- DAWSSA will undertake measurement of cavern deformation by use of installed devices.
- DAWSSA will learn how to record measurement results.
- A manual will be issued, describing classification of concrete cracks (structural cracks, non-structural cracks, cracks for water seepage).

4) Confirmation of Effects

Subjects	Effects	Confirmation of Effects
Tunnel Inspection and Repair	Manual will be issued.	To confirm the issue of a manual in Arabic language.
		To confirm the issue of a lesson video in Arabic language.
	Routine inspection system will be established.	To clarify inspection system (members of team, member's obligation)
		To confirm the compilation of the existing data and the list of data.
		To clarify inspection procedure, inspection spot, inspection route, inspection items. To confirm the descriptions of above in Arabic Manual.
		To check inspection sheet and record sheet.
		To confirm how, where and who to keep the apparatus and materials for inspection.
	DAWSSA will learn the use of tools for inspection.	To examine whether to undertake inspection in the limited time of water shut-down.
		To check whether to keep good conditions of tools and apparatus.
		To check whether the required tools and apparatus for inspection are available.
	DAWSSA will be able to undertake simple repair.	To examine whether to undertake repairing in the limited time of water shut-down.
		To check the record sheet after the repairing.
		To check whether the required tools for repairing are available.

Subjects	Effects	Confirmation of Effects
Deformation Measurement of Reservoir Cavern	DAWSSA will undertake measurement of cavern deformation by use of installed devices.	To clarify measurement procedure, measurement spot, measurement route, measurement items. To confirm the descriptions of above in Arabic Manual.
		To examine whether to undertake measurement in the limited time of water shut-down.
		To confirm how, where and who will keep the apparatus and materials for measurement.
	DAWSSA will undertake measurement of cavern deformation by use of installed devices.	To check the record sheet for measurement.
		To check the measurement at the designated intervals.
		To check whether to keep the record sheet in order.
	Manual will be issued, describing classification of concrete cracks (structural cracks, non-structural cracks, cracks for water seepage).	To check the record of judgment. To check whether other staff examines it.
		To check re-measurement when the result exceeds pre-alarm setting.

5) Activities (Inputs)

Tunnel Inspection and Repair

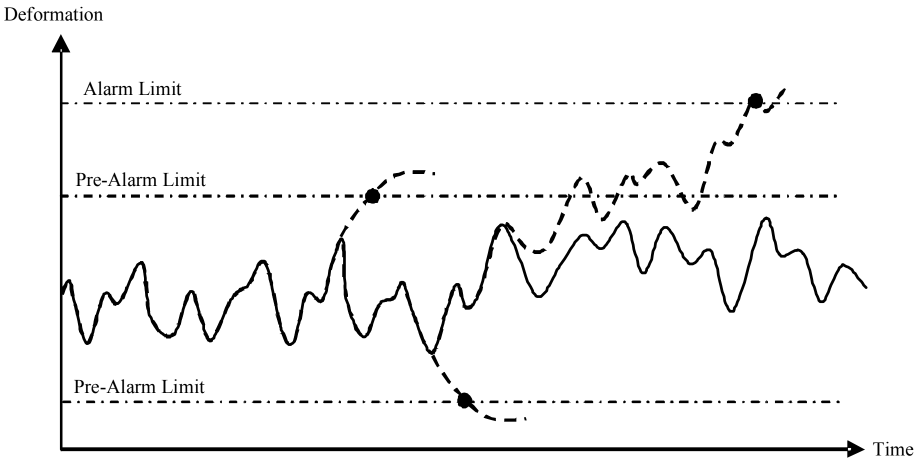
The Consultant will prepare a Manual discussing inspection items and inspection method, and provide lectures on the Manual. The Consultant will also provide on-the-job-training on site to DAWSSA staff. The DAWSSA staff will complete inspection records under the guidance of the Consultant. DAWSSA shall translate the Manual prepared by the Consultant, and produce it in Arabic language. DAWSSA also shall produce a lecture video in Arabic language so that the technology can be transferred to new staff and future generations.

The Consultant will also prepare a Manual discussing simple repairs, including repair materials and methods. When rehabilitation works commence, the consultant will provide on-the-job-training. DAWSSA will create a Manual and lecture video in the Arabic language.

Deformation Measurement of Reservoir Cavern

Measurement of deformation of the inner dimension in the cavern, measurement of development of crack width and measurement of strain of reinforcement bar are the minimum requirements for assessment of cavern stability. Laser distance meters will measure the movement of inner dimensions, and strain gauges will measure the movement of crack width and strain of reinforcement bar. More devices in the caverns is preferable. However, the measurement devices will be installed in a half section of Cavern No.3 or No.4 to minimize the costs of these devices. The section for device installation will be studied during detailed design. The Consultant will incorporate the measurement results into a three-dimensional structural model, which will indicate cavern stability according to development of deformation. The Consultant will produce a Manual discussing the results of structural analysis and establishing guidelines for countermeasures when deformation develops.

The Manual will provide pre-alarm and alarm limits. The image of chronological records of movement is shown below. DAWSSA will continue the measurement for several years, plotting the results in the chart.



Pre-Alarm Limit

Pre-Alarm Limit is the first warning level when devices will be re-checked, calibrated, and overall visual inspection of cavern will be undertaken. If it is not measurement error, additional measurement and monitoring will be made.

Alarm Limit

This limit indicates the warning of non-stability of cavern according to structural analysis. Additional investigation will be undertaken. Remedy works will be implemented if required.

6) Procurement

The Japanese Consultant will provide training and lectures to DAWSSA staff. The following devices, tools, apparatus and material will be procured during the Project:

Tunnel Inspection and Repair

Item	Description	Equipment and Material	Quantity	Specification
Crack Scale	To measure concrete crack width.	Loupe Type	3 sets	Magnification:20 power Minimum reading:0.05mm
		Gauge type	One set	Measurement extent:5mm(±2.5mm) Accuracy:1/1000mm Reach length:50,100mm
Concrete Test Hammer	To assume concrete compressive strength by measurement of rebound of a steel bar hitting the concrete surface.	Equipment box	One set	Range:150～600kgf/cm^2
Convergence Tape	To measure distance between designated points, aiming to measure inner dimensions of the old tunnel at Wali.	Equipment box	One set	Range:0.5～15m Minimum reading:0.1mm
		Point anchor	50 pieces	Ball point with cap.
Water depth	To measure water depth for tunnel discharge measurement.	Sensor and Equipment box	2 sets	Range:0～20m Precise:1mm (20mdepth) Accuracy:±0.1％Measurement Intervals: Option Cable length: 30m
Current Meter	To measure water velocity for tunnel discharge measurement.	Sensor and Equipment box	2 sets	Direction: One way Range:0.001～3.000m/sec Precise:0.002m/sec Accuracy: 2%±0.005m/sec of measurement Time intervals: Option Cable length:10m
Water Proof Coating	The Project will repair cracks more than 0.2 mm width. DAWSSA will repair the cracks after the Project. The quantity is estimated assuming repair of the old tunnel at Wali.	Polymer cement mortar	650 kg	Water proof: more than one atmosphere Elongation: More than 30% (in water) Tensile strength (28 days): More than :0.9N/mm^2 Bond strength (28 days): More than:1.1N/mm^2 Time to use: Less than 1 hour Non-liquation material

Deformation Measurement of Reservoir Cavern

Item	Description	Equipment and Material	Quantity	Specification
Displacement Measurement Devices for Cavern	To measure the distances between the points where laser reflectors are installed in the cavern. To obtain chronological deformation of the caverns.	Laser Distance Meter	One set	Angle accuracy:1” Distance accuracy: More than ±(2+2ppm×Distance) mm
		Laser Reflectors	40 pieces	Water proof prism
Strain Measurement of Concrete and Reinforcement Bars	To stick strain gauges on concrete crossing the cracks. To expose reinforcement bars and stick strain gauges on the bars after stress release. To measure strain of concrete and reinforcement bars connecting the lead wires to reading equipment.	Reading Equipment	One set	Range: (Range×1)0～±19900×10^{-6} (Range×10)0～±19900×10×10^{-6} Accuracy: (Range×1)1×10^{-6}strain (Range×10)10×10^{-6}strain Precise: (Range×1) ±(0.05% Measurement ＋1digit) (Range×10)±(0.05％Measurement ＋10digit)
		Strain Gauge	66 pieces	Capacity:10mm Accuracy:0.0025mm Precise:0.15mm

7) Program for Technical Assistance

The Implementation Program and inputs of the Consultants are shown below.

	In Charge	Months																MM	Remarks
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
Tunnel Rehabilitation																			
Old Tunnel	Contractor	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬						
New Tunnel	Contractor					▬	▬												
Technology Transfer - Tunnel Inspection and Repair																			
Handover Procured Equipment	Contractor		▲																
Preparation of Manual	Consultant		▬	▬															Tunnel Maintenance Eng.
Lecture on Manual	Consultant			▬	▬														Tunnel Maintenance Eng.
Manual and Video in Arabic	DAWSSA				▬	▬	▬	▬	▬	▬									
OJT for Inspection and Repa	Consultant									▬	▬								Tunnel Maintenance Eng.
Submission of Manual	Consultant			▲															Tunnel Maintenance Eng.
Submission of Completion Repo	Consultant																▲		Tunnel Maintenance Eng.
Technology Transfer - Deformation Measurement of Reservoir Cavern																			
Handover Procured Equipme	Contractor		▲																
Installation of Equipment	Consultant/DAWSSA		▬	▬															Tunnel Struture Eng. & Instal. Expert
Guidance of Measurement	Consultant			▬															
Measurement anr Recording	DAWSSA			▬		▬		▬		▬		▬		▬		▬			
Structure Modeling	Consultant				▭	▭													Tunnel Struture Eng.
Analysis/ Discussion	Consultant														▬	▬			Tunnel Struture Eng.
Submission of Manual	Consultant															▭	▲		Tunnel Struture Eng.
Submission of Completion Repo	Consultant																▲		Tunnel Struture Eng.
Technology Transfer - Inputs of Consultant																			
Tunnel Maintenance Eng.			▬	▬	▬					▬	▬							3.0	
Tunnel Struture Eng.			▬	▬	▭	▭									▬	▬	▭	4.5	
Equipment Installation Expert			▬	▬														1.0	
Total																		8.5	

8) Reports

The Consultant will submit the following reports.

Reports (Submission: Months after commencement of works)	DAWSSA	JICA
·Manual for Tunnel Inspection and Repair (3 months)	20 copies	5 copies
·Manual for Reservoir Stability (16 months)	20 copies	5 copies
·Completion Report for Technical Assistance (16 months)	20 copies	5 copies

9) Obligations of DAWSSA

DAWSSA shall undertake tunnel inspection periodically and record the inspection results in compliance with the Manual. DAWSSA shall implement minor repairing when identifying concrete damage. When working staff for tunnel maintenance are transferred, lectures using videos shall be provided to the new staff.

DAWSSA shall undertake deformation measurement in the Wali reservoir for 4 - 5 years in compliance with the Manual. The measurement results shall be recorded in the sheets attached to the Manual.

2.2.5 Implementation Schedule

The tunnels are in service for water supply. Meanwhile, the tunnel works require water shut-down in the tunnel. Studies on the duration of water shut-down in the tunnel in a day are possible for the tunnel works without disturbing the water supply service by scrutinizing actual water supply and consumption. A daily water balance is studied in Section 1.2.3

The rehabilitation works in the new tunnel shall be implemented during March to May, when water springs are abundant and the tunnel can transmit water to the maximum extent. In this period, the spring discharge at Figeh is higher than demands, with excess discharge being spilled to the Barada River.

The reservoir and tank facilities are listed in Table 2.4. There are four main reservoirs with a total volume of 145,344 m^3 in Damascus City as listed below:

i) New Wali reservoir (61,400 m^3)   ii) West reservoir (42,704 m^3)

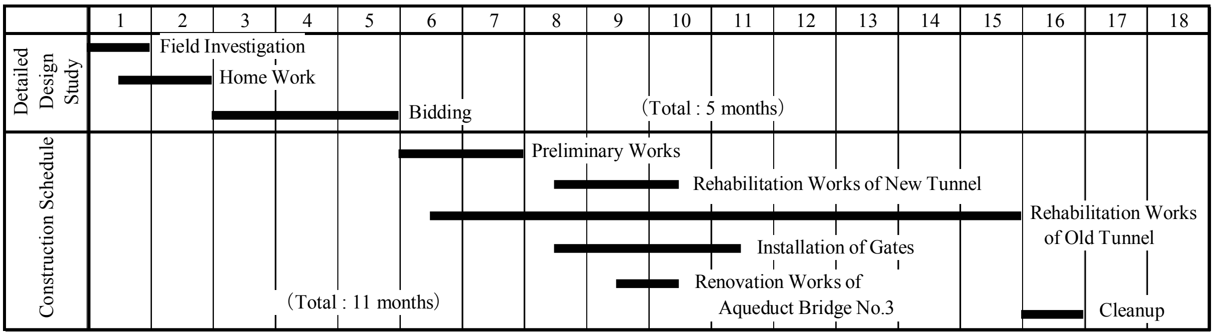
iii) East reservoir (28,240 m^3)   iv) Mezze Wround reservoir (13,000 m^3)

The new tunnel with the design capacity of 11.5 m^3/s has sufficient capacity to fill the reservoirs fully while performing water supply service. The water supply volumes were 18,580 m^3/day (= 5.16 m^3/s) in March 2003, 19,170 m^3/day (= 5.33 m^3/s) in April 2003 and 20,420 m^3/day (= 5.67 m^3/s) in May 2003. Since water was supplied continuously without interruption in these periods, the discharge equals demand. Full storage of the main reservoir can supply water for 7.1 hours (= 145,344/5.67/3,600 sec). There are also other reservoirs as listed in Table 2-4. The full capacity of some, including the main reservoirs, can supply water for more than 8 hours. Water traveling time from Figeh to Wali is about two hours. Therefore, water transfer through the new tunnel could be stopped for six hours without disturbing the water supply service. The minimum water consumption discharge between 0:00 and 6:00 is recorded, apart from 10 and 12 January 2003, as shown in Table 1-3-3. Through the discussions above, the rehabilitation works in the new tunnel shall be implemented from 00:00 to 06:00 during March to May on the condition that the main reservoirs and others shall be full with water until 00:00.

The old tunnel can receive water at Aqueduct No.3 through the installed pipe (800 mm diameter) in the Al Ayon access tunnel of the new tunnel. The water pump shall be operational until the commencement of the implementation. If sand bags can prevent backwater upstream of the old tunnel, the rehabilitation works upstream of the old tunnel can be undertaken for 24 hours. Main water consumption downstream of Aqueduct No.3 is water supply to Dummer area, and is abstracted from the bottom of the siphon pipe. If sand bags can prevent water flow downstream of the siphon pipe, the rehabilitation works downstream of the old tunnel can be undertaken for a long period. However, the tunnel work program is established on a basis of an 8-hour daily working period.

2.2.5.1 Implementation Schedule

The overall work program is summarized in the figure below.



2.3 Obligations of Recipient Country

The obligations of the Government of Syria and DAWSSA for the implementation of the Project are described below:

1) To provide necessary data and information;
2) To obtain permissions, licences, and other authorizations, if necessary;
3) To secure sufficient land (approximately 500 m^2) for a temporary stock yard in DAWSSA Figeh and Wali Office;
4) To provide facilities for distribution of electricity and other incidental facilities necessary for construction work in and around the site;
5) To stop water flow in the tunnels in accordance with the construction schedule;

6) To ensure prompt unloading and customs clearance of the construction materials and equipment purchased or bought under Japan's Grant Aid at ports of disembarkation in Syria;

7) To ensure prompt execution of the rehabilitation work;

8) To accord Japanese nationals whose services may be required in connection with the supply of the products and services under the verified contracts such facilities as may be necessary for their entry into Syria and stay therein for the performance of their work;

9) To bear commissions, namely advising commissions of an Authorization to Pay (A/P) and payment commissions, to the Japanese foreign exchange bank for the banking services based upon the Banking Arrangement (B/A);

10) To exempt Japanese nationals from customs duties, internal taxes and fiscal levies which may be imposed in Syria with respect to the supply of the products and services under the verified contracts;

11) To bear all the expenses, other than those covered by Japan's Grant Aid, necessary for the Project;

12) To allocate counterpart personnel and necessary budget;

13) To increase the visibility of the Project;

14) To accord the relevant stakeholders and concerned authorities in collaboration with the Consultant and the Contractor;

15) To install measurement devices in the new Wali Reservoir in collaboration with the Consultant;

16) To allow the Consultant and the Contractor to use the two battery cars in the new tunnel, when required;

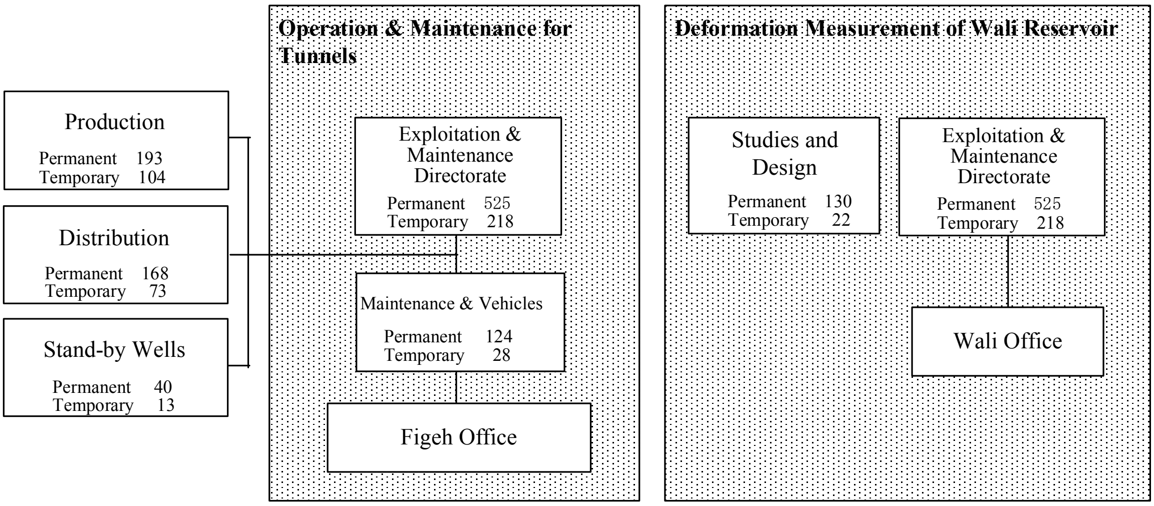
17) To provide office space for the Consultant members assigned for technical assistance.

2.4 Project Operation Plan

The Project will be implemented under the supervision of the Department of Studies and Design in collaboration with the Department of Construction & Supervision of DAWSSA. After Project completion, the Department of Maintenance & Vehicles will be responsible for the maintenance of the tunnels. The Figeh Office will be responsible for the operation of the tunnels.

The Wali office will maintain the apparatus for the deformation measurement in the Wali Reservoir. The Department of Studies & Design is responsible for the intermittent measurement, recording the results of measurement and safety evaluation in accordance with the manual prepared by the Consultant. The reservoir shall be drained at the time of measurement under the operation of Production Department and Wali Office.

The following figure shows the relevant organization for the works.



2.5 Project Approximate Costs

2.5.1 Project Costs by Japanese Side

The Project Costs under the Japanese Grand Aid Scheme are approximately estimated in the table below. This cost estimate is provisional and would be further examined by the Government of Japan for the approval of the Grant.

<u>Total Estimated Cost</u> <u>395 million Yen</u>

Rehabilitation Works in Tunnels Total Length 30.6km

Item			Estimated Costs (million Yen)	
Civil Works	Rehabilitation of Tunnels	FRP lining, Rock bolts, Concrete crack repair, Concrete repair	269	295
	Installation of Gates	Stainless gates	23	
	Rehabilitation of Aqueduct	Carbon textile	3	
Equipment	Crack scale, Concrete test hammer, Water level gauge, Current meter, Water proof coating, Displacement measurement devices for cavern, Strain Measurement		17	
Consulting Services and Soft Component			83	

The approximate estimate above is based on the following conditions.

- Estimate Time: December 2004
- Exchange Rate US$ 1 = Japanese Yen 109.93 = Syrian Pond 52.5

2.5.2 Project Costs by Syria Side

DAWSSA's financial status is shown below:

Revenue

Unit: thousand Syria Pond

	Year 2000	Year 2003	Year 2004
Net Sales			
Water sales income	332,838	448,059	429,573
Shares sales			
Contracting Income			
Share in network cost	8,703	7,130	8,605
Meter setting & connec.	3,387	3,177	4,701
Network maintenance	46,572	62,211	66,164
Tariff (subscription)	3,090	2,867	3,660
Excavation work	5,020	4,266	7,317
Service			
Meter rental & maint.	6,602	9,207	9,768
Annual basic cost	1,732	1,859	1,859
Stocks for Sale			
Connection material	6,252	60,000	60,000
Transferred Income			
Credit interests	228	145	518
Creditor rent	193	189	724
Compensation & Fine	561	129	560
Other income	27,708	26,485	26,373
Total	442,886	625,724	619,822

Expenditure

Unit: thousand Syria Pond

	Year 2000	Year 2003	Year 2004
Salaries	176,295	232,416	271,503
Consumers	60,562	96,327	97,000
Materials and purifications	6,261	10,000	10,000
Fuel & Lubrication oil	49,088	79,827	81,500
Stationary, printing & publication	4,956	6,000	5,000
Others	257	500	500
Service	57,482	68,838	74,838
External maintenance	18,314	26,000	30,000
Contracts	20,989	23,000	24,000
Propaganda, comercial & general relatior	1,675	2,200	2,200
Transportation & mobilization	566	700	700
Rental of equipment, devices & transp.	3,192	6,500	6,500
Electricity and water	481	600	600
Communication	2,615	1,550	1,550
Others	9,650	8,288	9,288
Procurement for selling	29,571	60,000	60,000
Running cost	137,383	149,143	185,264
Depreciation cost	135,466	146,593	182,714
Annual funds	700	700	700
Indirect tax	489	700	700
Other local taxes & dues	494	850	850
Real estate revenue	234	300	300
Specific running cost			3,600
Total	461,293	606,724	692,205

DAWSSA is arranging the budget for 2005 as shown below.

Unit: thousand Syria Ponds

	Status in 2004	Budget in 2005
Revenue	619,822	688,504
Expenditure	692,205	786,842
Profit	-72,383	-98,338
Subsidy	182,714	215,212

The ratios of expense costs for maintenance to total expense costs were 4.0 % in 2000, 4.3 % in 2003, and 4.3 % in 2004.

The additional costs for tunnel maintenance work after the Project is not generally required since DAWSSA has been undertaking tunnel inspection. The additional costs for the deformation measurement in the Wali cavern is relatively small since salary costs only are required for the measurement works and the works are undertaken intermittently, unlike daily routine works. The maintenance works after the Project could be undertaken within the current budget.

Chapter 3 Project Evaluation and Recommendations

3.1 Project Effects

3.1.1 Direct Effects

The flow discharge measurement measured water leakage at a rate of 27 % through the old tunnel. The Project will reduce this rate from 27 % to 5 %. Average water volume transferred through the old tunnel is calculated at 14.60 million m^3/year (= 0.463 m^3/s x 24 hrs x 3,600 sec x 365 days), as referred to in Section 1.3.3. The Project is expected to save some 3.21 million m^3/year of water (=14.60 x 22 %). Annual average volume of water supply is 196.14 million m^3/year, therefore the Project will save some 1.6 % of water presently used.

Water consumption per capita is estimated at 124 l/day/person as outlined in Section 1.2.2. The water to be saved by the Project corresponds to development of new water resources for 71,000 persons (= 3.21 x 10^6/ 0.124/ 365 days).

Other direct effects are listed below:

i) The Project will improve tunnel safety through remedying structural cracks at TD 300 m in the old tunnel and deteriorated concrete at TD 3,170 m in the new tunnel.

ii) The Project will prolong the life of the tunnels through remedying concrete cracks and patching damaged concrete.

iii) The Project will reduce inundation damage through replacement of gates at siphon pipes of the old tunnel, which occurred at the time of the pipe damage.

iv) The Project will introduce technology on tunnel inspection/maintenance and measurement of cavern displacement.

3.1.2 Indirect Effects

The Project will reduce water leakage in the old tunnel, which will increase the income from water charges. This is equivalent to about 16 million Syrian Ponds (= 3.21 x 10^6 x 4.94 SP/m^3). The increased income will strengthen DAWSSA management. The earlier the rehabilitation is implemented, the less the implementation cost will be and the Project will contribute to a reduction of a huge future implementation cost.

3.2 Recommendations

The following recommendations are provided:

a) The tunnels are in service. DAWSSA, the Contractor and the Consultant shall have good communications in daily activities so that Project implementation shall not disturb services.

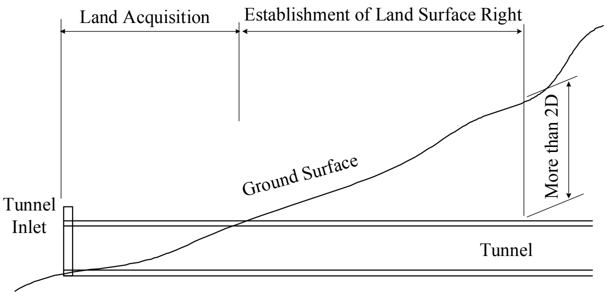
b) There is a steel pipe at TD 977.5 m in the old tunnel, which directs spring water from the ground into the old tunnel. The pipe shall be clogged to prevent this water from entering the tunnel to improve the safety of drinking water.

c) There is a vertical hole (40 cm diameter) from the ground at TD 9,206 m of the old tunnel that residents appear to dig. The hole shall be plugged for the sake of safety of drinking water.

d) Two gates will be provided at the siphon pipes of the old tunnel. Water in the three pipes not in use shall generally be drained. When the 1,400 mm diameter pipe in common use is damaged, the gates shall be opened and water transferred through the three pipes to allow the damaged pipe to be repaired.

e) The new tunnel is aligned in the mountain and has thick cover above the tunnel. The old tunnel is aligned along the Barada River and cover is sometimes minimal. The upstream stretch of the tunnel, up to 3 km from the tunnel inlet, has limited cover where structural cracks have developed, concrete has peeled and tree roots have intruded into the tunnel.

   The following measures are recommended.



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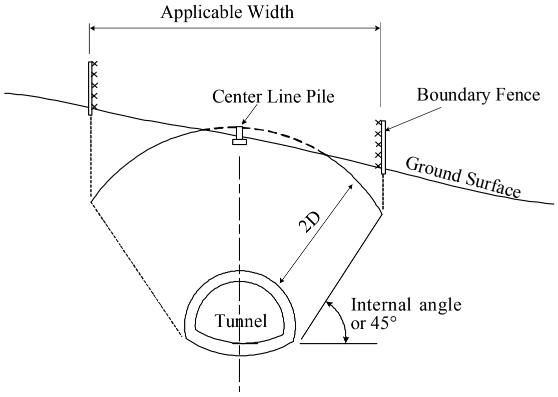


Section

   DAWSSA shall set up a centerline pile along the tunnel where the soil cover is less than 2D (D= tunnel diameter). DAWSSA will also set up boundary fences at a width as shown in the figure to the right. After the government enacts a new institution stipulating "Land Surface Right", which regulates social development above the tunnel, DAWSSA will negotiate compensation with land owners. Before enacting the institution, DAWSSA shall inspect social development above the tunnel. Outer loads on the ground, such as building load, shall not be increased.

f) The old tunnel at Wali area is located under the highway and near new high-storey buildings. Increased traffic loads may impact on the tunnel. Tunnel inspection shall be undertaken regularly and with care.

g) Free lime (non-hydrated lime) comes out at many joints of the lining concrete of the new tunnel. The free lime shall be removed as part of routine maintenance.

h) The Project will provide instruments to monitor the displacement of the cavern. DAWSSA shall continue the measurement for at least four or five years.

Tables and Figures

Table 1-1-1 Water Supply from Water Sources (1999)

1999

	Jan					Feb					Mar					Apr				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
Date	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)
1	3.343	1.453	2.211	605	567	2.907	1.446	2.190	565	532	4.738	1.446	2.142	719	675	6.919	0.000	0.205	615	645
2	3.348	1.453	2.203	605	569	3.098	1.446	2.125	576	528	4.858	1.446	2.022	719	695	7.052	0.000	0.205	627	628
3	3.400	1.406	2.213	606	566	3.403	1.446	2.178	607	567	4.892	1.446	2.130	732	681	7.055	0.000	0.205	627	633
4	3.357	1.453	2.202	606	564	3.492	1.446	2.149	612	577	4.987	1.474	1.291	670	691	7.432	0.000	0.249	664	658
5	3.360	1.453	2.208	607	569	3.474	1.446	2.098	606	576	5.062	1.488	1.913	731	698	7.627	0.000	0.249	680	646
6	3.308	1.453	2.194	601	558	3.604	1.446	2.194	626	578	4.947	1.488	2.212	747	678	7.368	0.000	0.249	658	643
7	3.325	1.453	2.204	603	565	3.605	1.446	2.165	623	587	5.154	1.488	1.584	711	689	7.535	0.000	0.205	669	674
8	3.352	1.453	2.188	604	562	3.478	1.446	2.172	613	572	5.273	1.488	1.384	704	694	7.514	0.000	0.268	672	660
9	3.280	1.453	2.266	605	567	3.442	1.402	2.147	604	571	5.249	1.488	1.447	707	669	7.343	0.000	0.307	661	686
10	3.312	1.453	2.196	601	562	3.306	1.446	2.176	599	570	5.441	1.471	1.927	764	708	7.810	0.000	0.307	701	674
11	3.203	1.453	2.213	593	552	3.663	1.392	2.116	620	608	5.319	1.488	0.583	638	657	7.543	0.000	0.270	675	668
12	3.274	1.453	2.170	596	561	3.641	1.446	2.147	625	543	5.557	1.488	1.362	726	699	7.600	0.000	0.275	680	683
13	3.288	1.453	2.225	602	558	3.558	1.446	2.173	620	589	5.201	1.488	1.180	680	655	7.482	0.000	0.305	673	662
14	3.322	1.453	2.216	604	567	4.174	1.446	2.132	670	627	5.472	1.488	1.080	695	698	7.500	0.000	0.295	673	659
15	3.303	1.453	2.242	605	564	4.315	1.446	2.117	681	642	5.477	1.482	2.066	780	706	7.379	0.000	0.269	661	662
16	3.353	1.409	1.940	579	549	4.336	1.446	2.035	675	687	5.401	1.415	1.252	697	673	7.643	0.000	0.279	685	666
17	3.440	1.409	1.902	583	547	4.250	1.446	2.227	685	599	5.441	1.415	0.889	669	671	7.602	0.000	0.282	681	680
18	3.266	1.409	1.861	565	532	4.302	1.446	2.093	677	643	5.208	1.465	1.595	714	686	7.853	0.000	0.289	703	679
19	3.295	1.409	1.858	567	527	4.143	1.446	2.154	669	639	5.192	1.422	2.176	760	713	7.446	0.000	0.277	667	677
20	3.275	1.330	1.883	561	535	4.336	1.446	2.169	687	636	5.142	1.420	2.189	756	710	7.601	0.000	0.270	680	697
21	3.120	1.382	1.840	548	514	4.713	1.440	2.118	715	672	5.297	1.480	1.654	728	692	9.438	0.000	0.291	841	790
22	3.348	1.382	1.862	569	532	4.604	1.446	2.094	704	686	5.337	1.488	0.565	638	646	9.703	0.000	0.238	859	852
23	3.215	1.379	1.901	561	534	4.436	1.446	2.188	697	647	5.164	1.488	1.201	678	684	7.893	0.000	0.257	704	704
24	3.260	1.379	2.173	589	545	4.188	1.446	2.099	668	633	5.394	1.488	1.796	750	692	7.526	0.000	0.260	673	678
25	3.165	1.379	2.183	581	547	4.021	1.446	2.183	661	625	5.193	1.488	1.833	736	712	7.838	0.000	0.247	699	692
26	3.176	1.409	2.225	588	541	4.197	1.446	2.147	673	621	4.876	1.488	2.295	748	722	7.784	0.000	0.243	694	704
27	3.250	1.443	2.180	594	546	4.311	1.446	2.140	682	653	5.214	1.471	2.234	771	735	7.832	0.000	0.246	698	690
28	3.179	1.437	2.180	587	551	4.355	1.446	2.171	689	642	6.256	0.639	0.490	638	589	7.580	0.000	0.231	675	678
29	3.124	1.437	2.188	583	544						6.697	0.000	0.329	607	603	7.938	0.000	0.233	706	683
30	3.224	1.436	2.157	589	556						7.195	0.000	0.266	645	643	7.759	0.000	0.246	692	701
31	3.324	1.446	2.217	604	557						7.240	0.000	0.266	649	629					
Total				18,292	17,108				18,130	17,050				21,906	21,093				20,593	20,452
Avg	3.284	1.426	2.120	590	552	3.906	1.442	2.146	647	609	5.415	1.301	1.463	707	680	7.687	0.000	0.258	686	682

	May					Jun					Jul					Aug				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
Date	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)
1	7.435	0.000	0.242	663	705	4.051	1.485	1.316	592	557	3.126	1.485	1.719	547	519	2.660	1.458	2.128	540	500
2	7.227	0.309	0.242	672	681	3.910	1.485	1.670	610	587	3.082	1.485	1.710	542	507	2.707	1.464	2.072	539	509
3	7.049	1.208	0.233	734	664	4.094	1.485	1.964	652	608	3.100	1.429	1.669	536	507	2.722	1.411	2.048	534	488
4	6.741	0.966	0.228	686	713	3.794	1.485	1.842	615	587	3.079	1.393	1.694	533	503	2.687	1.411	2.088	534	505
5	6.793	1.046	0.225	697	670	3.907	1.485	1.671	610	575	3.076	1.485	1.702	541	515	2.641	1.411	2.084	530	491
6	6.556	0.663	0.230	644	681	3.792	1.485	1.793	611	586	3.018	1.458	1.613	526	493	2.628	1.457	2.086	533	501
7	6.462	1.394	0.244	700	697	3.807	1.485	2.002	630	592	2.964	1.485	1.671	529	496	2.655	1.485	2.078	537	492
8	6.469	1.485	0.219	706	658	3.760	1.477	2.012	626	594	2.971	1.485	1.631	526	495	2.607	1.485	1.962	523	494
9	5.959	1.485	0.223	662	671	3.701	1.445	2.011	618	581	2.990	1.464	1.680	530	503	2.583	1.479	2.047	528	483
10	5.928	1.485	0.230	660	667	3.648	1.445	2.051	617	583	2.989	1.476	1.694	532	498	2.589	1.362	2.022	516	483
11	5.932	1.485	0.228	660	665	3.560	1.445	2.035	608	575	2.915	1.485	1.836	539	508	2.774	1.243	2.012	521	494
12	5.908	1.485	0.224	658	664	3.594	1.445	2.027	611	569	2.948	1.411	2.139	561	527	2.665	1.411	1.988	524	479
13	6.255	1.473	0.233	688	672	3.547	1.385	2.008	600	567	2.893	1.485	2.202	569	525	2.591	1.411	2.032	521	484
14	6.110	1.412	0.273	673	661	3.515	1.381	1.998	596	569	2.900	1.485	2.308	578	537	2.609	1.390	2.044	522	488
15	5.622	1.412	0.249	629	651	3.515	1.446	1.907	593	555	2.840	1.427	2.200	559	522	2.512	1.458	2.030	518	485
16	5.660	1.458	0.249	636	554	3.436	1.485	1.940	593	554	2.821	1.439	2.120	551	512	2.539	1.476	1.992	519	480
17	5.486	1.481	0.278	626	661	3.435	1.485	1.855	585	544	2.870	1.485	2.262	572	531	2.539	1.485	1.973	518	483
18	5.425	1.439	0.273	617	577	3.398	1.485	1.856	582	550	2.796	1.485	2.264	565	523	2.500	1.485	1.987	516	479
19	4.942	1.478	0.282	579	573	3.426	1.462	1.800	578	554	2.796	1.485	2.200	560	519	2.519	1.476	2.004	518	484
20	4.716	1.480	0.305	562	559	3.407	1.473	1.900	586	552	2.799	1.442	2.204	557	518	2.426	1.343	1.898	490	457
21	4.702	1.485	0.294	560	561	3.298	1.485	1.824	571	544	2.852	1.469	2.221	565	536	2.481	1.255	2.044	499	469
22	4.609	1.485	0.310	553	548	3.285	1.485	1.834	571	527	2.783	1.485	2.136	553	503	2.520	1.160	1.908	483	447
23	4.482	1.485	0.637	571	559	3.257	1.457	1.837	566	531	2.801	1.462	2.202	559	522	2.477	0.463	1.916	420	420
24	4.701	1.485	0.855	608	588	3.309	1.438	1.855	570	535	2.812	1.468	2.204	560	522	2.581	0.826	1.982	466	417
25	4.446	1.485	0.847	586	573	3.125	1.485	1.685	544	508	2.848	1.485	2.087	555	520	2.454	1.348	1.939	496	432
26	4.520	1.485	0.920	598	585	3.160	1.485	1.859	562	534	2.783	1.485	2.189	558	513	2.462	1.378	1.966	502	463
27	4.292	1.485	1.018	587	574	3.150	1.485	1.790	555	515	2.817	1.485	2.185	560	525	2.488	1.268	1.913	490	456
28	4.322	1.485	1.035	591	576	3.145	1.485	1.889	563	535	2.823	1.463	2.054	548	509	2.836	0.736	1.942	476	459
29	4.202	1.485	1.099	586	557	3.153	1.485	1.773	554	523	2.754	1.411	2.138	545	501	2.516	1.281	1.929	495	441
30	4.145	1.485	1.064	578	562	3.137	1.485	1.716	548	512	2.738	1.411	2.136	543	508	2.520	1.247	1.897	489	462
31	4.120	1.470	1.438	607	581						2.671	1.396	2.199	541	500	2.181	1.668	1.993	505	471
Total				19,579	19,308				17,717	16,703				17,040	15,917				15,803	14,696
Avg	5.523	1.321	0.465	632	623	3.511	1.468	1.857	591	557	2.892	1.461	2.009	550	513	2.570	1.330	2.000	510	474

	Sep					Oct					Nov					Dec				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
Date	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)
1	2.765	1.060	1.942	498	459	2.305	1.366	1.716	465	444	2.163	1.516	1.700	465	432	2.168	1.500	1.531	449	424
2	2.468	1.364	1.933	498	459	2.353	1.316	1.794	472	430	2.166	1.384	1.689	453	427	2.216	1.500	1.545	455	438
3	2.380	1.401	1.935	494	464	2.333	1.331	1.771	470	438	2.223	1.352	1.720	457	427	2.171	1.500	1.555	451	416
4	2.357	1.443	1.896	492	456	2.402	1.298	1.760	472	440	2.255	1.352	1.674	456	424	2.206	1.500	1.647	462	431
5	2.365	1.407	1.807	482	453	2.270	1.413	1.777	472	448	2.176	1.384	1.672	452	423	2.218	1.444	1.640	458	431
6	2.401	1.358	1.862	486	444	2.292	1.444	1.777	476	441	2.267	1.384	1.675	460	428	2.188	1.500	1.588	456	430
7	2.482	1.361	1.921	498	471	2.336	1.447	1.771	480	446	2.199	1.384	1.639	451	425	2.171	1.500	1.630	458	425
8	2.494	1.323	1.938	497	459	2.326	1.469	1.731	477	450	2.168	1.384	1.684	452	418	2.208	1.500	1.716	469	439
9	2.409	1.353	1.907	490	458	2.370	1.469	1.755	483	450	2.265	1.384	1.692	461	435	2.196	1.364	1.622	448	424
10	2.702	0.911	1.842	471	455	2.286	1.523	1.769	482	449	2.245	1.333	1.677	454	432	2.292	1.211	1.579	439	434
11	2.427	1.344	1.892	489	435	2.300	1.535	1.753	483	455	2.151	1.354	1.662	446	413	2.338	1.340	1.609	457	415
12	2.510	1.214	1.926	488	455	2.160	1.541	1.763	472	438	2.213	1.381	1.642	452	415	2.140	1.372	1.621	443	405
13	2.529	1.171	1.853	480	448	2.309	1.541	1.749	484	452	2.249	1.437	1.674	463	438	2.190	1.439	1.630	454	430
14	2.493	1.197	1.950	487	448	2.283	1.541	1.770	483	450	2.238	1.466	1.643	462	427	2.146	1.439	1.632	451	415
15	2.437	1.296	1.873	484	453	2.230	1.541	1.696	472	442	2.182	1.516	1.630	460	430	2.215	1.439	1.576	452	422
16	2.463	1.303	1.841	485	447	2.246	1.541	1.772	480	455	2.163	1.516	1.650	460	436	2.199	1.439	1.634	456	436
17	2.354	1.290	1.838	474	448	2.257	1.531	1.774	481	441	2.154	1.516	1.643	459	427	2.172	1.500	1.588	454	430
18	2.433	1.292	1.845	481	446	2.403	1.258	1.722	465	437	2.155	1.516	1.609	456	423	2.279	1.409	1.585	456	427
19	2.395	1.283	1.781	472	436	2.294	1.432	1.724	471	439	2.191	1.516	1.589	458	429	2.102	1.500	1.597	449	400
20	2.315	1.425	1.798	479	446	2.204	1.493	1.693	466	436	2.306	1.466	1.681	471	445	2.202	1.500	1.593	457	429
21	2.338	1.467	1.822	486	455	2.266	1.465	1.742	473	447	2.174	1.516	1.508	449	422	2.204	1.500	1.589	457	434
22	2.171	1.504	1.806	474	445	2.293	1.531	1.725	479	441	2.223	1.516	1.634	464	433	2.190	1.500	1.589	456	426
23	2.342	1.384	1.795	477	448	2.245	1.474	1.727	471	446	2.185	1.516	1.618	459	436	2.178	1.500	1.543	451	429
24	2.337	1.371	1.772	473	435	2.236	1.524	1.722	474	442	2.171	1.516	1.636	460	425	2.175	1.500	1.610	457	431
25	2.396	1.357	1.805	480	449	2.253	1.479	1.663	466	431	2.133	1.442	1.636	450	424	2.225	1.500	1.582	458	433
26	2.327	1.372	1.776	473	439	2.325	1.421	1.724	473	443	2.160	1.516	1.614	457	429	2.204	1.500	1.605	459	425
27	2.481	1.143	1.807	469	444	2.190	1.512	1.731	469	432	2.241	1.516	1.653	467	418	2.130	1.500	1.591	451	419
28	2.381	1.248	1.806	470	433	2.248	1.531	1.705	474	446	2.166	1.516	1.615	458	430	2.126	1.501	1.379	433	418
29	2.295	1.360	1.810	472	439	2.256	1.531	1.686	473	448	2.233	1.516	1.663	468	437	2.110	1.501	1.459	438	410
30	2.374	1.338	1.789	475	441	2.216	1.531	1.700	471	436	2.199	1.516	1.555	455	424	2.150	1.501	1.423	439	412
31						2.240	1.531	1.675	471	442						2.011	1.501	1.623	444	402
Total				14,474	13,468				14,699	13,735				13,739	12,832				14,017	13,140
Avg	2.421	1.311	1.852	482	449	2.281	1.470	1.737	474	443	2.200	1.454	1.646	458	428	2.185	1.465	1.584	452	424

Table 1-1-2 Water Supply from Water Sources (2000)

2000

	Jan					Feb					Mar					Apr				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
	Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total	
Date	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)
1	2.208	1.501	1.546	454	423	2.344	1.501	1.547	466	434	3.112	1.501	1.512	529	513	7.551	0.000	0.161	666	642
2	2.136	1.501	1.556	449	425	2.222	1.501	1.637	463	439	3.219	1.501	1.466	534	493	7.135	0.000	0.161	630	626
3	2.144	1.501	1.564	450	421	2.295	1.340	1.547	448	431	3.141	1.501	1.369	519	497	7.245	0.000	0.161	640	640
4	2.095	1.501	1.547	444	410	2.360	1.470	1.594	469	432	3.250	1.501	1.366	529	502	7.651	0.000	0.161	675	673
5	2.157	1.501	1.471	443	423	2.307	1.501	1.573	465	435	3.265	1.501	1.350	528	509	7.069	0.000	0.161	625	619
6	2.215	1.392	1.566	447	417	2.421	1.501	1.531	471	445	3.328	1.501	1.417	540	510	7.638	0.000	0.161	674	666
7	2.234	1.403	1.579	451	427	2.562	1.469	1.534	481	449	3.295	1.501	1.424	537	509	7.756	0.000	0.161	684	663
8	2.220	1.501	1.565	457	421	2.623	1.501	1.536	489	469	3.865	1.501	1.240	571	622	6.821	0.000	0.161	603	635
9	2.211	1.485	1.567	455	430	2.511	1.501	1.581	483	451	4.069	1.455	1.387	597	506	7.601	0.000	0.161	671	648
10	2.237	1.435	1.513	448	417	2.454	1.487	1.557	475	461	3.910	1.438	1.283	573	572	6.915	0.000	0.161	611	620
11	2.162	1.435	1.620	451	420	2.452	1.493	1.564	476	434	3.761	1.438	1.265	559	513	7.387	0.000	0.161	652	648
12	2.132	1.488	1.595	451	421	2.544	1.501	1.505	479	454	3.837	1.438	1.365	574	556	7.387	0.000	0.161	652	639
13	2.198	1.501	1.603	458	430	2.556	1.501	1.572	486	451	4.343	1.438	1.221	605	568	7.319	0.000	0.161	646	647
14	2.184	1.501	1.551	452	430	2.682	1.501	1.517	492	469	4.605	1.438	1.146	621	603	7.359	0.000	0.161	650	664
15	2.272	1.501	1.553	460	431	2.708	1.501	1.522	495	472	5.046	1.438	0.947	642	651	7.309	0.000	0.161	645	644
16	2.295	1.501	1.663	472	436	2.729	1.501	1.532	498	467	6.799	1.438	0.892	789	776	7.615	0.000	0.161	672	653
17	2.198	1.493	1.517	450	425	2.751	1.501	1.561	502	474	6.779	0.000	0.537	632	602	7.433	0.000	0.161	656	645
18	2.245	1.501	1.588	461	432	2.774	1.474	1.561	502	474	6.447	0.000	0.255	579	596	6.828	0.000	0.161	604	643
19	2.153	1.450	1.508	442	423	2.715	1.438	1.562	494	472	6.782	0.000	0.254	608	573	7.877	0.000	0.161	694	677
20	2.342	1.425	1.579	462	431	2.674	1.438	1.513	486	452	6.270	0.000	0.257	564	590	7.639	0.000	0.161	674	644
21	2.264	1.435	1.588	457	426	2.969	1.438	1.448	506	478	6.761	0.000	0.257	606	617	7.340	0.000	0.161	648	651
22	2.276	1.387	1.598	455	431	3.096	1.438	1.429	515	501	7.290	0.000	0.254	652	614	7.482	0.000	0.161	660	660
23	2.301	1.482	1.680	472	434	3.342	1.438	1.474	540	502	6.969	0.000	0.185	618	614	7.206	0.000	0.161	636	622
24	2.060	1.501	1.583	444	415	3.349	1.438	1.452	539	515	6.526	0.000	0.227	584	604	7.100	0.000	0.161	627	632
25	2.313	1.501	1.545	463	441	3.426	1.438	1.533	553	540	7.207	0.000	0.260	645	646	7.080	0.000	0.161	626	630
26	2.312	1.501	1.574	465	435	3.212	1.438	1.506	532	503	7.333	0.000	0.257	656	623	7.470	0.000	0.161	659	654
27	2.357	1.501	1.594	471	440	3.080	1.488	1.445	519	492	6.846	0.000	0.245	613	623	7.537	0.000	0.161	665	659
28	2.433	1.495	1.560	474	444	3.165	1.501	1.495	532	496	7.118	0.000	0.190	631	636	7.602	0.000	0.161	671	669
29	2.337	1.501	1.597	470	447	3.268	1.501	1.491	541	516	7.542	0.000	0.161	665	637	7.849	0.000	0.161	692	697
30	2.266	1.427	1.581	456	427						6.939	0.000	0.161	613	617	7.837	0.000	0.161	691	664
31	2.339	1.501	1.634	473	441						7.028	0.000	0.161	621	650					
Total				14,155	13,274				14,398	13,608				18,535	18,142				19,601	19,474
Avg	2.235	1.476	1.574	457	428	2.744	1.474	1.528	496	469	5.377	0.759	0.784	598	585	7.401	0.000	0.161	653	649

	May					Jun					Jul					Aug				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
	Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total	
Date	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)
1	6.755	0.000	0.161	598	618	5.186	1.100	1.665	687	671	3.563	1.100	1.676	548	515	2.988	1.100	1.503	483	456
2	7.581	0.000	0.161	669	663	5.383	1.100	1.783	714	689	3.460	1.100	1.616	534	525	3.019	1.100	1.330	471	448
3	7.387	0.000	0.161	652	652	5.199	1.100	1.882	707	670	3.425	1.100	1.620	531	498	2.963	1.100	1.446	476	448
4	7.480	0.000	0.161	660	651	4.951	1.100	2.102	704	661	3.427	1.100	1.573	527	501	2.940	1.100	1.473	476	453
5	7.698	0.000	0.161	679	689	4.704	1.100	2.101	683	666	3.275	1.100	1.584	515	484	2.933	1.100	1.457	474	448
6	7.756	0.000	0.161	684	656	4.817	1.100	1.989	683	604	3.377	1.100	1.603	525	503	2.944	1.100	1.447	474	457
7	7.115	0.000	0.161	629	644	4.673	1.100	1.759	651	644	3.388	1.100	1.551	522	486	2.892	1.100	1.411	467	436
8	7.602	0.000	0.161	671	664	4.721	1.100	2.015	677	616	3.342	1.100	1.558	518	501	2.879	1.100	1.455	469	433
9	7.677	0.000	0.161	677	656	4.448	1.100	1.858	640	622	3.343	1.100	1.638	525	486	2.996	1.100	1.410	476	454
10	7.355	0.000	0.161	649	658	4.405	1.100	1.839	634	585	3.358	1.100	1.479	513	494	2.875	1.100	1.538	476	451
11	7.388	0.000	0.161	652	649	4.310	1.100	1.817	624	613	3.333	1.100	1.610	522	494	2.783	1.100	1.511	466	443
12	7.390	0.000	0.161	652	664	4.406	1.100	1.851	636	570	3.198	1.100	1.508	502	469	2.759	1.100	1.516	464	437
13	7.480	0.000	0.161	660	659	4.310	1.100	1.757	619	580	3.344	1.100	1.671	528	499	2.836	1.100	1.477	468	437
14	7.600	0.000	0.161	670	668	4.259	1.100	1.802	619	584	3.197	1.100	1.529	503	476	2.726	1.100	1.565	466	438
15	7.460	0.000	0.161	658	672	4.238	1.100	1.763	613	602	3.265	1.100	1.581	514	482	2.780	1.100	1.451	461	434
16	7.364	0.000	0.161	650	673	3.976	1.100	1.717	587	538	3.270	1.100	1.646	520	489	2.887	1.100	1.467	471	436
17	7.204	0.622	0.161	690	665	3.893	1.100	1.760	583	557	3.321	1.100	1.549	516	491	2.839	1.100	1.444	465	446
18	7.283	0.608	0.161	696	664	3.793	1.100	1.736	573	536	3.141	1.100	1.555	501	473	2.742	1.100	1.443	457	430
19	6.893	0.608	0.161	662	664	3.821	1.100	1.513	556	530	3.043	1.100	1.344	474	452	2.835	1.100	1.492	469	444
20	6.722	0.608	0.161	647	648	3.824	1.100	1.638	567	527	3.019	1.100	1.538	489	458	2.760	1.100	1.406	455	428
21	6.573	0.675	0.161	640	651	3.770	1.100	1.534	553	528	3.012	1.100	1.440	480	450	2.720	1.100	1.413	452	434
22	6.393	0.810	0.161	636	643	3.717	1.100	1.621	556	524	2.959	1.100	1.532	483	458	2.724	1.100	1.402	452	422
23	6.124	1.159	0.161	643	651	3.637	1.100	1.465	536	518	2.972	1.100	1.521	483	460	2.783	1.100	1.366	453	448
24	5.812	1.599	0.161	654	637	3.631	1.100	1.590	546	512	3.114	1.100	1.590	501	475	2.856	1.100	1.414	464	430
25	5.597	1.567	0.161	633	632	3.572	1.100	1.658	547	519	3.106	1.100	1.739	514	483	2.884	1.100	1.398	465	449
26	5.534	1.542	0.161	625	635	3.532	1.100	1.675	545	510	3.067	1.100	1.452	485	471	2.704	1.100	1.384	448	420
27	5.393	1.579	0.161	616	623	3.673	1.100	1.777	566	537	3.081	1.100	1.483	489	456	2.737	1.100	1.398	452	422
28	5.593	1.469	0.161	624	629	3.635	1.100	1.598	547	515	3.033	1.100	1.515	488	465	2.838	1.100	1.315	454	433
29	5.784	1.100	0.900	673	633	3.604	1.100	1.629	547	520	3.042	1.100	1.510	488	461	2.809	1.100	1.423	461	430
30	5.518	1.100	1.325	686	651	3.523	1.100	1.592	537	497	3.039	1.100	1.593	495	459	2.786	1.100	1.327	450	431
31	5.229	1.100	1.620	687	650						2.962	1.100	1.491	480	453	2.661	1.100	1.357	442	416
Total				20,324	20,212				18,237	17,245				15,712	14,867				14,377	13,592
Avg	6.798	0.521	0.269	656	652	4.187	1.100	1.750	608	575	3.209	1.100	1.558	507	480	2.835	1.100	1.433	464	438

	Sep					Oct					Nov					Dec				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
	Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total	
Date	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)
1	2.674	1.100	1.403	447	424	2.572	1.100	1.356	434	406	2.685	1.100	1.236	434	417	2.556	1.100	1.181	418	402
2	2.672	1.100	1.300	438	416	2.586	1.100	1.309	431	410	2.644	1.100	1.237	430	403	2.592	1.100	1.229	425	396
3	2.807	1.100	1.378	457	427	2.491	1.100	1.298	422	398	2.667	1.100	1.281	436	420	2.620	1.100	1.256	430	404
4	2.771	1.100	1.246	442	422	2.554	1.100	1.288	427	407	2.690	1.100	1.297	440	412	2.561	1.100	1.257	425	402
5	2.667	1.100	1.346	442	415	2.739	1.100	1.300	444	420	2.688	1.100	1.264	436	419	2.630	1.100	1.218	427	405
6	2.549	1.100	1.333	430	410	2.557	1.100	1.251	424	394	2.642	1.100	1.226	429	404	2.580	1.100	1.201	422	413
7	2.639	1.100	1.301	435	417	2.726	1.100	1.252	439	423	2.657	1.100	1.248	432	412	2.538	1.100	1.255	423	391
8	2.716	1.100	1.310	443	424	2.637	1.100	1.253	431	406	2.297	1.100	1.223	399	386	2.661	1.100	1.247	433	415
9	2.723	1.100	1.373	449	421	2.645	1.100	1.308	437	410	2.810	1.100	1.254	446	417	2.655	1.100	1.295	436	416
10	2.706	1.100	1.362	446	411	2.608	1.100	1.281	431	410	2.746	1.100	1.240	439	412	2.657	1.100	1.244	432	400
11	2.682	1.100	1.343	443	422	2.531	1.100	1.235	420	393	2.702	1.100	1.229	435	427	2.640	1.100	1.226	429	409
12	2.539	1.100	1.307	427	406	2.683	1.100	1.244	434	411	2.620	1.100	1.194	425	397	2.613	1.100	1.247	428	401
13	2.651	1.100	1.316	438	415	2.660	1.100	1.251	433	410	2.676	1.100	1.264	435	414	2.684	1.100	1.294	439	422
14	2.735	1.100	1.313	445	414	2.605	1.100	1.222	426	406	2.734	1.100	1.203	435	406	2.579	1.100	1.234	424	390
15	2.717	1.100	1.298	442	423	2.669	1.100	1.317	439	411	2.601	1.100	1.186	422	402	2.530	1.100	1.228	420	416
16	2.514	1.100	1.269	422	418	2.715	1.100	1.288	441	421	2.702	1.100	1.253	437	409	2.557	1.100	1.185	418	392
17	2.738	1.100	1.301	444	401	2.722	1.100	1.239	437	414	2.618	1.100	1.223	427	402	2.438	1.100	1.270	415	396
18	2.570	1.100	1.150	416	401	2.579	1.100	1.241	425	404	2.621	1.100	1.219	427	417	2.557	1.100	1.257	425	394
19	2.733	1.100	1.336	447	417	2.723	1.100	1.266	440	416	2.661	1.100	1.228	431	400	2.546	1.100	1.244	422	404
20	2.764	1.100	1.328	449	425	2.604	1.100	1.244	428	409	2.634	1.100	1.256	431	416	2.656	1.100	1.240	432	405
21	2.674	1.100	1.308	439	415	2.738	1.100	1.225	437	413	2.618	1.100	1.170	422	396	2.636	1.100	1.198	426	403
22	2.704	1.100	1.299	441	416	2.649	1.100	1.259	433	412	2.553	1.100	1.208	420	400	2.658	1.100	1.238	432	410
23	2.758	1.100	1.299	446	426	2.587	1.100	1.223	424	403	2.606	1.100	1.241	427	408	2.629	1.100	1.244	430	411
24	2.768	1.100	1.306	447	419	2.710	1.100	1.255	438	412	2.673	1.100	1.104	421	397	2.623	1.100	1.221	427	401
25	2.576	1.100	1.247	425	400	2.639	1.100	1.262	432	411	2.635	1.100	1.253	431	419	2.597	1.100	1.252	427	415
26	2.424	1.100	1.267	414	398	2.500	1.100	1.276	421	399	2.576	1.100	1.101	413	386	2.823	1.100	1.278	449	417
27	2.700	1.100	1.300	441	412	2.697	1.100	1.262	437	410	2.617	1.100	1.236	428	405	2.857	1.100	1.199	445	424
28	2.564	1.100	1.277	427	411	2.664	1.100	1.313	439	418	2.607	1.100	1.232	427	404	2.816	1.100	1.252	446	426
29	2.501	1.100	1.265	420	394	2.643	1.100	1.274	433	409	2.689	1.100	1.213	432	409	2.676	1.100	1.234	433	405
30	2.451	1.100	1.277	417	396	2.596	1.100	1.273	429	410	2.700	1.100	1.219	434	414	2.688	1.100	1.252	435	416
31						2.780	1.100	1.270	445	417						2.630	1.100	1.254	431	411
Total				13,118	12,416				13,412	12,693				12,882	12,230				13,305	12,612
Avg	2.656	1.100	1.305	437	414	2.639	1.100	1.269	433	409	2.646	1.100	1.225	429	408	2.628	1.100	1.240	429	407

Table 1-1-3 Water Supply from Water Sources (2001)

2001

Date	Jan					Feb					Mar					Apr				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
	Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total	
Date	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)
1	2.816	1.100	1.298	450	425	2.731	1.100	1.249	439	425	4.272	1.100	1.118	561	535	7.451	0.000	0.000	644	648
2	2.901	1.100	1.188	448	430	2.869	1.100	1.217	448	416	4.906	1.100	1.237	626	593	7.322	0.000	0.000	633	641
3	2.930	1.100	1.221	454	428	2.947	1.100	1.281	460	437	5.320	1.100	0.639	610	594	7.414	0.000	0.000	641	654
4	2.876	1.100	1.220	449	430	2.945	1.100	1.274	460	435	5.708	1.100	0.617	641	695	7.222	0.000	0.000	624	626
5	2.834	1.100	1.214	445	413	2.968	1.100	1.189	454	433	7.128	1.100	0.127	722	677	7.466	0.000	0.000	645	645
6	2.686	1.100	1.268	437	424	2.943	1.100	1.285	460	436	9.892	0.000	0.000	855	863	7.152	0.000	0.000	618	631
7	2.977	1.100	1.223	458	432	3.023	1.100	1.319	470	446	6.509	0.000	0.000	562	579	7.613	0.000	0.000	658	643
8	2.966	1.100	1.170	452	429	2.965	1.100	1.231	458	435	7.023	0.000	0.000	607	607	7.122	0.000	0.000	615	617
9	2.966	1.100	1.185	454	436	2.999	1.100	1.229	460	438	6.598	0.000	0.000	570	584	7.316	0.000	0.000	632	630
10	2.936	1.100	1.198	452	431	3.026	1.100	1.248	464	443	6.925	0.000	0.000	598	612	7.120	0.000	0.000	615	625
11	2.916	1.100	1.271	457	431	3.141	1.100	1.269	476	453	7.159	0.000	0.000	619	639	7.447	0.000	0.000	643	629
12	3.059	1.100	1.200	463	438	3.237	1.100	1.286	486	462	7.393	0.000	0.000	639	650	7.386	0.000	0.000	638	647
13	3.106	1.100	1.287	475	461	3.221	1.100	1.208	478	458	7.752	0.000	0.000	670	675	7.327	0.000	0.000	633	631
14	3.125	1.100	1.215	470	444	3.402	1.100	1.198	492	469	7.209	0.000	0.000	623	624	7.391	0.000	0.000	639	647
15	3.080	1.100	1.136	459	437	3.589	1.100	1.146	504	486	6.962	0.000	0.000	601	617	5.688	0.000	0.000	491	563
16	3.113	1.100	1.231	470	447	3.732	1.100	1.285	528	505	7.201	0.000	0.000	622	636	7.427	0.000	0.000	642	630
17	3.062	1.100	1.111	456	438	3.875	1.100	1.280	540	518	7.172	0.000	0.000	620	633	7.793	0.000	0.000	673	601
18	3.068	1.100	1.185	462	439	3.820	1.100	1.245	533	510	7.577	0.000	0.000	655	666	7.492	0.000	0.000	647	653
19	3.053	1.100	1.235	465	446	3.822	1.100	1.344	541	530	7.402	0.000	0.000	640	646	6.369	0.000	0.000	550	602
20	3.049	1.100	1.235	465	456	3.902	1.100	1.277	542	521	7.451	0.000	0.000	644	660	8.044	0.000	0.000	695	644
21	2.982	1.100	1.242	460	424	3.813	1.100	1.197	528	508	7.520	0.000	0.000	650	660	7.951	0.000	0.000	687	679
22	2.889	1.100	1.239	452	441	4.137	1.100	1.244	560	538	8.468	0.000	0.000	732	732	7.632	0.000	0.000	659	659
23	2.928	1.100	1.215	453	423	4.053	1.100	1.253	553	522	7.330	0.000	0.000	633	650	7.386	0.000	0.000	638	652
24	2.935	1.100	1.196	452	441	3.792	1.100	1.234	529	542	7.713	0.000	0.000	666	677	7.264	0.000	0.000	628	633
25	2.868	1.100	1.275	453	420	3.761	1.100	1.190	523	476	7.224	0.000	0.000	624	638	7.339	0.000	0.000	634	618
26	2.809	1.100	1.171	439	428	3.735	1.100	1.281	528	525	7.148	0.000	0.000	618	628	7.112	0.000	0.000	615	615
27	2.847	1.100	1.250	449	422	3.842	1.100	1.186	529	492	7.062	0.000	0.000	610	627	6.881	0.000	0.000	594	608
28	2.791	1.100	1.232	443	412	3.976	1.100	1.215	544	516	7.379	0.000	0.000	638	644	6.656	0.000	0.000	575	607
29	2.707	1.100	1.211	433	410						7.345	0.000	0.000	635	656	6.539	0.000	0.000	565	540
30	2.706	1.100	1.251	437	425						7.520	0.000	0.000	650	647	6.341	0.000	0.000	548	529
31	2.664	1.100	1.235	432	397						7.279	0.000	0.000	629	644					
Total				14,043	13,358				13,989	13,375				19,767	19,988				18,720	18,747
Avg	2.924	1.100	1.220	453	431	3.438	1.100	1.245	500	478	7.082	0.177	0.121	638	645	7.222	0.000	0.000	624	625

Date	May					Jun					Jul					Aug				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
	Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total	
Date	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)
1	6.219	0.000	0.000	537	529	3.537	1.100	0.870	476	461	2.782	1.100	1.236	442	425	2.558	1.100	1.043	406	383
2	6.068	0.000	0.000	524	542	3.565	1.100	0.867	478	468	2.911	1.100	1.161	447	427	2.714	1.100	1.137	428	410
3	6.056	0.000	0.000	523	514	3.406	1.100	0.819	460	444	2.868	1.100	1.193	446	422	2.640	1.100	1.067	415	387
4	5.798	0.000	0.000	501	520	3.363	1.100	0.818	456	444	3.000	0.724	1.189	425	394	2.660	1.100	1.099	420	399
5	5.900	0.000	0.000	510	486	3.318	1.100	0.919	461	446	2.525	1.100	1.222	419	400	2.426	1.100	1.106	400	389
6	5.151	0.970	0.000	529	567	3.330	1.100	0.971	467	444	2.950	1.100	1.180	452	421	2.853	1.100	0.979	426	395
7	5.551	0.991	0.000	565	544	3.279	1.100	0.977	463	444	2.683	1.100	1.184	429	415	2.744	1.100	1.029	421	404
8	5.281	0.893	0.000	533	518	3.215	1.100	0.918	452	435	2.884	1.100	1.189	447	423	2.630	1.100	1.054	413	392
9	5.420	0.000	0.000	468	508	3.189	1.100	0.937	451	442	2.630	1.100	1.238	429	428	2.730	1.100	1.043	421	407
10	5.046	0.000	0.000	436	404	3.232	1.100	0.956	457	434	2.686	1.100	1.196	430	392	2.562	1.100	1.001	403	390
11	5.041	0.000	0.000	436	448	3.095	1.100	0.986	448	438	2.671	1.100	1.147	425	427	2.538	1.100	1.080	408	385
12	4.956	0.000	0.000	428	416	3.114	1.100	0.911	443	427	2.637	1.100	1.193	426	384	2.504	1.100	1.043	401	384
13	4.846	0.000	0.737	482	459	3.162	1.100	0.968	452	440	2.657	1.100	1.151	424	404	2.606	1.100	1.031	409	386
14	4.839	0.000	1.005	505	484	2.865	1.100	0.982	427	405	2.538	1.100	1.157	414	401	2.632	0.956	1.043	400	391
15	4.422	0.000	0.961	465	459	2.812	1.100	1.094	433	417	2.837	1.100	1.186	443	414	2.568	1.100	1.007	404	379
16	4.620	0.000	0.787	467	446	2.598	1.100	1.077	413	414	2.574	1.100	1.154	417	394	2.608	1.100	1.021	409	386
17	4.766	0.000	1.188	514	488	2.814	1.100	1.246	446	396	2.611	0.762	1.155	391	385	2.328	1.100	1.028	385	365
18	4.572	0.000	1.111	491	470	3.796	1.100	1.240	530	502	2.653	1.100	1.149	424	394	2.429	1.100	1.036	394	377
19	4.473	0.000	1.138	485	471	3.425	1.100	1.246	499	479	2.388	1.100	1.155	401	370	2.412	1.100	1.048	394	379
20	4.369	0.000	1.189	480	456	3.424	1.100	1.334	506	490	2.628	0.503	1.119	367	371	2.467	1.100	1.076	401	381
21	4.377	0.000	1.320	492	471	3.434	1.100	1.188	494	473	2.435	1.100	1.147	404	357	2.405	1.100	1.027	392	372
22	4.260	0.000	1.324	482	454	3.240	1.100	1.140	473	474	2.674	1.100	1.086	420	392	2.499	1.100	1.040	401	382
23	4.060	0.718	0.795	481	461	3.086	1.100	1.227	468	439	2.558	1.100	1.157	416	401	2.621	1.100	1.025	410	393
24	4.112	0.755	0.435	458	455	3.056	1.100	1.266	468	449	2.578	1.100	1.205	422	398	2.438	1.100	1.047	396	376
25	4.096	0.926	1.013	521	509	3.075	1.100	1.225	467	418	2.719	1.100	1.140	428	416	2.414	1.100	1.014	391	374
26	4.008	0.926	1.087	520	493	3.023	1.100	1.252	464	465	2.622	1.100	1.076	415	394	2.376	1.100	0.997	386	365
27	3.909	0.926	1.217	523	495	2.963	1.100	1.240	458	427	2.621	1.100	1.109	417	391	2.438	1.100	1.008	393	376
28	3.818	0.926	0.902	488	471	2.744	1.100	1.265	441	423	2.636	1.100	1.104	418	410	2.409	1.100	0.963	386	372
29	3.805	0.926	0.676	467	461	2.909	1.100	1.217	452	429	2.377	1.100	1.164	401	386	2.429	1.100	0.943	386	375
30	3.719	0.926	0.554	449	438	2.895	1.100	1.196	448	422	2.648	1.100	1.019	412	390	2.262	1.100	0.921	370	356
31	3.678	0.926	0.544	445	432						2.599	1.100	1.047	410	391	2.425	1.100	0.990	390	362
Total				15,209	14,869				13,850	13,289				13,061	12,417				12,460	11,872
Avg	4.750	0.349	0.580	491	480	3.165	1.100	1.079	462	443	2.664	1.057	1.155	421	401	2.527	1.095	1.031	402	383

Date	Sep					Oct					Nov					Dec				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
	Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total	
Date	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)
1	2.363	1.100	0.958	382	375	2.156	1.100	0.982	366	346	2.274	1.100	1.002	378	359	2.493	1.100	0.900	388	372
2	2.378	1.100	0.982	385	362	2.181	1.100	0.919	363	337	2.203	1.100	0.918	365	355	2.349	1.100	0.835	370	354
3	2.277	1.100	0.926	372	389	2.116	1.100	0.937	359	365	2.245	1.100	0.923	369	356	2.307	1.100	0.892	371	360
4	2.247	1.100	1.023	378	322	2.234	1.100	0.878	364	331	2.377	1.100	0.952	383	358	2.374	1.100	0.989	386	362
5	2.259	1.100	0.977	375	365	2.148	1.100	0.973	365	354	2.323	1.100	0.979	380	360	2.368	1.100	0.898	377	364
6	2.290	1.100	1.012	380	361	2.175	1.100	0.955	365	342	2.228	1.100	0.928	368	353	2.418	1.100	0.896	381	364
7	2.403	1.100	0.990	388	369	2.144	1.100	0.971	364	350	2.393	1.100	0.956	384	368	2.512	1.100	0.830	384	364
8	2.365	1.100	0.982	384	370	2.188	1.100	0.950	366	347	2.192	1.100	0.955	367	352	2.501	1.100	0.874	387	379
9	2.316	1.100	0.989	381	365	2.157	1.100	0.947	363	349	2.310	1.100	0.914	374	353	2.496	1.100	0.884	387	365
10	2.378	1.100	0.988	386	359	2.120	1.100	0.957	361	348	2.345	1.100	0.920	377	362	2.233	1.100	0.892	365	357
11	2.455	1.100	0.952	389	375	2.117	1.100	0.891	355	337	2.398	1.100	0.922	382	369	2.659	1.100	0.890	402	374
12	2.322	1.100	0.918	375	354	2.281	1.100	0.938	373	342	2.337	1.100	0.920	376	362	2.581	1.100	0.873	393	389
13	2.352	1.100	0.945	380	367	2.094	1.100	0.948	358	356	2.419	1.100	0.917	383	365	2.468	1.100	0.853	382	362
14	2.255	1.100	0.986	375	358	2.190	1.100	0.910	363	334	2.070	1.100	0.920	353	344	2.550	1.100	0.857	389	381
15	2.351	1.100	0.958	381	367	2.176	1.100	0.952	365	354	2.473	1.100	0.944	390	364	2.539	1.100	0.882	391	380
16	2.287	1.100	0.996	379	357	2.222	1.100	0.910	366	339	2.380	1.100	0.883	377	358	2.502	1.100	0.880	387	370
17	2.277	1.100	0.981	376	368	2.224	1.100	0.974	371	357	2.272	1.100	0.869	366	354	2.516	1.100	0.794	381	356
18	2.272	1.100	0.888	368	342	2.160	1.100	0.913	361	341	2.119	1.100	0.815	348	341	2.372	1.100	0.882	376	360
19	2.310	1.100	0.965	378	356	2.266	1.100	0.929	371	351	2.262	1.100	0.923	370	347	2.454	1.100	0.833	379	359
20	2.249	1.100	0.967	373	356	2.133	1.100	0.964	363	350	2.231	1.100	0.896	365	349	2.464	1.100	0.873	383	374
21	2.198	1.100	0.951	367	354	2.292	1.100	0.991	379	359	2.334	1.100	0.869	372	355	2.524	1.100	0.797	382	370
22	2.158	1.100	0.973	365	352	2.273	1.100	0.901	369	354	2.301	1.100	0.890	371	358	2.429	1.100	0.883	381	364
23	2.205	1.100	0.980	370	352	2.273	1.100	0.931	372	354	2.292	1.100	0.839	365	344	2.424	1.100	0.775	371	364
24	2.272	1.100	0.996	377	355	2.097	1.100	0.926	356	342	2.463	1.100	0.901	386	370	2.633	1.100	0.817	393	369
25	2.303	1.100	0.943	375	358	2.259	1.100	0.934	371	350	2.464	1.100	0.880	384	368	2.526	1.100	0.854	387	371
26	2.302	1.100	0.981	379	361	2.279	1.100	0.956	374	360	2.338	1.100	0.887	374	361	2.521	1.100	0.858	387	371
27	2.294	1.100	0.972	377	358	2.216	1.100	0.935	367	354	2.356	1.100	0.886	375	361	2.516	1.100	0.858	386	375
28	2.292	1.100	0.936	374	357	2.121	1.100	0.921	358	340	2.301	1.100	0.879	370	352	2.618	1.100	0.827	393	375
29	2.201	1.100	0.933	366	363	2.121	1.100	0.969	362	342	2.307	1.100	0.866	369	351	3.020	1.100	0.826	427	405
30	2.161	1.100	0.974	366	344	2.231	1.100	0.917	367	352	2.286	1.100	0.871	368	354	3.221	1.100	0.789	442	432
31						2.220	1.100	0.897	364	344						3.011	1.100	0.598	407	395
Total				11,301	10,791				11,320	10,781				11,189	10,703				12,016	11,537
Avg	2.293	1.100	0.967	377	360	2.189	1.100	0.938	365	348	2.310	1.100	0.907	373	357	2.536	1.100	0.851	388	372

Table 1-1-4 Water Supply from Water Sources (2002)

2002

	Jan					Feb					Mar					Apr				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
Date	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)
1	2.869	1.100	0.665	400	395	2.856	1.100	0.595	393	391	7.242	0.000	0.595	677	636	5.755	0.000	0.595	549	515
2	3.158	1.100	0.672	426	413	2.857	1.100	0.595	393	389	7.278	0.000	0.595	680	638	6.166	0.000	0.595	584	556
3	3.140	1.100	0.735	430	414	3.064	1.100	0.595	411	417	7.187	0.000	0.595	672	642	6.044	0.000	0.595	574	512
4	2.868	1.100	0.691	402	400	3.036	1.100	0.595	409	411	7.407	0.000	0.595	691	650	5.816	0.000	0.595	554	528
5	2.882	1.100	0.815	414	395	3.206	1.100	0.595	423	429	7.161	0.000	0.595	670	613	6.349	0.000	0.595	600	546
6	2.639	1.100	0.684	382	368	3.569	1.100	0.595	455	459	7.154	0.000	0.595	670	625	5.991	0.000	0.595	569	578
7	2.671	1.100	0.755	391	376	3.819	1.100	0.595	476	470	7.327	0.000	0.595	684	659	6.645	0.000	0.595	626	526
8	2.463	1.100	0.745	372	365	3.929	0.888	0.595	468	455	7.598	0.000	0.595	708	647	6.169	0.000	0.595	584	541
9	2.722	1.100	0.760	396	380	4.189	0.699	0.595	474	450	7.424	0.000	0.595	693	664	6.081	0.000	0.595	577	537
10	2.704	1.100	0.733	392	374	4.400	0.671	0.595	490	473	7.398	0.000	0.595	691	643	6.252	0.000	0.595	592	565
11	2.705	1.100	0.692	389	371	4.705	0.197	0.595	475	449	7.278	0.000	0.595	680	646	6.422	0.000	0.595	606	543
12	2.715	1.100	0.716	391	385	4.579	0.000	0.595	447	419	7.315	0.000	0.595	683	637	6.548	0.000	0.595	617	566
13	2.606	1.100	0.637	375	369	5.141	0.000	0.595	496	461	7.221	0.000	0.595	675	644	6.243	0.000	0.595	591	566
14	2.691	1.100	0.649	384	365	5.199	0.000	0.595	501	467	7.440	0.000	0.595	694	640	6.562	0.000	0.595	618	598
15	2.637	1.100	0.584	373	358	5.194	0.000	0.595	500	466	7.376	0.000	0.595	689	649	5.922	0.000	0.595	563	597
16	2.618	1.100	0.563	370	363	5.094	0.000	0.595	492	439	7.304	0.000	0.595	682	656	6.034	0.000	0.595	573	527
17	2.549	1.100	0.560	364	358	5.704	0.000	0.595	544	507	7.562	0.000	0.595	705	661	6.123	0.000	0.595	580	554
18	2.564	1.100	0.539	363	353	6.093	0.000	0.595	578	538	7.276	0.000	0.595	680	614	6.296	0.000	0.595	595	535
19	2.536	1.100	0.656	371	351	6.684	0.000	0.595	629	626	7.328	0.000	0.595	685	670	5.928	0.000	0.595	564	532
20	2.547	1.100	0.564	364	360	6.689	0.000	0.595	629	615	7.191	0.000	0.595	673	676	5.984	0.000	0.595	568	533
21	2.664	1.100	0.628	379	362	6.732	0.000	0.595	633	578	8.166	0.000	0.595	757	675	5.730	0.000	0.595	547	523
22	2.581	1.100	0.621	372	364	6.851	0.000	0.595	643	636	6.791	0.000	0.595	638	569	5.993	0.000	0.595	569	504
23	2.516	1.100	0.619	366	358	6.291	0.000	0.595	595	496	7.443	0.000	0.595	695	684	6.035	0.000	0.595	573	526
24	2.627	1.100	0.595	373	372	6.452	0.000	0.595	609	597	7.077	0.000	0.595	663	638	5.819	0.000	0.595	554	519
25	2.728	1.100	0.595	382	387	6.846	0.000	0.595	643	587	8.138	0.000	0.595	755	654	6.024	0.000	0.595	572	528
26	2.662	1.100	0.595	376	371	6.295	0.000	0.595	595	555	6.873	0.000	0.595	645	664	5.996	0.000	0.595	569	539
27	2.643	1.100	0.595	375	383	7.440	0.000	0.595	694	635	7.812	0.000	0.595	726	633	6.076	0.000	0.595	576	543
28	2.761	1.100	0.595	385	382	6.972	0.000	0.595	654	630	7.397	0.000	0.595	691	672	6.260	0.000	0.595	592	537
29	2.687	1.100	0.595	379	379						7.275	0.000	0.595	680	619	6.102	0.000	0.595	579	533
30	2.671	1.100	0.595	377	375						7.302	0.000	0.595	682	654	6.143	0.000	0.595	582	544
31	2.848	1.100	0.595	393	406						7.832	0.000	0.595	728	668					
Total				11,906	11,652				14,749	14,045				21,343	20,040				17,398	16,251
Avg	2.699	1.100	0.647	384	376	5.139	0.363	0.595	527	502	7.373	0.000	0.595	688	646	6.117	0.000	0.595	580	542

	May					Jun					Jul					Aug				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
Date	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)
1	6.063	0.000	0.595	575	541	5.402	0.621	0.595	572	536	3.548	1.100	0.595	453	467	2.682	1.100	0.595	378	417
2	6.343	0.000	0.595	599	566	5.409	0.520	0.595	564	524	2.568	1.100	0.595	368	356	2.563	1.100	0.595	368	413
3	6.463	0.000	0.595	610	550	5.405	0.260	0.595	541	527	3.628	1.100	0.595	460	494	2.489	1.100	0.595	361	423
4	6.477	0.000	0.595	611	579	5.049	0.000	0.595	488	420	3.554	1.100	0.595	453	496	2.587	1.100	0.595	370	412
5	6.463	0.000	0.595	610	567	5.191	0.509	0.595	544	509	3.243	1.100	0.595	427	458	2.929	1.100	0.595	400	444
6	5.823	0.000	0.595	555	545	5.340	0.529	0.595	558	517	3.222	1.100	0.595	425	464	2.778	1.100	0.595	386	430
7	6.492	0.000	0.595	612	570	5.267	0.530	0.595	552	519	3.300	1.100	0.595	432	484	2.708	1.100	0.595	380	426
8	6.586	0.000	0.595	620	562	5.044	0.530	0.595	533	501	3.208	1.100	0.595	424	418	2.618	1.100	0.595	373	420
9	6.614	0.000	0.595	623	572	4.720	0.804	0.595	529	504	2.966	1.100	0.595	403	432	2.689	1.100	0.595	379	429
10	6.240	0.000	0.595	591	571	4.329	1.090	0.595	520	479	3.162	1.100	0.595	420	439	2.899	1.100	0.595	397	429
11	6.674	0.000	0.595	628	593	4.470	1.090	0.595	532	492	3.450	1.100	0.595	444	461	2.751	1.100	0.595	384	439
12	6.718	0.000	0.595	632	575	4.383	1.088	0.595	524	496	3.269	1.100	0.595	429	447	2.827	1.100	0.595	391	433
13	6.443	0.000	0.595	608	573	4.084	1.088	0.595	498	462	3.438	1.100	0.595	443	474	2.747	1.100	0.595	384	422
14	6.863	0.000	0.595	644	579	4.248	0.783	0.595	486	463	3.145	1.100	0.595	418	438	2.676	1.100	0.595	378	416
15	6.106	0.000	0.595	579	564	4.198	0.783	0.595	482	457	2.891	1.100	0.595	396	419	2.815	1.100	0.595	390	428
16	6.538	0.000	0.595	616	565	4.411	0.783	0.595	500	465	3.478	1.100	0.595	447	480	2.560	1.100	0.595	368	410
17	6.019	0.000	0.595	571	552	4.238	1.045	0.595	508	475	3.304	1.100	0.595	432	455	2.721	1.100	0.595	382	411
18	6.640	0.000	0.595	625	586	4.312	1.100	0.595	519	492	3.438	1.100	0.595	443	463	2.299	1.100	0.595	345	383
19	6.835	0.000	0.595	642	576	4.129	1.100	0.595	503	476	3.255	1.100	0.595	428	455	2.983	1.100	0.595	404	451
20	6.489	0.000	0.595	612	576	3.749	1.100	0.595	470	441	3.227	1.100	0.595	425	451	2.611	1.100	0.595	372	402
21	6.007	0.000	0.595	570	551	3.688	1.100	0.595	465	446	2.947	1.100	0.595	401	439	2.849	1.100	0.595	393	434
22	6.496	0.000	0.595	613	589	3.530	1.100	0.595	451	429	2.807	1.100	0.595	389	419	2.666	1.100	0.595	377	416
23	6.491	0.000	0.595	612	570	3.767	1.100	0.595	472	441	3.199	1.100	0.595	423	469	2.802	1.100	0.595	389	428
24	6.405	0.000	0.595	605	578	3.611	1.100	0.595	458	444	3.002	1.100	0.595	406	438	2.644	1.100	0.595	375	414
25	6.368	0.000	0.595	602	563	3.612	1.100	0.595	459	440	2.976	1.100	0.595	404	434	2.367	1.100	0.595	351	395
26	6.277	0.000	0.595	594	579	3.855	1.100	0.595	480	487	3.035	1.100	0.595	409	443	2.900	1.100	0.595	397	443
27	6.246	0.343	0.595	621	526	3.742	1.100	0.595	470	455	2.866	1.100	0.595	394	430	2.709	1.100	0.595	380	422
28	5.868	0.520	0.595	603	544	4.004	1.100	0.595	492	480	2.837	1.100	0.595	392	439	2.627	1.100	0.595	373	411
29	5.775	0.260	0.595	573	541	4.107	1.100	0.595	501	473	2.611	1.100	0.595	372	417	2.839	1.100	0.595	392	431
30	5.783	0.527	0.595	597	554	3.589	1.100	0.595	456	453	2.622	1.100	0.595	373	428	2.594	1.100	0.595	371	413
31	5.594	0.549	0.595	582	532						2.672	1.100	0.595	377	410	2.867	1.100	0.595	394	438
Total				18,736	17,489				15,127	14,303				12,908	13,817				11,779	13,083
Avg	6.329	0.071	0.595	604	564	4.363	0.878	0.595	504	477	3.125	1.100	0.595	416	446	2.703	1.100	0.595	380	422

	Sep					Oct					Nov					Dec				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
Date	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)	Figeh (m^3/s)	Barada (m^3/s)	Wells (m^3/s)	Total (10^3 m^3)	(10^3 m^3)
1	2.454	1.100	0.595	358	398	2.352	1.100	0.595	350	387	2.792	1.100	0.595	388	423	2.319	1.100	0.595	347	377
2	2.581	1.100	0.595	369	405	2.545	1.100	0.595	366	402	2.773	1.100	0.595	386	425	2.354	1.100	0.595	350	384
3	2.675	1.100	0.595	378	421	2.444	1.100	0.595	358	401	2.776	1.100	0.595	386	421	2.376	1.100	0.595	352	384
4	2.668	1.100	0.595	377	420	2.521	1.100	0.595	364	397	2.700	1.100	0.595	380	409	2.339	1.100	0.595	348	382
5	2.644	1.100	0.595	375	416	2.479	1.100	0.595	361	398	2.659	1.100	0.595	376	416	2.428	1.100	0.595	356	393
6	2.632	1.100	0.595	374	412	2.526	1.100	0.595	365	405	2.686	1.100	0.595	378	406	2.340	1.100	0.595	349	376
7	2.560	1.100	0.595	368	405	2.427	1.100	0.595	356	387	2.780	1.100	0.595	387	424	2.321	1.100	0.595	347	377
8	2.420	1.100	0.595	355	400	2.272	1.100	0.595	343	377	2.681	1.100	0.595	378	410	2.248	1.100	0.595	341	368
9	2.584	1.100	0.595	370	398	2.264	1.100	0.595	342	373	2.699	1.100	0.595	380	408	2.288	1.100	0.595	344	377
10	2.713	1.100	0.595	381	429	2.293	1.100	0.595	345	388	2.561	1.100	0.595	368	402	2.197	1.100	0.595	336	402
11	2.330	1.100	0.595	348	379	2.189	1.100	0.595	336	369	2.732	1.100	0.595	382	416	2.610	1.100	0.595	372	405
12	2.763	1.100	0.595	385	431	2.293	1.100	0.595	345	391	2.644	1.100	0.595	375	402	2.754	1.100	0.595	384	413
13	2.670	1.100	0.595	377	408	2.412	1.100	0.595	355	385	2.628	1.100	0.595	373	407	2.672	1.100	0.595	377	397
14	2.732	1.100	0.595	382	424	2.472	1.100	0.595	360	396	2.490	1.100	0.595	362	393	2.826	1.100	0.595	391	404
15	2.746	1.100	0.595	384	420	2.404	1.100	0.595	354	388	2.472	1.100	0.595	360	391	2.721	1.100	0.595	381	403
16	2.647	1.100	0.595	375	416	2.462	1.100	0.595	359	400	2.496	1.100	0.595	362	394	2.773	1.100	0.595	386	416
17	2.557	1.100	0.595	367	404	2.402	1.100	0.595	354	382	2.481	1.100	0.595	361	398	2.610	1.100	0.595	372	384
18	2.777	1.100	0.595	386	424	2.495	1.100	0.595	362	404	2.320	1.100	0.595	347	372	2.865	1.100	0.595	394	414
19	2.614	1.100	0.595	372	413	2.572	1.100	0.595	369	402	2.323	1.100	0.595	347	387	2.986	1.100	0.595	404	425
20	2.726	1.100	0.595	382	420	2.521	1.100	0.595	364	407	2.326	1.100	0.595	347	378	3.145	1.100	0.595	418	431
21	2.752	1.100	0.595	384	423	2.423	1.100	0.595	356	393	2.319	1.100	0.595	347	381	4.852	1.100	0.595	566	538
22	2.705	1.100	0.595	380	423	1.986	1.100	0.595	318	351	2.474	1.100	0.595	360	394	6.165	0.000	0.595	584	567
23	2.779	1.100	0.595	387	419	2.784	1.100	0.595	387	403	2.418	1.100	0.595	355	390	6.126	0.000	0.595	581	543
24	2.884	1.100	0.595	396	437	2.840	1.100	0.595	392	424	2.360	1.100	0.595	350	377	5.750	0.000	0.595	548	539
25	2.607	1.100	0.595	372	402	2.752	1.100	0.595	384	400	2.405	1.100	0.595	354	384	5.440	0.000	0.595	521	469
26	2.769	1.100	0.595	386	430	2.731	1.100	0.595	382	406	2.483	1.100	0.595	361	385	4.825	0.000	0.595	468	412
27	2.587	1.100	0.595	370	397	2.725	1.100	0.595	382	412	2.473	1.100	0.595	360	405	4.524	0.000	0.595	442	421
28	2.787	1.100	0.595	387	431	2.678	1.100	0.595	378	414	2.288	1.100	0.595	344	372	4.153	0.000	0.595	410	368
29	2.490	1.100	0.595	362	399	2.727	1.100	0.595	382	416	2.421	1.100	0.595	356	402	4.051	0.000	0.595	401	383
30	2.501	1.100	0.595	363	400	2.733	1.100	0.595	383	424	2.349	1.100	0.595	349	375	4.288	0.000	0.595	422	407
31						2.661	1.100	0.595	376	412						4.259	0.000	0.595	419	395
Total				11,249	12,404				11,225	12,294				10,960	11,947				12,713	12,954
Avg	2.645	1.100	0.595	375	413	2.496	1.100	0.595	362	397	2.534	1.100	0.595	365	398	3.407	0.745	0.595	410	418

Table 1-1-5 Water Supply from Water Sources (2003)

2003

	Jan					Feb					Mar					Apr				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
	Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total	
Date	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)
1	4.229	0.000	0.595	417	394	6.045	0.000	0.595	574	521	6.710	0.000	0.595	631	592	6.507	0.000	0.595	614	557
2	4.309	0.000	0.595	424	413	6.174	0.000	0.595	585	561	6.185	0.000	0.595	586	569	6.494	0.000	0.595	613	572
3	4.007	0.000	0.595	398	382	6.366	0.000	0.595	601	573	6.409	0.000	0.595	605	542	6.571	0.000	0.595	619	584
4	4.107	0.000	0.595	406	403	6.256	0.000	0.595	592	529	6.344	0.000	0.595	600	563	6.748	0.000	0.595	634	589
5	4.484	0.000	0.595	439	415	6.065	0.000	0.595	575	546	5.961	0.000	0.595	566	548	6.674	0.000	0.595	628	591
6	6.586	0.000	0.595	620	611	6.393	0.000	0.595	604	555	6.853	0.000	0.595	644	584	6.784	0.000	0.595	638	599
7	6.413	0.000	0.595	606	559	6.307	0.000	0.595	596	566	6.466	0.000	0.595	610	565	6.622	0.000	0.595	624	575
8	5.960	0.000	0.595	566	540	6.429	0.000	0.595	607	582	6.589	0.000	0.595	621	589	6.712	0.000	0.595	631	576
9	6.367	0.000	0.595	602	556	6.529	0.000	0.595	616	562	6.525	0.000	0.595	615	566	6.155	0.000	0.595	583	591
10	6.515	0.000	0.595	614	564	6.427	0.000	0.595	607	572	6.232	0.000	0.595	590	552	6.750	0.000	0.595	635	571
11	6.049	0.000	0.595	574	539	6.355	0.000	0.595	601	590	6.359	0.000	0.595	601	584	6.900	0.000	0.595	648	591
12	6.097	0.000	0.595	578	525	6.250	0.000	0.595	591	521	6.623	0.000	0.595	624	553	6.260	0.000	0.595	592	586
13	6.411	0.000	0.595	605	564	5.895	0.000	0.595	561	519	6.501	0.000	0.595	613	570	6.926	0.000	0.595	650	577
14	5.953	0.000	0.595	566	532	6.050	0.000	0.595	574	530	6.524	0.000	0.595	615	576	6.375	0.000	0.595	602	567
15	6.024	0.000	0.595	572	551	6.073	0.000	0.595	576	534	6.590	0.000	0.595	621	589	6.536	0.000	0.595	616	584
16	6.216	0.000	0.595	588	525	6.347	0.000	0.595	600	564	6.639	0.000	0.595	625	591	6.833	0.000	0.595	642	573
17	4.272	0.000	0.595	421	369	6.289	0.000	0.595	595	542	6.315	0.000	0.595	597	553	6.272	0.000	0.595	593	572
18	6.898	0.000	0.595	647	635	6.264	0.000	0.595	593	565	6.268	0.000	0.595	593	530	6.681	0.000	0.595	629	593
19	6.335	0.000	0.595	599	542	6.412	0.000	0.595	605	558	5.653	0.000	0.595	540	535	6.412	0.000	0.595	605	574
20	5.672	0.000	0.595	541	524	6.393	0.000	0.595	604	558	5.584	0.000	0.595	534	527	6.738	0.000	0.595	634	587
21	6.145	0.000	0.595	582	531	6.492	0.000	0.595	612	569	6.107	0.000	0.595	579	539	6.492	0.000	0.595	612	563
22	5.999	0.000	0.595	570	512	6.324	0.000	0.595	598	564	5.608	0.000	0.595	536	531	6.232	0.000	0.595	590	562
23	5.893	0.000	0.595	561	522	6.479	0.000	0.595	611	563	6.475	0.000	0.595	611	569	6.494	0.000	0.595	613	558
24	5.755	0.000	0.595	549	510	6.291	0.000	0.595	595	552	6.269	0.000	0.595	593	546	6.452	0.000	0.595	609	586
25	5.739	0.000	0.595	547	488	5.550	0.000	0.595	531	503	6.124	0.000	0.595	581	553	6.700	0.000	0.595	630	589
26	5.640	0.000	0.595	539	503	5.897	0.000	0.595	561	550	6.211	0.000	0.595	588	543	6.727	0.000	0.595	633	594
27	5.697	0.000	0.595	544	513	6.449	0.000	0.595	609	558	6.303	0.000	0.595	596	552	6.543	0.000	0.595	617	573
28	5.772	0.000	0.595	550	500	6.554	0.000	0.595	618	566	6.428	0.000	0.595	607	596	6.111	0.000	0.595	579	555
29	5.882	0.000	0.595	560	523						6.995	0.000	0.595	656	604	6.454	0.000	0.595	609	565
30	5.958	0.000	0.595	566	526						6.583	0.000	0.595	620	550	6.685	0.000	0.595	629	586
31	5.803	0.000	0.595	553	507						6.122	0.000	0.595	580	572					
Total				16,903	15,778				16,590	15,473				18,577	17,433				18,550	17,340
Avg	5.716	0.000	0.595	545	509	6.263	0.000	0.595	593	553	6.341	0.000	0.595	599	562	6.561	0.000	0.595	618	578

	May					Jun					Jul					Aug				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
	Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total	
Date	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)
1	6.972	0.000	0.595	654	615	7.035	0.000	0.595	659	616	7.442	0.000	0.595	694	625	7.470	0.000	0.595	697	661
2	6.859	0.000	0.595	644	608	6.919	0.000	0.595	649	607	7.312	0.000	0.595	683	672	7.616	0.000	0.595	709	661
3	6.665	0.000	0.595	627	589	7.039	0.000	0.595	660	618	7.520	0.000	0.595	701	638	7.411	0.000	0.595	692	670
4	6.967	0.000	0.595	653	617	6.537	0.000	0.595	616	603	7.237	0.000	0.595	677	663	7.564	0.000	0.595	705	671
5	6.917	0.000	0.595	649	602	7.452	0.000	0.595	695	636	7.427	0.000	0.595	693	667	7.609	0.000	0.595	709	676
6	6.802	0.000	0.595	639	604	7.609	0.000	0.595	709	675	7.522	0.000	0.595	701	673	7.790	0.000	0.595	724	668
7	6.780	0.000	0.595	637	627	7.049	0.000	0.595	660	626	7.651	0.000	0.595	712	663	7.795	0.000	0.595	725	689
8	7.114	0.000	0.595	666	609	7.388	0.000	0.595	690	650	7.487	0.000	0.595	698	644	7.416	0.000	0.595	692	673
9	7.118	0.000	0.595	666	605	6.928	0.000	0.595	650	612	7.436	0.000	0.595	694	684	7.521	0.000	0.595	701	659
10	6.826	0.000	0.595	641	635	7.144	0.000	0.595	669	620	7.043	0.000	0.595	660	613	7.663	0.000	0.595	714	675
11	7.040	0.000	0.595	660	617	6.751	0.000	0.595	635	628	7.321	0.000	0.595	684	650	7.703	0.000	0.595	717	684
12	7.254	0.000	0.595	678	644	7.405	0.000	0.595	691	632	7.283	0.000	0.595	681	638	7.436	0.000	0.595	694	667
13	7.190	0.000	0.595	673	626	7.461	0.000	0.595	696	653	7.547	0.000	0.595	703	662	7.620	0.000	0.595	710	671
14	7.040	0.000	0.595	660	647	6.949	0.000	0.595	652	635	7.070	0.000	0.595	662	625	7.469	0.000	0.595	697	660
15	7.300	0.000	0.595	682	642	7.227	0.000	0.595	676	638	7.211	0.000	0.595	674	661	7.641	0.000	0.595	712	685
16	7.338	0.000	0.595	685	643	7.138	0.000	0.595	668	624	7.283	0.000	0.595	681	626	7.453	0.000	0.595	695	651
17	7.104	0.000	0.595	665	634	7.380	0.000	0.595	689	639	7.877	0.000	0.595	732	716	7.555	0.000	0.595	704	662
18	7.232	0.000	0.595	676	640	6.983	0.000	0.595	655	639	7.392	0.000	0.595	690	642	7.463	0.000	0.595	696	668
19	7.133	0.000	0.595	668	610	7.206	0.000	0.595	674	639	7.319	0.000	0.595	684	650	7.074	0.000	0.595	663	603
20	7.309	0.000	0.595	683	658	7.439	0.000	0.595	694	655	7.512	0.000	0.595	700	662	7.249	0.000	0.595	678	665
21	7.064	0.000	0.595	662	610	7.167	0.000	0.595	671	630	7.424	0.000	0.595	693	660	7.200	0.000	0.595	674	630
22	7.282	0.000	0.595	681	645	6.925	0.000	0.595	650	637	7.487	0.000	0.595	698	672	7.591	0.000	0.595	707	667
23	6.942	0.000	0.595	651	616	7.252	0.000	0.595	678	630	7.536	0.000	0.595	703	656	6.796	0.000	0.595	639	635
24	7.293	0.000	0.595	682	639	7.438	0.000	0.595	694	633	7.605	0.000	0.595	709	660	7.360	0.000	0.595	687	652
25	7.026	0.000	0.595	659	635	7.130	0.000	0.595	667	656	7.396	0.000	0.595	690	666	7.493	0.000	0.595	699	650
26	7.315	0.000	0.595	683	630	7.556	0.000	0.595	704	645	7.528	0.000	0.595	702	650	7.080	0.000	0.595	663	637
27	7.080	0.000	0.595	663	635	7.347	0.000	0.595	686	668	7.402	0.000	0.595	691	670	7.076	0.000	0.595	663	644
28	7.216	0.000	0.595	675	636	7.050	0.000	0.595	661	629	7.380	0.000	0.595	689	665	7.240	0.000	0.595	677	644
29	6.718	0.000	0.595	632	587	7.498	0.000	0.595	699	646	7.534	0.000	0.595	702	664	7.331	0.000	0.595	685	641
30	6.081	0.000	0.595	577	542	7.258	0.000	0.595	679	654	7.643	0.000	0.595	712	666	7.000	0.000	0.595	656	621
31	6.907	0.000	0.595	648	627						7.351	0.000	0.595	687	664	7.321	0.000	0.595	684	659
Total				20,419	19,274				20,176	19,073				21,481	20,367				21,467	20,399
Avg	7.029	0.000	0.595	659	622	7.189	0.000	0.595	673	636	7.425	0.000	0.595	693	657	7.420	0.000	0.595	692	658

	Sep					Oct					Nov					Dec				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
	Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total	
Date	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)
1	6.969	0.000	0.595	654	639	6.249	0.000	0.595	591	568	5.559	1.100	0.595	627	585	4.977	1.100	0.595	576	517
2	7.328	0.000	0.595	685	639	6.246	0.000	0.595	591	553	5.027	1.100	0.595	581	562	4.621	1.100	0.595	546	512
3	7.383	0.000	0.595	689	659	6.196	0.000	0.595	587	533	5.461	1.100	0.595	618	583	4.133	0.984	0.595	494	487
4	6.952	0.000	0.595	652	616	6.162	0.000	0.595	584	573	5.355	1.100	0.595	609	571	4.670	1.100	0.595	550	510
5	7.431	0.000	0.595	693	648	6.314	0.000	0.595	597	575	5.311	1.100	0.595	605	572	4.660	1.091	0.595	548	503
6	6.604	0.000	0.595	622	600	6.285	0.000	0.595	594	553	5.236	1.100	0.595	599	567	4.293	1.100	0.595	517	499
7	7.044	0.000	0.595	660	626	6.068	0.000	0.595	576	548	5.333	1.100	0.595	607	579	4.614	1.100	0.595	545	511
8	6.896	0.000	0.595	647	619	6.044	0.000	0.595	574	524	5.361	1.100	0.595	610	585	4.505	1.100	0.595	536	515
9	6.925	0.000	0.595	650	629	5.996	0.000	0.595	569	550	5.415	1.100	0.595	614	570	4.636	1.062	0.595	544	522
10	6.871	0.000	0.595	645	599	5.980	0.000	0.595	568	527	4.989	0.926	0.595	563	546	4.337	1.100	0.595	521	493
11	6.816	0.000	0.595	640	615	5.922	0.000	0.595	563	534	5.152	1.100	0.595	592	547	4.344	1.100	0.595	522	501
12	7.005	0.000	0.595	657	632	6.063	0.000	0.595	575	548	5.103	1.100	0.595	587	540	4.308	1.100	0.595	519	499
13	6.886	0.000	0.595	646	608	5.994	0.000	0.595	569	527	5.059	1.100	0.595	584	553	4.502	1.100	0.595	535	507
14	6.959	0.000	0.595	653	621	5.852	0.000	0.595	557	531	5.338	1.100	0.595	608	588	4.294	1.029	0.595	511	496
15	6.749	0.000	0.595	635	601	6.006	0.000	0.595	570	540	5.282	1.100	0.595	603	576	4.557	1.100	0.595	540	508
16	6.701	0.000	0.595	630	599	5.971	0.000	0.595	567	543	5.343	1.100	0.595	608	582	4.284	1.100	0.595	517	484
17	6.684	0.000	0.595	629	604	5.945	0.000	0.595	565	520	5.563	1.100	0.595	627	582	4.341	1.100	0.595	521	499
18	6.646	0.000	0.595	626	607	5.911	0.250	0.595	584	546	5.285	1.100	0.595	603	559	4.394	0.994	0.595	517	487
19	6.720	0.000	0.595	632	612	5.734	0.354	0.595	577	549	5.178	1.100	0.595	594	587	4.272	1.097	0.595	515	475
20	6.754	0.000	0.595	635	564	5.795	0.396	0.595	586	553	5.185	1.100	0.595	594	578	4.449	1.058	0.595	527	486
21	6.661	0.000	0.595	627	607	5.636	0.339	0.595	568	532	5.555	1.100	0.595	626	589	4.222	0.868	0.595	491	464
22	6.607	0.000	0.595	622	598	5.605	0.280	0.595	560	529	5.344	1.100	0.595	608	589	5.088	0.962	0.595	574	515
23	6.550	0.000	0.595	617	593	5.614	0.240	0.595	557	528	5.343	1.100	0.595	608	588	4.038	1.100	0.595	495	466
24	6.488	0.000	0.595	612	573	5.565	0.280	0.595	556	543	5.308	1.100	0.595	605	587	4.636	0.800	0.595	521	481
25	6.411	0.000	0.595	605	569	5.783	0.480	0.595	593	540	5.179	1.100	0.595	594	559	4.290	1.100	0.595	517	488
26	6.431	0.000	0.595	607	582	5.606	0.640	0.595	591	611	5.354	1.100	0.595	609	562	4.550	1.100	0.595	540	495
27	6.376	0.000	0.595	602	561	5.530	1.100	0.595	624	592	4.901	1.100	0.595	570	523	4.577	1.100	0.595	542	501
28	6.348	0.000	0.595	600	581	5.738	1.100	0.595	642	589	4.971	1.100	0.595	576	542	4.548	1.100	0.595	539	502
29	6.319	0.000	0.595	597	550	5.294	1.100	0.595	604	553	4.765	1.100	0.595	558	543	4.386	1.100	0.595	525	486
30	6.276	0.000	0.595	594	566	5.658	0.556	0.595	588	577	5.372	1.100	0.595	611	580	4.513	1.100	0.595	536	496
31						5.661	1.100	0.595	636	588						4.496	1.100	0.595	535	495
Total				19,064	18,117				18,065	17,077				17,997	17,074				16,418	15,400
Avg	6.760	0.000	0.595	635	604	5.885	0.265	0.595	583	551	5.254	1.094	0.595	600	569	4.469	1.066	0.595	530	497

Table 1-1-6 Water Supply from Water Sources (2004)

2004

	Jan					Feb					Mar					Apr				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
	Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total	
Date	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)
1	4.781	1.100	0.595	560	524	5.899	0.570	0.595	610	574	6.126	0.000	0.595	581	551	6.465	0.000	0.595	610	576
2	4.618	1.100	0.595	545	505	6.005	0.000	0.595	570	520	6.598	0.000	0.595	622	568	6.551	0.000	0.595	617	576
3	4.538	1.100	0.595	539	508	5.476	0.167	0.595	539	510	6.067	0.000	0.595	576	566	6.527	0.000	0.595	615	594
4	4.536	1.100	0.595	538	497	5.549	0.280	0.595	555	514	6.600	0.000	0.595	622	553	6.722	0.000	0.595	632	590
5	4.392	1.100	0.595	526	483	5.458	0.280	0.595	547	519	6.142	0.000	0.595	582	553	6.660	0.000	0.595	627	580
6	4.611	1.100	0.595	545	508	5.578	0.553	0.595	581	535	6.743	0.000	0.595	634	580	6.226	0.000	0.595	589	569
7	4.483	1.100	0.595	534	490	5.401	0.373	0.595	550	516	5.736	0.000	0.595	547	536	6.342	0.000	0.595	599	553
8	4.364	1.001	0.595	515	482	5.779	0.720	0.595	613	571	6.331	0.000	0.595	598	548	6.511	0.000	0.595	614	578
9	4.630	1.003	0.595	538	492	5.689	0.533	0.595	589	527	6.211	0.000	0.595	588	562	6.691	0.000	0.595	630	588
10	4.553	1.042	0.595	535	501	6.141	0.000	0.595	582	561	6.350	0.000	0.595	600	541	6.622	0.000	0.595	624	593
11	4.451	1.100	0.595	531	482	6.151	0.000	0.595	583	530	6.062	0.000	0.595	575	561	6.720	0.000	0.595	632	589
12	4.614	0.932	0.595	531	497	5.619	0.000	0.595	537	553	6.645	0.000	0.595	626	557	6.450	0.000	0.595	609	584
13	4.339	0.948	0.595	508	477	6.311	0.000	0.595	597	527	6.462	0.000	0.595	610	586	6.748	0.000	0.595	634	592
14	4.614	1.037	0.595	540	501	6.106	0.000	0.595	579	549	6.254	0.000	0.595	592	557	6.794	0.000	0.595	638	613
15	4.755	0.926	0.595	542	500	6.189	0.000	0.595	586	544	6.188	0.000	0.595	586	543	6.736	0.000	0.595	633	592
16	4.621	1.100	0.595	546	507	5.613	0.000	0.595	536	499	6.104	0.000	0.595	579	547	6.631	0.000	0.595	624	583
17	4.710	1.100	0.595	553	514	6.155	0.000	0.595	583	540	6.211	0.000	0.595	588	560	6.359	0.000	0.595	601	561
18	4.678	0.661	0.595	513	478	6.201	0.000	0.595	587	551	6.674	0.000	0.595	628	561	6.652	0.000	0.595	626	598
19	4.973	0.747	0.595	546	507	6.138	0.000	0.595	582	540	6.173	0.000	0.595	585	575	6.425	0.000	0.595	607	573
20	5.103	1.100	0.595	587	560	6.179	0.000	0.595	585	552	6.493	0.000	0.595	612	562	6.415	0.000	0.595	606	567
21	5.157	0.345	0.595	527	524	6.105	0.000	0.595	579	548	6.255	0.000	0.595	592	571	6.383	0.000	0.595	603	562
22	5.410	1.100	0.595	614	556	6.244	0.000	0.595	591	555	6.710	0.000	0.595	631	576	6.567	0.000	0.595	619	590
23	4.714	1.100	0.595	554	532	6.030	0.000	0.595	572	500	6.268	0.000	0.595	593	564	6.388	0.000	0.595	603	565
24	5.571	0.637	0.595	588	531	6.097	0.000	0.595	578	562	6.601	0.000	0.595	622	583	6.608	0.000	0.595	622	580
25	5.946	0.000	0.595	565	537	6.179	0.000	0.595	585	550	6.568	0.000	0.595	619	581	6.250	0.000	0.595	591	561
26	6.118	0.000	0.595	580	546	6.001	0.000	0.595	570	536	6.735	0.000	0.595	633	588	6.771	0.000	0.595	636	586
27	5.629	0.693	0.595	598	544	6.270	0.000	0.595	593	548	6.558	0.000	0.595	618	591	6.432	0.000	0.595	607	581
28	5.341	0.650	0.595	569	545	6.582	0.000	0.595	620	578	6.587	0.000	0.595	621	581	6.436	0.000	0.595	607	588
29	5.718	0.390	0.595	579	552	6.225	0.000	0.595	589	551	6.448	0.000	0.595	609	592	6.940	0.000	0.595	651	586
30	5.661	1.100	0.595	636	568						6.557	0.000	0.595	618	575	6.887	0.000	0.595	646	620
31	5.446	0.773	0.595	589	576						6.700	0.000	0.595	630	561					
Total				17,168	16,024				16,771	15,660				18,715	17,530				18,556	17,468
Avg	4.938	0.877	0.595	554	517	5.978	0.120	0.595	578	540	6.392	0.000	0.595	604	565	6.564	0.000	0.595	619	582

	May					Jun					Jul					Aug				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
	Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total	
Date	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)
1	6.589	0.000	0.595	621	585	6.898	0.000	0.595	647	607	7.189	0.000	0.595	673	604	6.206	0.400	0.595	622	596
2	6.926	0.000	0.595	650	608	6.952	0.000	0.595	652	604	6.762	0.000	0.595	636	628	6.106	0.467	0.595	619	572
3	6.328	0.000	0.595	598	569	6.247	0.000	0.595	591	590	7.091	0.000	0.595	664	596	6.071	0.280	0.595	600	571
4	6.695	0.000	0.595	630	585	7.140	0.000	0.595	668	600	5.952	0.000	0.595	566	561	6.051	0.490	0.595	617	572
5	6.558	0.000	0.595	618	582	6.633	0.000	0.595	624	604	6.344	0.000	0.595	600	582	5.972	0.367	0.595	599	566
6	6.716	0.000	0.595	632	597	7.021	0.000	0.595	658	623	6.511	0.000	0.595	614	573	5.891	1.000	0.595	647	643
7	6.747	0.000	0.595	634	605	6.905	0.000	0.595	648	617	5.804	0.000	0.595	553	508	6.099	0.300	0.595	604	544
8	6.923	0.000	0.595	650	598	7.177	0.000	0.595	672	633	6.254	0.000	0.595	592	545	5.956	0.400	0.595	601	569
9	6.708	0.000	0.595	631	616	7.100	0.000	0.595	665	631	7.804	0.000	0.595	726	666	5.854	0.500	0.595	600	557
10	6.736	0.000	0.595	633	586	7.169	0.000	0.595	671	626	6.903	0.000	0.595	648	609	5.808	0.556	0.595	601	560
11	7.079	0.000	0.595	663	629	6.798	0.000	0.595	639	611	7.167	0.000	0.595	671	637	5.758	0.500	0.595	592	555
12	6.854	0.000	0.595	644	604	6.920	0.000	0.595	649	613	7.083	0.000	0.595	663	632	5.746	0.500	0.595	591	562
13	6.743	0.000	0.595	634	606	6.934	0.000	0.595	651	608	7.086	0.000	0.595	664	636	5.666	1.034	0.595	630	631
14	6.834	0.000	0.595	642	605	7.184	0.000	0.595	672	633	7.045	0.000	0.595	660	624	5.885	0.587	0.595	611	551
15	6.942	0.000	0.595	651	584	7.175	0.000	0.595	671	643	6.897	0.000	0.595	647	592	5.636	0.427	0.595	575	537
16	6.808	0.000	0.595	640	608	6.841	0.000	0.595	643	617	6.814	0.000	0.595	640	634	5.626	0.600	0.595	589	541
17	6.560	0.000	0.595	618	578	7.171	0.000	0.595	671	629	6.870	0.000	0.595	645	617	5.663	0.457	0.595	580	544
18	6.559	0.000	0.595	618	587	7.292	0.000	0.595	681	638	6.617	0.579	0.595	673	638	5.491	1.050	0.595	617	574
19	6.751	0.000	0.595	635	596	6.939	0.000	0.595	651	626	6.780	0.000	0.595	637	595	5.543	0.000	0.595	530	499
20	6.631	0.000	0.595	624	599	7.268	0.000	0.595	679	644	6.601	0.000	0.595	622	601	5.234	1.457	0.595	629	637
21	6.692	0.000	0.595	630	593	6.691	0.000	0.595	629	601	6.210	0.538	0.595	634	567	5.234	1.013	0.595	591	513
22	6.929	0.000	0.595	650	602	7.424	0.000	0.595	693	637	6.458	0.000	0.595	609	579	5.321	0.570	0.595	560	542
23	6.676	0.000	0.595	628	607	7.071	0.000	0.595	662	637	6.271	0.567	0.595	642	632	5.022	1.520	0.595	617	564
24	6.923	0.000	0.595	650	612	6.878	0.000	0.595	646	616	6.385	0.289	0.595	628	565	5.536	0.767	0.595	596	555
25	6.894	0.000	0.595	647	604	7.053	0.000	0.595	661	628	6.404	0.000	0.595	605	565	5.374	0.887	0.595	592	554
26	6.741	0.000	0.595	634	605	6.709	0.000	0.595	631	598	6.373	0.000	0.595	602	573	5.396	0.723	0.595	580	551
27	6.733	0.000	0.595	633	607	7.132	0.000	0.595	668	625	6.246	0.559	0.595	639	606	5.297	0.833	0.595	581	607
28	7.051	0.000	0.595	661	621	6.586	0.000	0.595	620	586	6.283	0.313	0.595	621	574	5.423	0.782	0.595	587	488
29	6.839	0.000	0.595	642	598	7.394	0.000	0.595	690	620	6.220	0.280	0.595	613	579	5.219	0.614	0.595	555	518
30	6.621	0.000	0.595	623	591	6.342	0.000	0.595	599	606	6.158	0.937	0.595	664	653	4.996	0.723	0.595	546	515
31	6.958	0.000	0.595	653	623						6.187	0.373	0.595	618	563	5.359	0.756	0.595	580	543
Total				19,716	18,590				19,604	18,551				19,670	18,534				18,442	17,331
Avg	6.766	0.000	0.595	636	600	6.968	0.000	0.595	653	618	6.606	0.143	0.595	635	598	5.627	0.663	0.595	595	559

	Sep					Oct					Nov					Dec				
	Production				Consump.	Production				Consump.	Production				Consump.	Production				Consump.
	Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total		Figeh	Barada	Wells	Total	
Date	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)	(m^3/s)	(m^3/s)	(m^3/s)	(10^3 m^3)	(10^3 m^3)
1	5.153	0.775	0.595	564	534	4.647	1.505	0.595	583	585	4.190	1.405	0.595	535	527	4.689	0.723	0.595	519	463
2	5.132	0.880	0.595	571	533	4.558	1.366	0.595	563	553	4.222	1.394	0.595	537	541	4.522	1.023	0.595	530	487
3	5.140	1.192	0.595	599	552	4.567	1.520	0.595	577	569	4.189	1.385	0.595	533	532	4.886	1.263	0.595	583	530
4	5.028	1.019	0.595	574	537	4.663	1.443	0.595	579	536	4.169	1.406	0.595	533	525	4.646	1.024	0.595	541	517
5	5.055	1.076	0.595	581	548	4.498	1.447	0.595	565	533	4.163	1.406	0.595	533	534	4.545	1.331	0.595	559	508
6	5.024	1.088	0.595	579	550	4.593	1.447	0.595	573	537	4.140	1.422	0.595	532	550	3.896	1.100	0.595	483	499
7	5.001	1.100	0.595	579	549	4.505	1.406	0.595	562	535	4.112	1.401	0.595	528	524	4.468	1.344	0.595	554	495
8	4.952	1.053	0.595	570	568	4.458	1.386	0.595	556	534	4.141	1.417	0.595	532	530	4.557	1.296	0.595	557	530
9	5.036	1.053	0.595	578	571	4.429	1.485	0.595	562	533	4.131	1.455	0.595	534	531	4.593	1.321	0.595	562	541
10	4.823	1.262	0.595	577	591	4.436	1.305	0.595	547	532	4.040	1.494	0.595	529	558	4.607	1.308	0.595	562	506
11	5.077	0.938	0.595	571	591	4.343	1.414	0.595	549	550	4.058	1.483	0.595	530	526	4.597	1.331	0.595	564	525
12	4.740	1.007	0.595	548	530	4.387	1.489	0.595	559	541	4.125	1.451	0.595	533	546	4.646	1.296	0.595	565	526
13	4.664	1.007	0.595	541	547	4.442	1.470	0.595	562	553	4.059	1.498	0.595	532	550				0	
14	4.976	0.914	0.595	560	588	4.324	1.343	0.595	541	546	4.060	1.481	0.595	530	500				0	
15	4.726	1.053	0.595	551	541	4.513	1.343	0.595	557	568	4.040	1.480	0.595	528	501				0	
16	4.761	1.094	0.595	557	542	4.377	1.525	0.595	561	568	3.998	1.477	0.595	524	497				0	
17	4.601	1.296	0.595	561	561	4.374	1.445	0.595	554	546	3.984	1.474	0.595	523	477				0	
18	4.911	1.040	0.595	566	554	4.515	1.366	0.595	560	550	3.967	1.475	0.595	522	481				0	
19	4.809	1.025	0.595	555	551	4.313	1.492	0.595	553	531	3.986	1.471	0.595	523	499				0	
20	4.678	1.105	0.595	551	549	4.361	1.500	0.595	558	551	3.901	1.466	0.595	515	486				0	
21	4.592	1.146	0.595	547	531	4.341	1.502	0.595	556	537	3.975	1.493	0.595	524	499				0	
22	4.602	1.072	0.595	542	526	4.226	1.503	0.595	546	552	3.490	1.131	0.595	451	458				0	
23	4.625	1.324	0.595	565	556	4.301	1.318	0.595	537	539	3.768	1.300	0.595	489	484				0	
24	4.935	0.893	0.595	555	576	4.192	1.285	0.595	525	547	3.845	1.169	0.595	485	456				0	
25	4.623	1.249	0.595	559	549	4.218	1.360	0.595	533	546	3.916	1.238	0.595	497	473				0	
26	4.328	1.098	0.595	520	560	4.155	1.374	0.595	529	535	3.959	1.231	0.595	500	484				0	
27	4.687	0.984	0.595	541	503	4.155	1.387	0.595	530	543	4.822	0.688	0.595	527	485				0	
28	4.528	1.273	0.595	553	570	4.183	1.389	0.595	533	529	6.004	0.000	0.595	570	560				0	
29	4.466	1.215	0.595	542	542	4.223	1.404	0.595	538	553	4.692	0.488	0.595	499	446				0	
30	4.638	1.285	0.595	563	563	4.207	1.302	0.595	527	544	4.247	0.917	0.595	498	543				0	
31						4.213	1.378	0.595	534	531									0	
Total				16,820	16,563				17,113	16,907				15,625	15,303					
Avg	4.810	1.084	0.595	561	552	4.378	1.416	0.595	552	545	4.146	1.287	0.595	521	510					

Table 1-2-1 Suspension Hours of Water Supply (1999-2000)

	Jan			Feb			Mar			Apr			May			Jun			Jul			Aug			Sep			Oct			Nov			Dec		
Date	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.
1999																																				
1	19:00	5:00	10:00	18:00	5:00	11:00	0:00	5:00	5:00							21:45	5:00	7:15	18:00	5:00	11:00	14:25	5:00	14:35	14:00	5:00	15:00	13:30	5:00	15:30	15:30	5:00	13:30	15:30	5:00	13:30
2	19:00	5:00	10:00	18:00	5:00	11:00										21:45	5:00	7:15	18:00	5:00	11:00	14:15	4:55	14:40	14:00	5:00	15:00	13:30	5:00	15:30	15:30	5:00	13:30	15:30	5:00	13:30
3	19:00	5:00	10:00	18:00	5:00	11:00										20:30	4:30	8:00	18:00	5:00	11:00	14:15	4:55	14:40	14:00	5:00	15:00	13:30	5:00	15:30	15:00	5:00	14:00	15:30	5:00	13:30
4	19:00	5:00	10:00	18:00	5:00	11:00	0:00	5:00	5:00										18:00	5:00	11:00	14:30	4:55	14:25	14:00	5:00	15:00	13:30	5:00	15:30	15:00	5:00	14:00	15:30	5:00	13:30
5	19:00	5:00	10:00	18:00	5:00	11:00													18:00	5:00	11:00	14:30	5:00	14:30	14:00	5:00	15:00	13:30	5:00	15:30	15:00	5:00	14:00	15:30	5:00	13:30
6	19:00	5:00	10:00	18:00	5:00	11:00													18:00	5:00	11:00	14:30	5:00	14:30	14:00	5:45	15:45	13:30	5:00	15:30	15:00	5:00	14:00	15:30	5:00	13:30
7	19:00	5:00	10:00	19:40	5:00	9:20										20:45	5:30	8:45	18:00	5:00	11:00	15:00	5:30	14:30	14:00	4:45	14:45	13:30	5:00	15:30	15:30	4:35	13:05	15:30	5:00	13:30
8	19:00	5:00	10:00	19:50	4:50	9:00										21:00	5:00	8:00	16:30	5:00	12:30	14:30	5:00	14:30	14:00	5:00	15:00	13:30	5:00	15:30	15:30	4:35	13:05	15:30	5:00	13:30
9	19:00	5:00	10:00	20:00	4:50	8:50										21:00	5:00	8:00	16:30	5:00	12:30	15:00	5:00	14:00	14:00	5:00	15:00	13:30	5:00	15:30	15:30	5:00	13:30	15:30	5:00	13:30
10	19:00	5:00	10:00	20:00	4:50	8:50										21:00	5:00	8:00	16:30	5:00	12:30	15:00	5:00	14:00	14:00	5:00	15:00	14:30	4:20	13:50	15:30	5:00	13:30	15:30	5:25	13:55
11	19:00	5:00	10:00	20:00	4:50	8:50										21:00	5:00	8:00	16:30	5:00	12:30	15:00	5:00	14:00	14:00	5:00	15:00	15:00	5:00	14:00	15:00	4:40	13:40	15:30	5:15	13:45
12	19:00	5:00	10:00	19:30	5:00	9:30										21:00	5:00	8:00	16:30	5:00	12:30	15:00	5:00	14:00	14:00	5:00	15:00	15:30	5:00	13:30	15:00	4:50	13:50	15:30	5:00	13:30
13	19:00	5:00	10:00	19:30	5:00	9:30										21:00	5:00	8:00	15:30	5:00	13:30	15:00	5:00	14:00	14:00	5:00	15:00	15:30	5:00	13:30	15:00	5:15	14:15	15:30	5:00	13:30
14	19:00	5:00	10:00	20:50	4:00	7:10										21:00	5:00	8:00	16:00	5:00	13:00	15:00	5:00	14:00	14:00	5:00	15:00	15:30	5:00	13:30	15:00	4:50	13:50	15:30	5:00	13:30
15	19:00	5:00	10:00	22:55	4:55	6:00										21:10	5:00	7:50	15:30	5:00	13:30	15:00	5:00	14:00	14:00	4:50	14:50	15:30	5:00	13:30	15:00	4:40	13:40	15:30	5:00	13:30
16	19:00	5:00	10:00	0:00	4:50	4:50							21:30	5:00	7:30	20:00	5:00	9:00	15:30	5:00	13:30	15:00	5:00	14:00	14:00	5:00	15:00	15:30	5:00	13:30	15:30	5:00	13:30	15:30	5:00	13:30
17	19:00	5:00	10:00	22:55	4:50	5:55										20:00	5:00	9:00	15:30	5:00	13:30	15:00	5:00	14:00	14:00	5:15	15:15	15:30	5:00	13:30	15:30	4:40	13:10	15:30	4:20	12:50
18	19:00	5:00	10:00	23:00	4:50	5:50							23:00	5:00	6:00	20:00	5:00	9:00	15:30	5:00	13:30	15:00	5:00	14:00	14:00	5:00	15:00	15:30	5:00	13:30	15:30	5:00	13:30	15:30	4:50	13:20
19	19:00	5:00	10:00	0:00	5:00	5:00										20:00	5:00	9:00	15:00	5:00	14:00	15:00	5:00	14:00	14:00	5:15	15:15	15:30	5:00	13:30	15:30	5:10	13:40	15:30	5:00	13:30
20	19:00	5:00	10:00	0:35	5:00	4:25							22:00	5:00	7:00	20:00	5:00	9:00	15:00	5:00	14:00	15:00	5:00	14:00	14:00	5:15	15:15	15:30	5:00	13:30	15:30	5:00	13:30	15:00	5:00	14:00
21	19:00	5:00	10:00	0:15	3:20	3:05							22:00	5:00	7:00	19:00	5:00	10:00	15:30	5:00	13:30	15:00	5:00	14:00	14:00	4:50	14:50	15:30	5:00	13:30	15:30	5:00	13:30	15:00	5:00	14:00
22	18:30	5:00	10:30										22:00	5:00	7:00	19:00	5:00	10:00	14:30	5:00	14:30	14:00	5:00	15:00	14:00	5:00	15:00	15:30	5:00	13:30	15:30	4:55	13:25	15:00	5:00	14:00
23	18:30	5:00	10:30										22:00	5:00	7:00	19:00	5:00	10:00	14:30	5:00	14:30	13:00	5:00	16:00	14:00	5:00	15:00	15:30	5:00	13:30	15:30	5:00	13:30	15:30	5:00	13:30
24	18:00	5:00	11:00													18:30	5:00	10:30	14:30	5:00	14:30	9:00	2:30	17:30	14:00	5:00	15:00	15:30	5:00	13:30	15:30	5:00	13:30	15:30	5:00	13:30
25	18:00	5:00	11:00	22:00	5:00	7:00										18:00	5:00	11:00	14:30	5:00	14:30	14:30	5:00	14:30	14:00	5:00	15:00	15:30	5:00	13:30	15:30	5:00	13:30	15:30	5:00	13:30
26	18:00	5:00	11:00	21:50	5:00	7:10										19:00	5:00	10:00	14:30	5:00	14:30	14:00	5:00	15:00	14:00	5:00	15:00	15:30	4:45	13:15	15:30	5:00	13:30	15:30	5:00	13:30
27	18:00	5:00	11:00	21:55	5:00	7:05										18:30	5:00	10:30	14:30	5:00	14:30	14:00	5:00	15:00	14:00	5:00	15:00	15:30	4:35	13:05	15:30	5:00	13:30	15:30	5:00	13:30
28	18:00	5:00	11:00	23:15	5:00	5:45							22:00	5:00	7:00	18:00	5:00	11:00	14:30	5:00	14:30	12:30	3:00	14:30	13:30	4:50	15:20	15:30	5:00	13:30	15:30	5:00	13:30	15:30	5:00	13:30
29	18:00	5:00	11:00													18:00	5:00	11:00	14:35	4:50	14:15	14:00	5:00	15:00	13:30	5:00	15:30	15:30	5:15	13:45	15:30	5:00	13:30	15:00	5:00	14:00
30	18:00	5:00	11:00													18:00	5:00	11:00	14:35	4:50	14:15	14:00	5:00	15:00	13:30	5:00	15:30	15:30	5:00	13:30	15:30	5:00	13:30	14:30	5:00	14:30
31	18:00	5:00	11:00																14:35	4:50	14:15	14:00	5:00	15:00				15:30	4:45	13:15				14:30	5:20	14:50
Total	308hrs			199hrs			10hrs			0hrs			48hrs			245hrs			391hrs			436hrs			452hrs			423hrs			408hrs			408hrs		
days	31			25			2			0			7			27			31			31			30			31			31			31		
2000																																				
1	14:30	5:45	15:15	16:00	5:00	13:00	20:00	5:00	9:00										18:00	5:00	11:00	15:00	6:00	15:00	14:00	6:00	16:00	13:00	6:00	17:00	13:30	5:45	16:15	13:30	6:00	16:30
2	14:30	5:00	14:30	16:30	5:00	12:30	19:00	5:00	10:00										17:30	5:00	11:30	15:30	6:00	14:30	14:00	6:00	16:00	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
3	14:30	5:00	14:30	16:00	5:00	13:00	19:30	5:00	9:30										17:00	5:00	12:00	15:00	6:00	15:00	14:00	6:00	16:00	13:00	6:00	17:00	13:00	6:00	17:00	13:30	6:00	16:30
4	14:30	5:00	14:30	16:30	5:00	12:30	19:30	5:00	9:30										17:00	5:00	12:00	15:30	6:00	14:30	14:00	6:00	16:00	13:30	6:00	16:30	13:00	6:00	17:00	13:30	6:00	16:30
5	14:30	5:00	14:30	16:00	5:00	13:00	20:00	5:00	9:00										17:00	5:00	12:00	15:00	6:00	15:00	14:00	6:00	16:00	13:30	6:00	16:30	13:30	6:00	16:30	13:30	6:00	16:30
6	14:30	5:00	14:30	16:30	5:00	12:30	19:30	5:00	9:30							23:00	5:00	6:00	17:00	5:00	12:00	15:30	6:00	14:30	14:00	6:00	16:00	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
7	14:30	5:00	14:30	16:00	5:00	13:00	20:30	5:00	8:30										16:30	5:00	12:30	15:00	6:00	15:00	14:00	6:00	16:00	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
8	14:30	5:00	14:30	16:30	5:00	12:30										23:00	5:00	6:00	17:00	5:00	12:00	15:30	6:00	14:30	14:00	6:00	16:00	12:00	6:00	18:00	13:30	6:00	16:30	13:30	6:00	16:30
9	14:30	5:00	14:30	17:00	5:00	12:00	20:00	5:00	9:00							23:00	5:00	6:00	16:30	5:00	12:30	15:00	6:00	15:00	14:00	6:00	16:00	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
10	14:30	5:00	14:30	17:00	5:00	12:00	0:00	5:00	5:00							0:00	5:00	5:00	17:00	5:00	12:00	15:30	6:00	14:30	13:30	6:00	16:30	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
11	14:30	5:00	14:30	16:00	5:00	13:00	20:30	5:00	8:30							23:00	5:00	6:00	17:00	5:00	12:00	15:00	6:00	15:00	13:30	6:00	16:30	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
12	14:30	5:00	14:30	16:30	5:00	12:30	21:30	5:00	7:30							23:00	5:00	6:00	17:00	5:00	12:00	15:30	6:00	14:30	13:30	6:00	16:30	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
13	14:30	5:00	14:30	16:30	5:00	12:30	22:00	5:00	7:00							21:00	5:00	8:00	16:30	5:00	12:30	15:00	6:00	15:00	13:30	6:00	16:30	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
14	14:30	5:00	14:30	17:30	5:00	11:30	23:20	5:00	5:40							21:00	5:00	8:00	16:30	5:30	13:00	15:30	6:00	14:30	13:30	6:00	16:30	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
15	14:30	5:00	14:30	17:30	5:00	11:30	0:00	5:00	5:00							22:45	4:50	6:05	16:30	6:00	13:30	15:00	6:00	15:00	14:00	6:00	16:00	13:00	6:00	17:00	13:30	6:00	16:30	14:00	6:00	16:00
16	14:30	5:00	14:30	17:30	5:00	11:30										22:30	5:00	6:30	16:30	5:30	13:00	14:30	6:00	15:30	14:00	6:00	16:00	13:00	6:00	17:00	13:00	6:00	17:00	13:30	6:00	16:30
17	15:00	5:00	14:00	17:30	5:00	11:30										19:30	5:00	9:30	16:30	5:30	13:00	14:30	6:00	15:30	13:30	6:00	16:30	13:00	6:00	17:00	13:00	6:00	17:00	13:30	6:00	16:30
18	15:30	5:00	13:30	17:30	5:00	11:30										19:30	5:00	9:30	16:30	6:00	13:30	14:30	6:00	15:30	13:30	6:00	16:30	13:00	6:00	17:00	14:00	6:00	16:00	13:00	6:00	17:00
19	15:30	5:00	13:30	17:30	5:00	11:30										19:00	5:00	10:00	16:30	6:00	13:30	14:30	6:00	15:30	13:30	6:00	16:30	13:00	6:00	17:00	13:30	6:00	16:30	13:00	6:00	17:00
20	17:00	5:00	12:00	17:30	5:00	11:30										18:15	5:00	10:45	16:30	5:50	13:20	14:30	6:00	15:30	13:30	6:00	16:30	13:00	6:00	17:00	13:30	6:00	16:30	13:00	6:00	17:00
21	15:00	5:45	14:45	17:30	5:00	11:30										18:00	5:00	11:00	16:30	6:00	13:30	14:30	6:00	15:30	13:00	6:00	17:00	13:00	6:00	17:00	13:30	6:00	16:30	13:00	5:50	16:50
22	15:00	5:35	14:35	18:00	5:00	11:00										18:30	5:00	10:30	16:30	5:30	13:00	14:30	6:00	15:30	13:30	6:00	16:30	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
23	15:00	5:00	14:00	20:30	4:45	8:15										18:00	5:00	11:00	16:30	5:00	12:30	14:00	6:00	16:00	13:00	6:00	17:00	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
24	16:00	5:00	13:00	20:30	4:45	8:15										18:00	5:00	11:00	16:30	6:00	13:30	14:00	6:00	16:00	13:00	6:00	17:00	13:00	6:00	17:00	13:00	6:00	17:00	13:00	6:00	17:00
25	16:00	5:00	13:00	21:00	5:00	8:00										18:00	5:00	11:00	16:30	6:00	13:30	14:00	6:00	16:00	13:00	6:00	17:00	13:00	6:00	17:00	13:00	6:00	17:00	13:30	6:00	16:30
26	16:00	5:00	13:00	21:30	5:00	7:30										18:00	5:00	11:00	16:30	6:00	13:30	14:00	6:00	16:00	13:00	6:00	17:00	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
27	16:00	5:00	13:00	20:30	5:00	8:30										18:30	5:00	10:30	16:30	6:00	13:30	14:00	6:00	16:00	13:00	6:00	17:00	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
28	16:00	5:00	13:00	20:00	5:00	9:00										18:30	5:00	10:30	16:30	6:00	13:30	14:00	6:00	16:00	13:00	6:00	17:00	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
29	16:30	5:00	12:30	20:00	5:00	9:00										18:30	5:00	10:30	16:00	6:00	14:00	14:00	6:00	16:00	13:00	6:00	17:00	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
30	16:30	5:00	12:30													18:30	5:00	10:30	15:00	6:00	15:00	14:00	6:00	16:00	13:00	6:00	17:00	13:00	6:00	17:00	13:30	6:00	16:30	13:30	6:00	16:30
31	15:30	5:00	13:30																15:30	6:00	14:30	14:00	6:00	16:00				13:30	6:00	16:30				13:30	6:00	16:30
Total	433hrs			325hrs			113hrs			0hrs			0hrs			211hrs			399hrs			474hrs			494hrs			527hrs			497hrs			513hrs		
days	31			28			14			0			0			24			31			31			30			31			30			31		

Table 1-2-2 Suspension Hours of Water Supply (2001-2002)

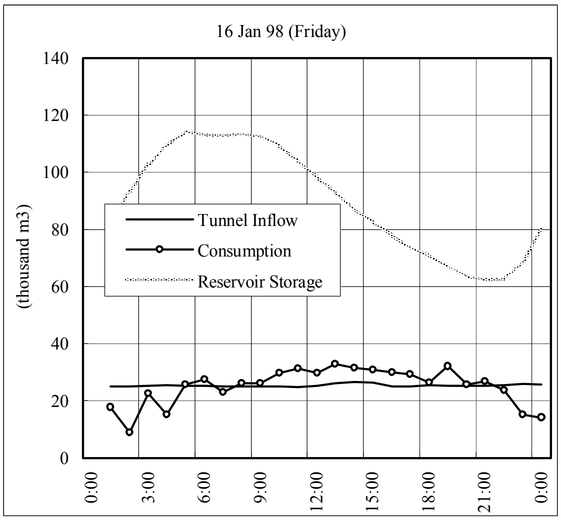
	Jan			Feb			Mar			Apr			May			Jun			Jul			Aug			Sep			Oct			Nov			Dec		
Date	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.
2001																																				
1	14:00	6:00	16:00	14:30	6:00	15:30	20:30	6:00	9:30							18:00	6:00	12:00	15:00	6:00	15:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00
2	14:00	6:00	16:00	14:30	6:00	15:30	22:00	6:00	8:00							18:00	6:00	12:00	15:00	6:00	15:00	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:30	18:30	12:00	6:00	18:00	13:00	6:00	17:00
3	14:00	6:00	16:00	14:30	6:00	15:30	23:00	6:00	7:00							18:00	6:00	12:00	15:00	6:00	15:00	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	12:00	6:00	18:00	13:00	6:00	17:00
4	13:30	6:00	16:30	14:30	6:00	15:30										18:00	6:00	12:00	15:00	6:00	15:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:30	6:00	16:30
5	14:00	6:00	16:00	14:30	6:00	15:30										18:00	6:00	12:00	14:00	6:00	16:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	14:00	6:00	16:00
6	14:00	6:00	16:00	15:00	6:00	15:00							0:00	6:00	6:00	18:00	6:00	12:00	14:00	6:00	16:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	14:00	6:00	16:00
7	14:30	6:00	15:30	15:00	6:00	15:00							0:00	6:00	6:00	18:00	6:00	12:00	14:00	6:00	16:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	14:00	6:00	16:00
8	14:30	6:00	15:30	15:00	6:00	15:00							0:00	6:00	6:00	18:00	6:00	12:00	14:00	6:00	16:00	13:30	6:00	16:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	14:00	6:00	16:00
9	14:30	6:00	15:30	15:00	6:00	15:00							0:00	6:00	6:00	18:00	6:00	12:00	14:00	6:00	16:00	13:30	6:00	16:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	14:00	6:00	16:00
10	14:30	6:00	15:30	15:00	6:00	15:00							21:00	6:00	9:00	17:30	6:00	12:30	13:00	6:00	17:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	14:00	6:00	16:00
11	14:30	6:00	15:30	15:00	6:00	15:00							21:00	6:00	9:00	17:30	6:00	12:30	14:00	6:00	16:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	13:00	6:00	17:00	14:00	6:00	16:00
12	15:00	6:30	15:30	16:00	6:00	14:00							19:30	6:00	10:30	17:30	6:00	12:30	13:00	6:00	17:00	16:30	6:00	13:30	12:30	6:00	17:30	12:30	6:00	17:30	13:00	6:00	17:00	14:00	6:00	16:00
13	15:30	6:30	15:00	16:00	6:00	14:00							18:00	6:00	12:00	17:30	6:00	12:30	13:00	6:00	17:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	13:00	6:00	17:00	14:00	6:00	16:00
14	15:30	5:30	14:00	16:00	6:00	14:00							18:00	6:00	12:00	17:00	6:00	13:00	13:00	6:00	17:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	13:00	6:00	17:00	14:00	6:00	16:00
15	15:30	5:55	14:25	18:30	6:00	11:30							19:00	6:00	11:00	16:00	6:00	14:00	13:00	6:00	17:00	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
16	15:30	6:00	14:30	19:30	6:00	10:30							17:00	6:00	13:00	16:00	6:00	14:00	13:00	6:00	17:00	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
17	15:30	6:00	14:30	20:00	6:00	10:00							17:00	6:00	13:00	16:00	6:00	14:00	13:00	6:00	17:00	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
18	15:30	6:00	14:30	21:00	6:00	9:00							17:00	6:00	13:00	16:30	6:00	13:30	13:00	6:00	17:00	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
19	16:00	6:00	14:00	21:00	6:00	9:00							17:00	6:00	13:00	16:30	5:30	13:00	13:00	6:00	17:00	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
20	16:00	6:00	14:00	21:00	6:00	9:00							17:00	6:00	13:00	16:30	6:00	13:30	12:00	6:00	18:00	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
21	15:30	6:00	14:30	21:00	6:00	9:00							17:00	6:00	13:00	16:30	6:00	13:30	12:00	6:00	18:00	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
22	13:30	6:00	16:30	21:30	6:00	8:30							17:00	6:00	13:00	16:30	6:00	13:30	12:00	6:00	18:00	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
23	15:30	6:00	14:30	21:00	6:00	9:00							17:00	6:00	13:00	16:30	6:00	13:30	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
24	15:30	6:00	14:30	22:00	6:00	8:00							17:00	6:00	13:00	17:00	5:00	12:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
25	15:30	6:00	14:30	21:00	6:00	9:00							17:00	6:00	13:00	14:00	6:00	16:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
26	15:30	6:20	14:50	21:00	6:00	9:00							17:00	6:00	13:00	15:00	6:00	15:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
27	15:30	6:35	15:05	20:30	6:00	9:30							17:00	6:00	13:00	15:00	6:00	15:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
28	15:00	6:00	15:00	20:30	6:00	9:30							17:00	6:00	13:00	15:00	6:00	15:00	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
29	15:00	6:00	15:00										18:00	6:00	12:00	14:30	6:00	15:30	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	14:00	6:00	16:00
30	14:30	6:00	15:30										18:00	6:00	12:00	14:30	6:00	15:30	12:30	6:00	17:30	12:30	6:00	17:30	12:30	6:00	17:30	12:00	6:00	18:00	13:00	6:00	17:00	16:00	6:00	14:00
31	14:30	6:00	15:30										18:00	6:00	12:00				12:30	6:00	17:30	12:30	6:00	17:30				12:00	6:00	18:00				16:00	6:00	14:00
Total			470hrs			340hrs			25hrs			0hrs			293hrs			398hrs			521hrs			537hrs			525hrs			553hrs			520hrs			496hrs
days			31			28			3			0			16			30			31			31			30			31			30			31
2002																																				
1	16:00	6:00	14:00	15:00	6:00	15:00										23:00	5:00	6:00	18:00	5:00	11:00	14:00	5:00	15:00	14:00	5:00	15:00	13:00	5:00	16:00	13:00	5:00	16:00	14:00	5:00	15:00
2	16:00	6:00	14:00	15:00	6:00	15:00										23:00	5:00	6:00	18:00	5:00	11:00	14:00	5:00	15:00	14:00	5:00	15:00	13:00	5:00	16:00	13:00	5:00	16:00	14:00	5:00	15:00
3	16:00	6:00	14:00	15:00	6:00	15:00										23:00	5:00	6:00	18:00	5:00	11:00	14:00	5:00	15:00	14:00	5:00	15:00	13:00	5:00	16:00	13:00	5:00	16:00	14:00	5:00	15:00
4	16:00	6:00	14:00	15:00	6:00	15:00										0:00	5:00	5:00	17:00	5:00	12:00	14:00	5:00	15:00	14:00	5:00	15:00	13:00	5:00	16:00	13:00	5:00	16:00	14:00	5:00	15:00
5	16:00	6:00	14:00	16:00	6:00	14:00										23:00	5:00	6:00	17:00	5:00	12:00	15:00	5:00	14:00	14:00	5:00	15:00	13:00	5:00	16:00	13:00	5:00	16:00	14:00	5:00	15:00
6	14:00	6:00	16:00	17:00	6:00	13:00										23:00	5:00	6:00	17:00	5:00	12:00	16:00	5:00	13:00	14:00	5:00	15:00	13:00	5:00	16:00	13:00	5:00	16:00	14:00	5:00	15:00
7	14:00	6:00	16:00	17:00	6:00	13:00										23:00	5:00	6:00	17:00	5:00	12:00	14:00	5:00	15:00	12:30	5:00	16:30	13:00	5:00	16:00	13:00	5:00	16:00	14:00	5:00	15:00
8	14:00	6:00	16:00	17:00	6:00	13:00										23:00	5:00	6:00	17:00	5:00	12:00	14:00	5:00	15:00	11:40	5:00	17:20	12:00	5:00	17:00	13:00	5:00	16:00	14:00	5:00	15:00
9	14:00	6:00	16:00	17:00	6:00	13:00										22:00	5:00	7:00	17:00	5:00	12:00	14:00	5:00	15:00	12:00	5:00	17:00	12:00	5:00	17:00	13:00	5:00	16:00	14:00	5:00	15:00
10	14:00	6:00	16:00	17:00	6:00	13:00										21:00	5:00	8:00	16:00	5:00	13:00	14:00	5:00	15:00	12:00	5:00	17:00	12:00	5:00	17:00	13:00	5:00	16:00	13:00	5:00	16:00
11	14:00	6:00	16:00	17:00	6:00	13:00										20:00	5:00	9:00	17:00	5:00	12:00	14:00	5:00	15:00	14:00	5:00	15:00	12:00	5:00	17:00	13:00	5:00	16:00	14:00	5:00	15:00
12	14:00	6:00	16:00	17:00	6:00	13:00										20:00	5:00	9:00	17:00	5:00	12:00	14:00	5:00	15:00	14:00	5:00	15:00	12:00	5:00	17:00	13:00	5:00	16:00	15:00	5:00	14:00
13	14:00	6:00	16:00	16:00	6:00	14:00										19:00	5:00	10:00	17:00	5:00	12:00	14:00	5:00	15:00	14:00	5:00	15:00	12:00	5:00	17:00	13:00	5:00	16:00	16:00	5:00	13:00
14	14:00	6:00	16:00	16:00	6:00	14:00										19:00	5:00	10:00	17:00	5:00	12:00	14:00	5:00	15:00	14:00	5:00	15:00	12:00	5:00	17:00	13:00	5:00	16:00	16:00	5:00	13:00
15	14:00	6:00	16:00	16:00	6:00	14:00										19:00	5:00	10:00	16:00	5:00	13:00	14:00	5:00	15:00	14:00	5:00	15:00	12:00	5:00	17:00	13:00	5:00	16:00	16:00	5:00	13:00
16	14:00	6:00	16:00	16:00	6:00	14:00										19:00	5:00	10:00	17:00	5:00	12:00	14:00	5:00	15:00	14:00	5:00	15:00	12:00	5:00	17:00	13:00	5:00	16:00	16:00	5:00	13:00
17	13:00	6:00	17:00	18:00	6:00	12:00										19:00	5:00	10:00	17:00	5:00	12:00	14:00	5:00	15:00	13:00	5:00	16:00	12:00	5:00	17:00	13:00	5:00	16:00	16:00	5:00	13:00
18	13:00	6:00	17:00	18:00	6:00	12:00										19:00	5:00	10:00	17:00	5:00	12:00	13:00	5:00	16:00	13:00	5:00	16:00	12:00	5:00	17:00	13:00	5:00	16:00	16:00	5:00	13:00
19	13:00	6:00	17:00													19:00	5:00	10:00	17:00	5:00	12:00	14:00	5:00	15:00	13:00	5:00	16:00	12:00	5:00	17:00	13:00	5:00	16:00	16:00	5:00	13:00
20	13:00	6:00	17:00													19:00	5:00	10:00	17:00	5:00	12:00	14:00	5:00	15:00	13:00	5:00	16:00	12:00	5:00	17:00	13:00	5:00	16:00	16:00	5:00	13:00
21	13:00	6:00	17:00	22:00	6:00	8:00										19:00	5:00	10:00	17:00	5:00	12:00	14:00	5:00	15:00	13:00	5:00	16:00	12:00	5:00	17:00	13:00	5:00	16:00	19:00	21:00	2:00
22	13:00	6:00	17:00													19:00	5:00	10:00	16:00	5:00	13:00	14:00	5:00	15:00	13:00	5:00	16:00	13:00	5:00	16:00	13:00	5:00	16:00			
23	13:00	6:00	17:00													19:00	5:00	10:00	16:00	5:00	13:00	14:00	5:00	15:00	13:00	5:00	16:00	13:00	5:00	16:00	13:00	5:00	16:00			
24	13:00	6:00	17:00													19:00	5:00	10:00	16:00	5:00	13:00	14:00	5:00	15:00	13:00	5:00	16:00	13:00	5:00	16:00	13:00	5:00	16:00			
25	14:00	6:00	16:00													19:00	5:00	10:00	16:00	5:00	13:00	14:00	5:00	15:00	13:00	5:00	16:00	13:00	5:00	16:00	14:00	5:00	15:00	0:00	5:00	5:00
26	14:00	6:00	16:00													19:00	5:00	10:00	16:00	5:00	13:00	14:00	5:00	15:00	13:00	5:00	16:00	13:00	5:00	16:00	14:00	5:00	15:00	20:00	5:00	9:00
27	14:00	6:00	16:00													19:00	5:00	10:00	16:00	5:00	13:00	14:00	5:00	15:00	13:00	5:00	16:00	13:00	5:00	16:00	14:00	5:00	15:00	17:00	5:00	12:00
28	14:00	6:00	16:00													19:00	5:00	10:00	16:00	5:00	13:00	14:00	5:00	15:00	12:30	5:00	16:30	12:00	5:00	17:00	14:00	5:00	15:00	17:00	5:00	12:00
29	14:00	6:00	16:00													19:00	5:00	10:00	15:00	5:00	14:00	14:00	5:00	15:00	13:00	5:00	16:00	12:00	5:00	17:00	14:00	5:00	15:00	15:00	5:00	14:00
30	14:00	6:00	16:00										23:00	5:00	6:00	18:00	5:00	11:00	15:00	5:00	14:00	14:00	5:00	15:00	13:00	5:00	16:00	13:00	5:00	16:00	14:00	5:00	15:00	18:00	5:00	11:00
31	15:00	6:00	15:00										23:00	5:00	6:00				14:00	5:00	15:00	14:00	5:00	15:00				13:00	5:00	16:00				18:00	5:00	11:00
Total			493hrs			253hrs			0hrs			0hrs			12hrs			261hrs			385hrs			463hrs			472hrs			512hrs			474hrs			384hrs
days			31			19			0			0			0			30			31			31			30			31			30			28

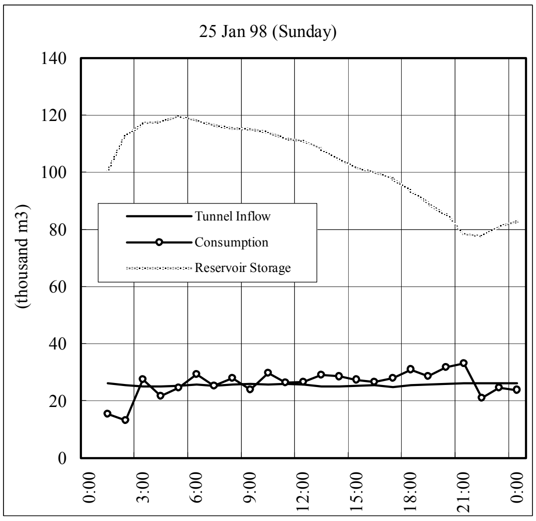
Table 1-2-3 Suspension Hours of Water Supply (2003-2004)

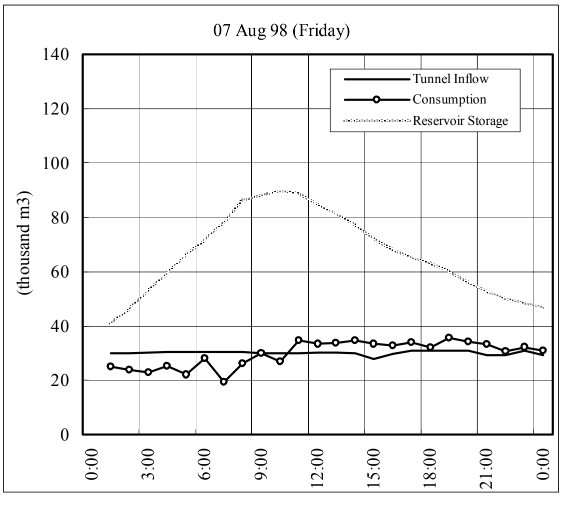
	Jan			Feb			Mar			Apr			May			Jun			Jul			Aug			Sep			Oct			Nov			Dec		
Date	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.	From	To	hrs.
2003																																				
1	18:00	5:00	11:00	23:00	5:00	6:00																						0:00	2:00	2:00				0:00	3:00	3:00
2	18:00	5:00	11:00																									0:00	2:00	2:00				0:00	3:30	3:30
3	17:00	5:00	12:00																									0:00	4:30	4:30				0:00	5:00	5:00
4	17:00	5:00	12:00																									0:00	3:00	3:00				0:00	5:00	5:00
5	17:00	5:00	12:00																									0:00	3:00	3:00				0:00	5:00	5:00
6																												0:00	4:00	4:00				0:00	5:00	5:00
7																												0:00	4:00	4:00				0:00	5:00	5:00
8																												22:00	4:00	6:00				0:00	5:00	5:00
9																												0:00	4:00	4:00				0:00	3:30	3:30
10																												22:00	4:00	6:00				0:00	5:00	5:00
11																												22:00	4:00	6:00				0:00	4:00	4:00
12																												22:00	4:00	6:00				0:00	5:00	5:00
13																												22:00	4:00	6:00				0:00	5:00	5:00
14																												23:00	4:00	5:00				0:00	5:00	5:00
15																												23:00	4:00	5:00				0:00	5:00	5:00
16																												23:00	4:00	5:00				0:00	3:30	3:30
17																												22:00	4:00	6:00				0:00	4:30	4:30
18																												22:00	4:00	6:00				0:00	4:00	4:00
19																												0:00	4:00	4:00				0:00	4:45	4:45
20																												23:00	4:00	5:00				0:00	5:00	5:00
21																												22:00	2:30	4:30				0:00	5:00	5:00
22	0:30	5:00	4:30																									22:00	4:00	6:00				0:00	5:00	5:00
23	0:00	5:00	5:00																									22:00	4:00	6:00				0:00	4:00	4:00
24	0:00	5:00	5:00																									22:00	4:00	6:00				0:00	4:30	4:30
25	22:00	5:00	7:00																						0:00	3:00	3:00	22:00	4:00	6:00				0:00	5:00	5:00
26	22:00	5:00	7:00																						0:00	3:00	3:00	22:00	4:00	6:00				0:00	5:00	5:00
27	1:00	5:00	4:00																						0:00	4:00	4:00	22:00	4:00	6:00				0:00	5:00	5:00
28	1:00	5:00	4:00																						0:00	2:00	2:00							0:00	5:00	5:00
29	2:00	5:00	3:00																						0:00	3:00	3:00							0:00	3:30	3:30
30	3:00	5:00	2:00																						0:00	2:00	2:00							0:00	5:00	5:00
31	22:00	5:00	7:00																																	
Total			203hrs			6hrs			0hrs			0hrs			0hrs			0hrs			0hrs			0hrs			17hrs			133hrs			0hrs			138hrs
days			15			1			0			0			0			0			0			0			6			27			0			30
2004																																				
1	12:00	4:00	4:00																			12:00	4:00	4:00	12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	11:00	4:30	5:30
2	12:00	4:00	4:00																			12:00	4:00	4:00	12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	10:30	5:00	6:30
3	12:00	4:00	4:00																			12:00	5:00	5:00	12:00	4:00	4:00	12:00	5:00	5:00	9:00	2:00	5:00	12:00	4:00	4:00
4	12:00	4:00	4:00																			12:00	4:00	4:00	12:00	4:30	4:30	12:00	5:00	5:00	9:00	2:00	5:00	11:00	4:00	5:00
5	12:00	5:00	5:00																			12:00	5:00	5:00	12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	11:00	4:30	5:30
6	12:00	4:00	4:00																			12:00	3:00	3:00	12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	10:30	5:00	6:30
7	12:00	4:00	4:00																			12:00	3:00	3:00	12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	11:00	5:00	6:00
8	12:00	5:00	5:00																			12:00	3:00	3:00	12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	12:00	5:00	5:00
9	12:00	5:00	5:00																			12:00	4:30	4:30	12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00			
10	12:00	5:00	5:00																			11:20	4:00	4:00	12:00	5:00	5:00	12:00	5:00	5:00						
11	11:15	5:15	6:00																			12:00	4:00	4:00	12:00	4:00	4:00	12:00	5:00	5:00	9:00	2:00	5:00	12:00	4:00	4:00
12	12:00	4:30	4:30																			12:00	4:30	4:30	12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00			
13	12:00	5:00	5:00																						12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00			
14	12:00	5:00	5:00																			12:00	3:00	3:00	12:00	5:00	5:00	12:00	5:00	5:00	11:00	5:00	6:00			
15	12:00	5:00	5:00																			12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	11:00	5:00	6:00			
16	12:00	4:00	4:00																			12:00	5:00	5:00				9:00	2:00	5:00	12:00	4:00	4:00			
17	12:00	4:30	4:30																			12:00	5:00	5:00				9:00	2:00	5:00	12:00	5:00	5:00			
18	12:00	4:30	4:30																			12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00						
19	12:00	4:00	4:00																			10:00	5:00	7:00				9:00	2:00	5:00	11:00	5:00	6:00			
20																						12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	11:00	5:00	6:00			
21																						12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	10:30	5:00	6:30			
22																						12:00	5:00	5:00	11:00	5:00	6:00	9:00	2:00	5:00	9:00	5:00	8:00			
23																						12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	10:00	3:00	5:00			
24																			12:00	3:00	3:00	12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	11:00	5:00	6:00			
25																			12:00	4:00	4:00	12:00	4:30	4:30	12:00	5:00	5:00	9:00	2:00	5:00	9:00	4:30	7:30			
26																			13:00	3:00	2:00	12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	9:00	5:00	8:00			
27																			12:00	4:00	4:00				12:00	5:00	5:00	9:00	2:00	5:00	10:00	5:00	7:00			
28																						12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	12:00	5:00	5:00			
29																			12:00	4:00	4:00	12:00	5:00	5:00	12:00	5:00	5:00	9:00	2:00	5:00	9:00	4:30	7:30			
30																						10:30	5:00	6:30	12:00	5:00	5:00	9:00	2:00	5:00						
31																			12:00	3:00	3:00	12:00	4:20	4:20				9:00	2:00	5:00						
Total			87hrs			0hrs			0hrs			0hrs			0hrs			0hrs			20hrs			133hrs			134hrs			155hrs			154hrs			48hrs
days			19			0			0			0			0			0			6			29			27			30			27			9

Table 1-3-1 Daily Water Balance at New Wali Reservoir (1998)

	16 Jan '98 (Friday)			25 Jan '98 (Sunday)			07 Aug '98 (Friday)			16 Aug '98 (Sunday)		
Time	Inflow	Outflow	Reservoir	Inflow	Outflow	Reservoir	Inflow	Outflow	Reservoir	Inflow	Outflow	Reservoir
0:00												
1:00	24.984	17.734	81.500	25.999	15.499	101.000	30.012	25.012	41.000	28.574	20.149	49.000
2:00	25.184	8.934	93.250	25.429	13.179	112.375	30.001	23.876	46.563	28.477	11.402	61.750
3:00	25.309	22.559	102.750	24.838	27.463	117.188	30.253	22.878	53.313	28.703	9.703	79.788
4:00	25.437	15.187	109.250	25.161	21.786	117.563	30.374	25.249	59.563	28.764	11.889	97.725
5:00	25.370	25.620	114.250	25.216	24.591	119.563	30.373	21.998	66.313	28.793	18.543	111.288
6:00	25.259	27.509	113.000	25.719	29.219	118.125	30.368	27.993	71.688	28.821	31.571	115.038
7:00	25.012	23.012	112.875	25.205	25.205	116.375	30.419	19.169	78.500	28.820	26.820	114.663
8:00	24.946	25.946	113.375	25.699	27.949	115.250	30.288	26.163	86.188	28.857	29.407	115.388
9:00	24.949	25.949	112.375	25.816	23.941	115.063	30.035	30.035	88.250	28.468	31.543	113.575
10:00	24.916	29.666	109.500	25.752	29.877	113.938	29.907	26.907	89.750	28.440	33.190	109.663
11:00	24.785	31.285	103.875	25.914	26.414	111.625	30.038	34.788	88.875	28.986	35.861	103.850
12:00	25.281	29.656	98.438	25.705	26.580	110.938	30.091	33.341	84.875	28.746	35.121	97.225
13:00	26.310	32.885	92.963	24.865	29.115	108.375	30.106	33.731	81.438	28.392	31.767	92.350
14:00	26.620	31.545	87.213	24.940	28.565	104.438	29.995	34.620	77.313	28.202	31.077	89.225
15:00	26.503	30.753	82.625	25.198	27.323	101.563	27.775	33.275	72.250	28.754	35.629	84.350
16:00	25.150	30.025	78.063	25.555	26.555	100.000	29.851	32.726	68.063	28.816	34.691	77.975
17:00	25.023	29.273	73.500	24.719	27.969	97.875	30.877	33.877	65.125	28.788	33.363	72.750
18:00	25.410	26.410	70.875	25.450	30.950	93.500	30.869	31.994	63.063	28.792	33.217	68.250
19:00	25.194	32.069	66.938	25.714	28.714	89.250	30.877	35.502	60.188	28.746	31.496	64.663
20:00	25.299	25.674	63.313	25.900	31.650	84.875	30.841	34.091	56.250	28.752	31.377	61.975
21:00	25.275	26.775	62.375	26.069	33.069	78.500	29.256	33.131	52.688	28.776	32.126	58.988
22:00	25.378	23.628	62.500	26.018	20.893	77.563	29.142	30.642	50.000	28.778	31.153	56.125
23:00	25.903	15.028	68.813	26.014	24.514	80.875	30.707	32.207	48.500	29.085	32.235	53.363
0:00	25.607	14.107	80.000	26.282	23.782	82.875	29.230	30.855	46.938	29.337	29.712	51.600
Max		32.885	114.250		33.069	119.563		35.502	89.750		35.861	115.388
Min		8.934	62.375		13.179	77.563		19.169	41.000		9.703	49.000
		23.951	51.875		19.890	42.000		16.333	48.750		26.158	66.388


16 Jan 98 (Friday)


25 Jan 98 (Sunday)


07 Aug 98 (Friday)

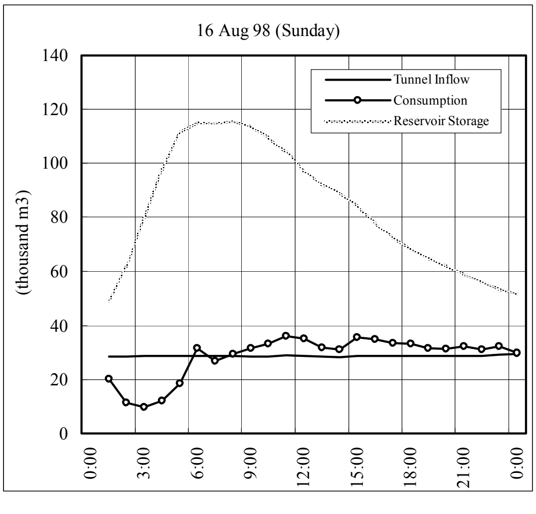
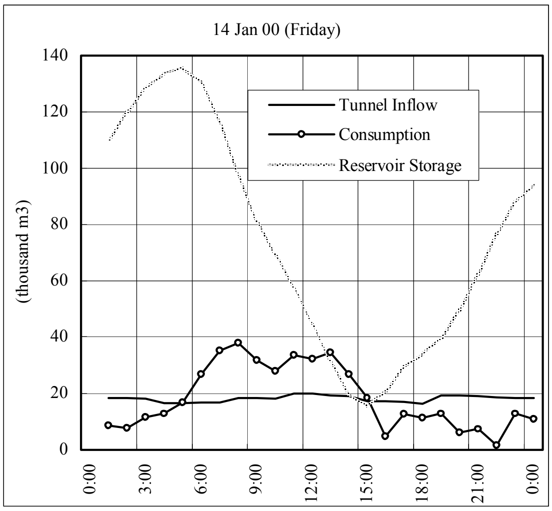
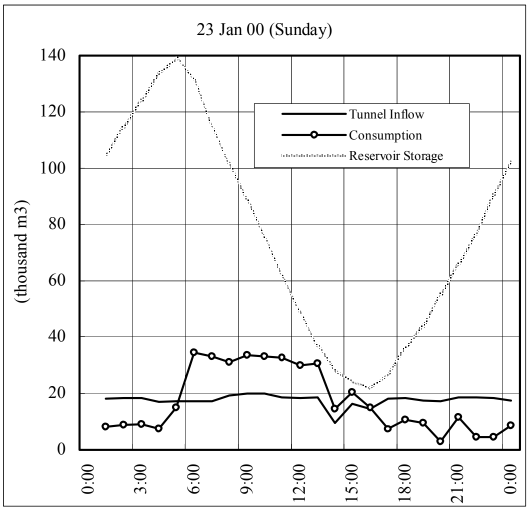
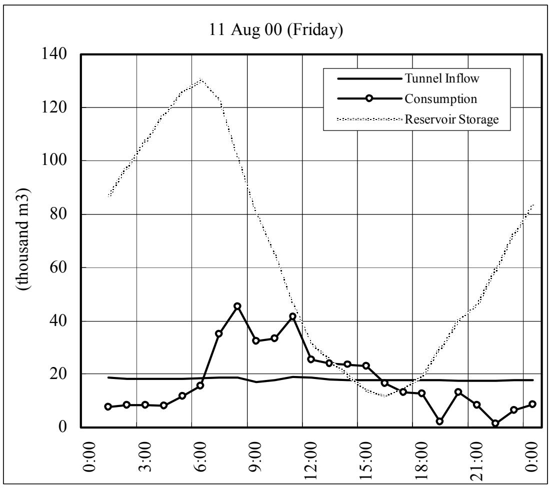

16 Aug 98 (Sunday)

Table 1-3-2 Daily Water Balance at New Wali Reservoir (2000)

	14 Jan '00 (Friday)			23 Jan '00 (Sunday)			11 Aug '00 (Friday)			20 Aug '00 (Sunday)		
Time	Inflow	Outflow	Reservoir	Inflow	Outflow	Reservoir	Inflow	Outflow	Reservoir	Inflow	Outflow	Reservoir
0:00												
1:00	18.317	8.692	110.000	18.157	8.157	105.000	18.585	7.710	87.000	18.455	11.330	90.000
2:00	18.163	7.788	120.000	18.162	8.787	114.688	18.293	8.418	97.375	18.458	8.958	98.313
3:00	18.145	11.395	128.563	18.164	8.939	123.988	18.309	8.309	107.313	18.706	7.206	108.813
4:00	16.555	12.805	133.813	16.984	7.459	133.363	18.204	8.204	117.313	18.168	7.543	119.875
5:00	16.536	16.661	135.625	17.109	15.109	139.125	18.286	11.786	125.563	18.471	12.221	128.313
6:00	16.755	26.630	130.625	17.392	34.392	131.625	18.515	15.765	130.188	18.445	13.695	133.813
7:00	16.747	35.247	116.438	17.387	33.137	115.250	18.595	35.095	123.313	18.389	40.264	125.250
8:00	18.427	37.927	97.438	19.332	30.957	101.563	18.631	45.256	101.750	18.381	41.506	102.750
9:00	18.386	31.886	80.938	19.992	33.617	88.938	17.088	32.338	80.813	19.079	34.204	83.625
10:00	18.123	27.873	69.313	19.946	33.196	75.500	17.714	33.339	65.375	18.961	44.211	63.438
11:00	19.939	33.564	57.625	18.541	32.791	61.750	19.070	41.570	46.313	18.203	37.078	41.375
12:00	19.967	32.092	44.750	18.385	30.010	48.813	18.734	25.484	31.688	17.867	30.867	25.438
13:00	19.383	34.383	31.188	18.576	30.701	36.938	18.102	23.977	25.375	16.228	22.728	15.688
14:00	19.038	26.788	19.813	9.605	14.480	28.438	17.861	23.611	19.563	16.882	19.882	10.938
15:00	17.355	18.480	15.375	16.292	20.292	24.000	17.633	23.133	13.938	17.823	17.198	9.750
16:00	17.044	4.669	21.000	14.409	14.909	21.750	17.579	16.454	11.750	18.096	11.846	13.188
17:00	17.029	12.654	29.375	18.084	7.334	26.875	17.608	13.233	14.500	18.075	11.575	19.563
18:00	16.348	11.348	34.063	18.211	10.461	36.125	17.775	12.650	19.250	17.972	9.597	27.000
19:00	19.220	12.720	39.813	17.483	9.358	44.063	17.794	2.169	29.625	17.962	7.337	36.500
20:00	19.292	6.042	49.688	17.049	2.799	55.250	17.570	13.195	39.625	17.937	9.312	46.125
21:00	19.013	7.388	62.125	18.613	11.488	65.938	17.388	8.263	46.375	17.532	7.282	55.563
22:00	18.618	1.493	76.500	18.583	4.583	76.500	17.543	1.418	59.000	18.053	10.178	64.625
23:00	18.385	12.885	87.813	18.528	4.528	90.500	17.813	6.563	72.688	17.903	9.903	72.563
0:00	18.208	10.833	94.250	17.441	8.566	101.938	17.597	8.722	82.750	16.587	8.212	80.750
Max	19.967	37.927	135.625	19.992	34.392	139.125	19.070	45.256	130.188	19.079	44.211	133.813
Min	16.348	1.493	15.375	9.605	2.799	21.750	17.088	1.418	11.750	16.228	7.206	9.750
	3.619	36.434	120.250	10.387	31.593	117.375	1.982	43.838	118.438	2.851	37.005	124.063







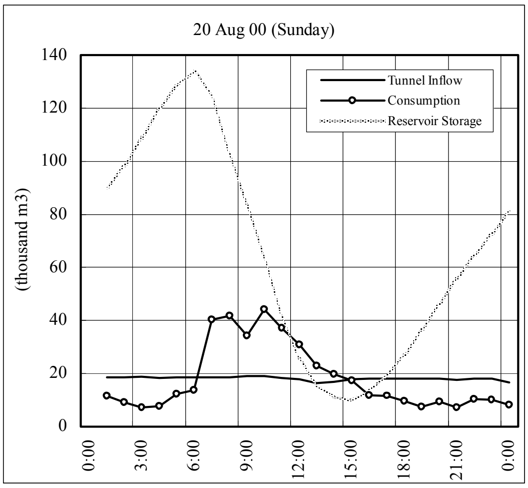
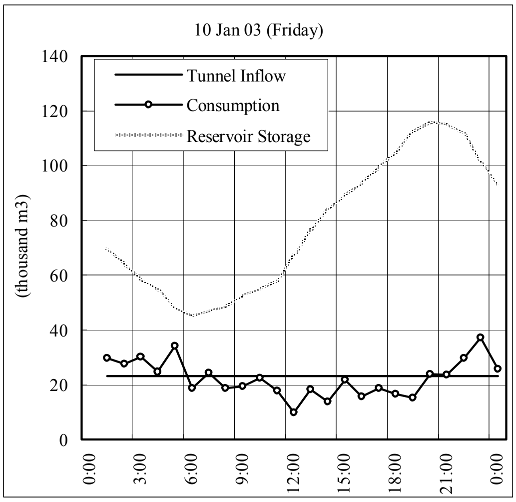
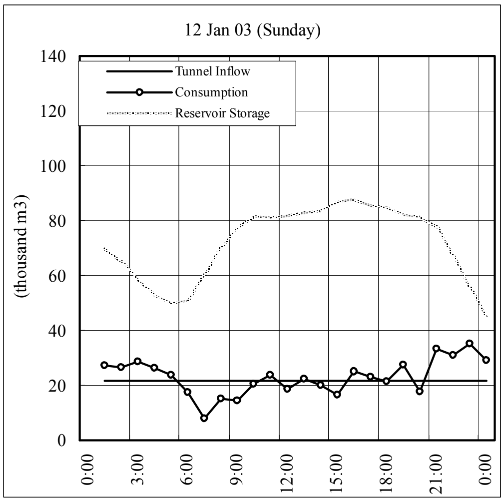
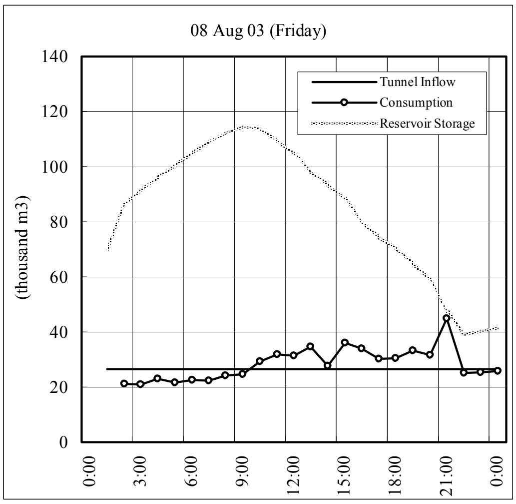


Table 1-3-3 Daily Water Balance at New Wali Reservoir (2003)

	10 Jan '03 (Friday)			12 Jan '03 (Sunday)			08 Aug '03 (Friday)			10 Aug '03 (Sunday)		
Time	Inflow	Outflow	Reservoir	Inflow	Outflow	Reservoir	Inflow	Outflow	Reservoir	Inflow	Outflow	Reservoir
0:00												
1:00	23.231	29.752	70.000	21.733	27.156	70.000	26.460		70.000	27.371		70.000
2:00	23.231	27.721	64.494	21.733	26.669	64.821	26.460	21.006	85.957	27.371	23.947	85.397
3:00	23.231	30.191	58.769	21.733	28.637	58.901	26.460	20.756	91.536	27.371	21.115	90.237
4:00	23.231	24.765	54.522	21.733	26.438	53.096	26.460	22.827	96.204	27.371	19.917	97.092
5:00	23.231	33.985	48.378	21.733	23.662	49.779	26.460	21.496	100.503	27.371	23.354	102.828
6:00	23.231	18.823	45.205	21.733	17.533	50.915	26.460	22.529	104.951	27.371	25.138	105.953
7:00	23.231	24.336	46.856	21.733	7.935	59.914	26.460	22.375	108.959	27.371	19.035	111.237
8:00	23.231	18.734	48.552	21.733	15.080	70.140	26.460	24.033	112.214	27.371	27.617	115.281
9:00	23.231	19.381	52.725	21.733	14.301	77.182	26.460	24.684	114.316	27.371	32.227	112.730
10:00	23.231	22.540	54.996	21.733	20.496	81.517	26.460	29.229	113.819	27.371	29.519	109.228
11:00	23.231	17.914	57.999	21.733	23.698	81.153	26.460	31.815	109.756	27.371	33.999	104.839
12:00	23.231	9.901	67.323	21.733	18.705	81.684	26.460	31.168	104.725	27.371	31.711	99.355
13:00	23.231	18.266	76.471	21.733	22.295	82.917	26.460	34.609	98.297	27.371	31.567	95.087
14:00	23.231	13.825	83.656	21.733	20.051	83.478	26.460	27.641	93.632	27.371	31.402	90.974
15:00	23.231	21.783	89.083	21.733	16.589	86.891	26.460	35.862	88.340	27.371	30.524	87.382
16:00	23.231	15.789	93.528	21.733	25.047	87.806	26.460	33.870	79.934	27.371	29.831	84.575
17:00	23.231	18.808	99.460	21.733	23.157	85.437	26.460	30.113	74.402	27.371	31.595	81.233
18:00	23.231	16.816	104.878	21.733	21.557	84.814	26.460	30.581	70.515	27.371	34.358	75.627
19:00	23.231	15.111	112.145	21.733	27.344	82.096	26.460	33.218	65.076	27.371	31.644	69.997
20:00	23.231	23.981	115.830	21.733	17.728	81.293	26.460	31.466	59.194	27.371	31.982	65.555
21:00	23.231	23.835	115.153	21.733	33.156	77.585	26.460	44.926	47.458	27.371	29.722	62.074
22:00	23.231	29.822	111.555	21.733	30.939	67.271	26.460	25.037	38.936	27.371	28.455	60.356
23:00	23.231	37.284	101.234	21.733	35.205	55.932	26.460	25.226	40.264	27.371	27.101	59.949
0:00	23.231	25.617	93.014	21.733	29.212	45.457	26.460	25.590	41.316	27.371	26.733	60.403
Max		37.284	115.830		35.205	87.806		44.926	114.316		34.358	115.281
Min		9.901	45.205		7.935	45.457		20.756	38.936		19.035	59.949
		27.383	70.625		27.270	42.349		24.170	75.380		15.323	55.332







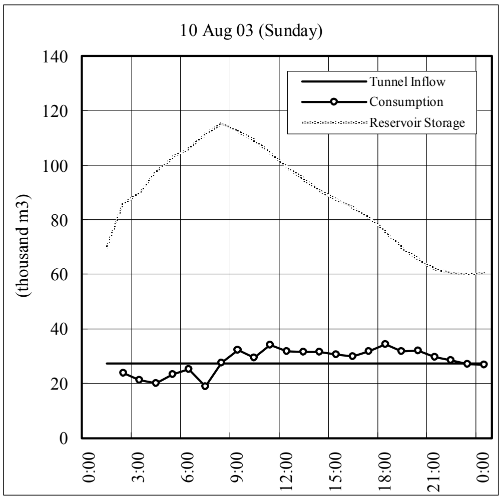


Table 1-4-1 Daily Rainfall (1999-2001)

Sta.1: Sergaya Sta.2: Zabadani Sta.3: Madaya Sta.4: Looudan Sta.5: Herera

(Source : DAWSSA Data)

	Oct. '99					Nov. '99					Dec. '99					Jan. '00					Feb. '00					Mar. '00					Apr. '00					May '00					Total
Date	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	
1	No. in () stands for rainfall in Sep					1.0	2.0	2.5	1.3	0.0																	5.5	3.5	3.0	7.0	5.5												
2																												15.5	14.0	12.0	15.0	17.0												
3																												0.7	1.5	1.0	0.0	0.0												
4																3.5	3.5	3.0	3.5	3.6																									
5																13.0	16.0	12.0	4.2	4.0																									
6																23.0	23.0	19.0	31.0	26.0	11.0	8.5	7.0	13.0	4.0																				
7						6.0	3.0	3.0	.8	3.4											3.0	2.0	2.0	_	_	2.0	2.5	1.5	1.5	2.0												
8																4.0	4.5	5.0	3.0	0.0																									
9	(0.5)	(0.0)	(0.0)	(0.0)	(0.0)											0.7	0.5	0.5	1.0	3.5						5.2	5.0	4.0	7.4	0.0	2.0	1.0	1.0	0.6	1.0							
10																8.0	2.0	1.5	2.5	0.0											9.7	12.0	10.0	5.5	6.5							
11																5.7	3.5	3.0	3.6	3.0																									
12																												1.0	1.5	1.0	0.7	1.5												
13																					1.0	1.3	1.0	1.0	2.0																				
14											7.0	6.5	6.0	6.5	3.0						5.0	4.5	4.0	6.2	11.0																				
15											28.0	23.0	20.0	17.0	11.2						0.3	1.0	1.0	0.8	_																				
16																					11.7	12.0	9.0	16.0	15.0																				
17																					12.5	16.0	13.0	9.0	4.0																				
18																																									
19																25.0	22.0	20.0	23.5	22.0																									
20																13.0	6.0	5.0	5.8	4.5	5.0	8.0	6.0	2.5	2.0																				
21																45.0	44.0	40.0	24.3	26.0																									
22																5.0	3.0	2.0	5.4	6.0						12.8	11.0	10.0	10.5	12.0												
23																13.0	23.0	20.0	19.5	12.0	3.5	2.0	1.5	3.0	3.5																				
24																2.5	2.0	2.0	1.5	0.0	0.7	1.0	1.0	0.4	0.0	4.0	1.5	1.5	4.0	3.0	2.8	1.9	1.8	0.8	3.5							
25											2.0	1.0	1.0	2.2	3.2											0.5	1.0	1.0	0.0	3.0	0.5	0.0	0.0	0.7	7.0							
26						8.0	12.0	10.0	7.0	3.5	8.0	3.0	3.0	2.5	2.0	16.0	15.0	13.0	5.0	8.0																									
27	2.5	1.0	1.5	0.0	0.0											13.3	5.5	5.0	9.2	10.0																									
28											4.3	3.0	2.5	2.6	0.7	20.0	13.0	10.0	8.2	12.0	0.1	0.0	0.0	0.0	0.0						5.3	2.0	2.0	6.0	4.5							
29																																									
30																																									
31																																									
Total	3	1	2	0	0	15	17	16	14	7	49	37	33	31	20	211	187	161	151	141	54	56	46	52	42	47	42	35	46	44	20	17	15	14	23	0	0	0	0	0	
Avg.					1					14					34					170					50					43					18					0	329

	Oct. '00					Nov. '00					Dec. '00					Jan. '01					Feb. '01					Mar. '01					Apr. '01					May '01					Total
Date	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	
1	No. in () stands for rainfall in Sep.											34.0	26.0	27.0	38.5	35.0																									0.5	0.1	0.1	0.5	1.0	
2																																				2.5	0.6	0.2	0.0	0.0	
3																															0.5	0.0	0.0	0.8	0.0	4.0	0.2	0.1	1.0	1.0	
4																					31.7	26.0	16.6	22.0	10.0						0.5	0.0	0.0	0.3	2.0						
5																					10.0	6.5	10.0	7.0	10.0																
6																															0.0	1.0	1.0	0.0	0.0						
7																																									
8																					5.3	6.0	9.0	6.0	7.0																
9																																				5.2	0.6	1.0	0.4	0.9	
10											2.0	3.0	1.0	6.6	18.0																									1.6	3.0	3.5	3.2	1.5	
11																																									
12											0.3	0.7	0.8	0.7	0.0																													
13											25.3	12.0	10.0	12.3	15.0																									2.0	1.5	1.0	1.2	0.0	
14											0.8	10.0	12.0	5.4	6.0						4.3	3.0	3.0	3.2	10.0	0.4	1.5	3.0	0.2	0.0						0.8	0.5	0.0	0.0	0.0	
15	1.5	2.7	1.5	0.0	0.0																47.6	39.0	28.0	28.3	20.0																
16	2.0	0.6	1.0	0.0	2.0																3.6	2.0	1.0	3.0	2.0																
17	1.8	1.0	3.0	0.5	14.0																1.0	0.0	0.0	1.0	2.4																
18						1.0	0.5	1.0	1.0	0.0						3.0	4.0	4.0	2.7	9.5	16.0	8.5	6.0	10.0	5.0																
19											1.4	0.3	1.0	1.3	0.0	2.8	2.5	1.5	3.9	2.4	0.5	0.1	0.0	0.3	2.0																
20											44.6	33.0	30.0	41.5	33.0	3.4	2.0	1.3	2.5	3.0	13.7	4.0	5.0	10.0	6.0																
21											9.4	24.0	38.0	9.0	30.0	0.0	0.6	0.3	1.2	0.0	25.0	16.0	14.0	17.6	21.0																
22											0.9	4.0	2.0	0.0	12.0						1.4	0.5	1.0	0.0	0.0																
23	10.7	7.0	2.0	7.0	1.6												1.3	1.0	0.5	0.4	1.2	4.5	3.0	4.0	5.0	1.0																
24	4.5	2.5	1.5	3.2	2.0												1.0	1.5	2.0	0.5	1.5	15.7	12.0	8.0	9.5	6.0	16.0	17.0	15.8	8.2	3.5											
25	2.0	1.0	1.8	2.1	3.0						21.0	18.0	18.0	17.2	18.0	21.5	21.5	26.0	19.0	18.0	0.6	2.0	2.0	2.0	2.0																
26	1.8	1.0	1.0	2.3	6.0						2.5	2.5	5.0	1.2	0.0	5.0	2.0	1.0	0.0	0.0																					
27																																									
28																																									
29	(3.5)	(1.0)	(2.0)	(4.8)	(3.0)																																			
30	(0.0)	(3.5)	(1.0)	(2.5)	(2.0)	9.0	5.0	6.3	7.4	9.0																														
31																																									
Total	28	20	15	22	34	10	6	7	8	9	142	134	145	134	167	38	35	37	30	36	181	129	108	125	104	16	19	19	8	4	1	1	1	1	2	17	7	6	6	4	
Avg.					24					8					144					35					129					13					1					8	363

Table 1-4-2 Daily Rainfall (2001-2003)

Sta.1: Sergaya   Sta.2: Zabadani   Sta.3: Madaya   Sta.4: Looudan   Sta.5: Herera

(Source : DAWSSA Data)

	Oct. '01					Nov. '01					Dec. '01					Jan. '02					Feb. '02					Mar. '02					Apr. '02					May '02					Total
Date	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	
1											14.0	8.5	6.8	12.0	6.0																6.4	3.0	3.0	7.0	11.0						
2											8.7	5.0	4.0	5.3	5.2																2.6	1.0	1.0	2.1	2.0						
3																8.6	7.5	7.0	10.0	7.0											15.0	15.0	15.1	12.3	11.0						
4											5.1	4.0	3.6	4.0	4.5	6.6	5.5	7.5	8.2	9.5											1.8	2.0	2.0	1.0	1.0						
5											8.1	14.0	12.0	13.2	19.0																4.5	2.0	3.0	4.0	2.5						
6											1.2	2.0	3.2	1.8	1.0	0.5	0.5	0.0	0.0	0.0																					
7						3.0	1.5	2.3	1.9	[illegible]	5.0	3.0	1.7	3.3	2.5	35.6	13.0	12.0	17.0	13.0																					
8											0.4	0.2	0.8	0.0	1.0	38.8	32.0	25.0	40.0	35.0	1.6	0.5	0.5	1.0	2.5																
9											1.3	1.5	2.1	3.5	2.6																										
10																13.7	13.0	8.0	22.0	12.0																					
11																					29.2	15.0	13.0	25.0	10.0																
12																					16.8	13.0	15.0	13.7	11.5																
13											5.8	6.0	2.5	3.6	3.6						9.8	6.0	5.4	9.1	9.5																
14																															3.8	3.0	2.2	3.0	3.0	1.0	1.0	1.0	2.0	2.0	
15											19.0	12.8	10.2	14.0	15.0																					9.4	6.0	7.0	7.0	6.0	
16																																				1.4	2.0	2.0	1.8	5.0	
17						3.5	5.0	9.3	7.0	9.2																															
18						2.0	2.7	5.0	0.6	0.0											1.4	3.0	1.2	1.4	0.5	8.2	7.0	9.2	1.0	2.0											
19											3.0	2.0	0.4	1.3	0.0																										
20											12.3	10.0	9.0	11.2	12.4											12.2	10.0	9.0	5.5	7.0	2.4	1.3	1.2	1.5	2.0						
21											2.2	1.0	0.5	0.0	0.0	18.0	15.0	12.0	22.0	24.0						16.8	12.0	14.0	9.0	15.0	24.5	22.0	21.0	20.0	18.0						
22						19.5	22.0	19.0	15.8	13.0						4.8	4.0	5.5	3.0	2.0						26.3	27.0	27.0	16.2	20.0	0.2	2.0	1.0	0.0	1.5						
23																33.7	30.0	25.0	31.8	20.0																					
24											1.0	0.0	0.0	0.0	0.0																										
25																					21.4	28.0	23.4	17.2	10.0																
26						7.5	6.5	5.2	5.7	4.0											21.8	24.0	14.5	16.3	10.0																
27	2.3	1.0	0.0	0.1	0.0	0.7	0.6	2.2	0.4	0.0	2.0	2.5	4.3	2.0	2.0											15.2	15.0	13.2	13.0	10.0											
28	7.4	3.5	3.2	3.2	0.0						5.0	2.5	2.0	3.0	3.0	5.3	3.0	3.5	3.5	5.5						10.4	9.0	8.3	9.5	10.0											
29	16.6	19.0	11.0	13.8	9.0											8.6	2.0	2.0	2.0	6.5						7.2	4.5	6.2	6.0	4.5											
30	3.5	2.5	2.7	3.0	3.6						4.6	3.0	1.2	1.8	0.0	0.0	4.0	5.3	4.0	5.0						18.6	15.0	17.3	17.0	20.0											
31																										3.8	2.5	2.7	2.2	6.0											
Total	30	26	17	20	13	36	38	43	31	30	99	78	64	80	78	174	130	113	164	140	102	90	73	84	54	119	102	107	79	95	61	51	50	51	52	12	9	10	11	13	
Avg.					21					36					80					144					80					100					53					11	525

	Oct. '02					Nov. '02					Dec. '02					Jan. '03					Feb. '03					Mar. '03					Apr. '03					May '03					Total
Date	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	
1											0.5	4.0	3.0	1.6	3.5																										
2																																									
3	0.7	0.1	0.0	0.0	0.0											4.0	2.5	1.0	5.0	2.0																					
4																3.8	4.2	5.0	4.3	5.0	56.4	41.0	32.0	45.3	50.0	9.2	17.0	7.5	12.0	7.0											
5						3.7	1.8	1.0	2.4	3.2						38.4	46.0	28.0	35.7	15.0	24.4	26.0	28.0	22.0	20.0																
6						14.5	16.0	13.0	17.0	20.0																2.6	1.5	1.0	2.5	1.5											
7																										8.5	9.0	10.0	8.2	10.0											
8																					7.1	5.5	4.5	5.8	5.0																
9																					11.3	13.5	12.1	11.0	10.0																
10						3.0	2.0	1.7	6.3	1.2	61.4	61.0	40.5	39.7	34.0						3.0	3.5	5.0	5.0	13.0																
11											28.2	32.0	36.5	19.0	23.0						2.8	3.0	2.0	2.0	0.0																
12	0.5	1.0	10.7	6.2	3.0	2.6	2.5	2.0	3.4	2.0	8.2	10.0	5.0	5.0	3.4						0.5	0.0	0.0	0.0	0.0	2.7	1.5	0.3	4.3	0.0											
13						3.0	5.0	2.5	2.5	2.2											24.4	15.0	35.0	31.5	30.0	2.2	3.5	2.0	3.0	2.0	2.2	2.5	0.0	1.0	0.0						
14																					48.8	46.0	45.0	38.0	30.0											4.5	6.0	2.0	6.2	1.0	
15	2.8	0.8	2.5	1.3	0.5											11.0	12.2	5.5	4.6	3.0	14.2	12.0	10.0	9.6	5.0						1.6	1.8	1.0	1.8	1.2						
16	0.8	0.0	0.0	1.7	0.5						5.2	4.2	4.0	4.8	5.0	7.2	8.0	7.7	5.0	7.0	5.6	10.0	5.0	6.7	10.0																
17	2.2	2.0	1.7	2.5	3.5						0.6	0.6	0.5	0.5	1.0						1.0	0.6	0.0	1.3	0.0	1.0	1.2	3.6	1.2	3.5											
18	0.2	0.0	2.5	0.0	0.5						24.2	26.0	27.0	26.5	26.0	10.4	10.0	7.0	5.5	4.5	2.7	1.3	2.4	2.5	2.0																
19											1.0	1.0	1.0	0.6	1.0	2.8	7.0	4.8	0.0	0.0	11.8	17.6	18.0	11.0	8.5	29.4	33.0	27.0	17.3	20.0											
20											75.2	81.0	60.0	63.0	35.0	0.5	0.0	0.0	0.7	2.0	53.8	48.0	29.0	34.7	20.0	28.4	47.0	23.5	20.5	12.0	3.0	3.0	4.0	5.5	4.6						
21	2.0	2.1	0.6	1.2	0.0						54.7	50.0	25.0	34.0	33.0	2.7	5.0	4.0	6.0	7.0	28.4	23.0	18.8	26.0	35.0	3.3	5.5	2.0	3.0	3.5	4.0	5.0	4.0	3.0	2.5						
22																1.8	5.6	6.0	2.5	2.5	45.8	52.0	37.0	40.0	55.0						1.2	1.0	0.0	2.5	0.6						
23																					2.7	0.0	0.0	0.3	0.0	2.8	2.2	1.0	3.2	3.6											
24						8.2	7.5	7.5	6.1	5.0	0.3	1.5	4.0	1.2	0.0						9.2	7.0	8.7	9.0	5.0	10.5	5.5	4.0	9.4	7.0											
25						16.0	17.5	14.5	11.2	16.0	6.2	6.0	6.0	6.3	7.0						52.4	33.0	19.0	48.0	20.0	14.5	22.5	18.0	17.5	24.0											
26											3.5	4.0	2.2	4.0	4.5						46.7	26.0	12.0	56.0	35.0	24.2	25.5	22.0	26.0	18.0	5.0	2.0	2.0	3.0	1.5						
27											3.4	5.0	3.0	4.2	3.0						2.8	3.0	9.5	12.5	0.0	7.5	10.0	6.0	6.3	0.0	10.8	12.0	7.4	8.8	10.5						
28											0.0	0.2	1.5	0.0	1.0	69.8	49.0	42.0	50.4	40.0	4.4	4.0	1.0	6.2	2.0																
29																18.7	21.5	12.0	19.2	9.0																					
30						21.0	10.0	16.0	18.7	10.0						4.8	9.0	7.5	8.7	7.0																1.7	1.2	1.1	1.2	1.0	
31											0.6	0.3	1.0	0.5	0.0																										
Total	9	6	18	13	8	72	62	58	68	60	273	287	220	211	180	176	180	131	148	104	460	391	334	424	356	147	185	128	134	112	28	27	18	26	21	6	7	3	7	2	
Avg.					11					64					234					148					393					141					24					5	1020

Table 1-4-3 Daily Rainfall (2003-2004)

Sta.1: Sergaya Sta.2: Zabadani Sta.3: Madaya Sta.4: Looudan Sta.5: Herera

Date	Oct. '03					Nov. '03					Dec. '03					Jan. '04					Feb. '04					Mar. '04					Apr. '04					May '04					Total
	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	
1						1.3	0.8	1.0	1.5	[illegible]											6.6	4.5	3.0	6.5	3.5																
2																4.7	3.4	2.3	6.4	6.5	2.0	1.7	3.0	1.7	2.4																
3											6.4	2.0	1.5	2.6	4.0	8.0	9.5	3.5	4.0	3.0	1.0	0.0	0.0	0.0	0.0																
4											3.8	5.0	4.0	2.8	4.5						2.2	2.0	1.2	3.1	0.0																
5											5.6	6.0	9.5	12.7	19.0						5.6	2.0	3.0	2.0	0.0																
6											1.0	0.5	0.4	0.5	0.0	4.4	4.5	4.0	3.0	3.0	1.8	0.5	2.2	0.0	12.0	6.2	7.5	6.0	4.6	4.6											
7																40.3	32.0	25.3	36.5	27.0																					
8											0.3	0.0	0.0	0.0	0.0	33.7	37.0	14.6	42.0	18.0																					
9						0.5	0.0	0.0	0.0	0.0						6.0	6.0	5.0	7.5	10.0																					
10						2.4	0.0	0.0	0.0	0.0						10.8	11.5	7.8	14.0	16.0																					
11						34.7	20.0	9.0	13.9	15.5						1.0	1.0	2.0	0.0	1.5																					
12						1.3	3.0	0.9	0.4	[illegible]											3.5	3.0	2.0	2.0	1.0																
13																4.1	3.0	2.3	3.3	5.0																					
14																7.6	7.0	7.3	7.0	6.5	28.7	26.0	14.0	12.0	9.5																
15											2.9	2.5	6.9	9.5	15.0	2.4	3.0	4.0	3.5	5.5	48.4	45.0	42.0	65.0	28.0	0.8	0.0	0.0	0.0	0.0											
16																1.5	1.5	0.6	2.3	1.4	31.6	15.0	10.0	38.0	17.5						8.8	5.0	5.0	6.0	5.0						
17																					18.0	19.0	20.0	20.5	9.0						1.4	9.0	4.0	3.0	2.5						
18											11.2	3.0	2.2	5.6	2.0						0.6	1.0	1.2	0.0	0.6																
19											71.0	66.0	41.2	68.0	37.0						19.2	11.0	8.0	14.3	9.0	3.4	1.0	0.5	0.5	0.5											
20											19.0	18.0	15.0	17.0	10.0						2.0	3.0	3.0	3.5	1.0																
21																																									
22																					36.8	40.0	39.0	39.0	32.0											0.4	0.5	2.5	5.0	2.6	
23																30.5	20.0	17.2	28.9	8.8	3.2	1.0	2.0	3.0	2.0						1.6	0.5	1.0	0.4	0.4						
24						8.0	4.0	1.5	5.4	5.0						49.2	40.0	25.0	41.0	57.0											1.3	1.3	0.5	0.8	0.8						
25																9.3	10.5	6.5	7.5	7.0																					
26											0.6	0.3	0.3	0.0	0.0	16.2	14.0	9.0	15.7	14.0																					
27											9.4	11.0	5.2	12.0	7.5	36.3	27.0	18.0	38.0	22.0																					
28											4.8	9.2	7.0	10.0	7.0	5.8	11.5	8.3	6.0	3.5																					
29	12.8	5.5	3.0	6.0	4.5																																				
30																					▨	▨	▨	▨	▨																
31						▨	▨	▨	▨	▨						0.6	1.0	0.0	0.0	0.0	▨	▨	▨	▨	▨						▨	▨	▨	▨	▨						
Total	13	6	3	6	5	48	28	12	21	22	136	124	93	141	106	272	243	163	267	216	211	175	154	211	128	10	9	7	5	5	13	16	11	10	9	0	1	3	5	3	
Avg.					6					26					120					232					176					7					12					2	581

(Source : DAWSSA Data)

Date	Oct. '04					Nov. '04					Dec. '04					Jan. '05					Feb. '05					Mar. '05					Apr. '05					May '05					Total
	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	Sta.1	Sta.2	Sta.3	Sta.4	Sta.5	
1						6.3	2.0	7.0	4.0	14.0																															
2																																									
3																																									
4																																									
5																																									
6																																									
7																																									
8																																									
9																																									
10						0.0	0.3	0.0	4.4	0.5																															
11																																									
12	2.0	0.5	1.0	3.0	0.5																																				
13																																									
14	0.0	3.0	7.2	2.5	6.0																																				
15																																									
16																																									
17						1.0	1.3	0.0	1.0	0.0																															
18						35.4	44.0	38.0	23.5	19.0																															
19						0.0	3.0	1.0	0.0	0.0																															
20																																									
21																																									
22						30.3	33.0	18.0	15.4	11.6																															
23						44.6	35.0	33.0	39.0	23.0																															
24						1.0	1.5	1.0	3.0	4.0																															
25																																									
26						52.4	41.0	25.0	34.0	35.0																															
27						41.4	42.0	26.6	37.0	32.0																															
28																																									
29																																									
30	1.4	2.0	2.5	5.5	4.0																▨	▨	▨	▨	▨																
31						▨	▨	▨	▨	▨											▨	▨	▨	▨	▨						▨	▨	▨	▨	▨						
Total	3	6	11	11	11	212	203	150	161	139	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	
Avg.					8					173					0					0					0					0					0					0	181

Table 1-5-1 Daily Spring Discharge at Figeh (1999-2000)

1999

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.381	2.964	4.810	11.575	7.549	4.132	3.203	2.741	2.850	2.396	2.249	2.244
2	3.419	3.160	4.891	11.383	7.342	3.996	3.168	2.793	2.554	2.444	2.257	2.293
3	3.462	3.412	4.969	10.352	7.164	4.171	3.162	2.808	2.461	2.429	2.309	2.247
4	3.419	3.531	5.068	9.755	6.855	3.885	3.165	2.773	2.443	2.493	2.341	2.282
5	3.412	3.555	5.143	9.477	6.907	3.984	3.162	2.727	2.451	2.351	2.262	2.299
6	3.375	3.676	5.014	9.817	6.671	3.868	3.104	2.718	2.487	2.387	2.352	2.259
7	3.378	3.667	5.236	9.261	6.576	3.879	3.050	2.741	2.568	2.426	2.289	2.248
8	3.399	3.549	5.388	9.964	6.584	3.837	3.057	2.693	2.580	2.416	2.254	2.280
9	3.328	3.518	5.335	9.070	6.050	3.777	3.071	2.669	2.495	2.451	2.351	2.272
10	3.368	3.383	5.517	9.307	6.042	3.734	3.075	2.675	2.788	2.372	2.331	2.349
11	3.269	3.744	5.405	9.609	6.046	3.646	3.001	2.860	2.513	2.381	2.232	2.352
12	3.316	3.718	5.638	8.901	5.999	3.680	3.034	2.751	2.596	2.246	2.328	2.188
13	3.340	3.634	5.282	9.748	6.346	3.628	2.994	2.677	2.615	2.390	2.330	2.262
14	3.374	4.250	5.577	9.629	6.205	3.601	2.986	2.695	2.579	2.364	2.319	2.198
15	3.360	4.391	5.563	8.926	5.737	3.601	2.926	2.598	2.523	2.315	2.258	2.273
16	3.420	4.408	5.510	9.626	5.755	3.522	2.898	2.625	2.549	2.332	2.239	2.266
17	3.469	4.317	5.522	9.152	5.601	3.497	2.956	2.625	2.440	2.333	2.240	2.248
18	3.333	4.364	5.318	9.190	5.520	3.503	2.882	2.586	2.528	2.489	2.236	2.356
19	3.338	4.196	5.273	9.224	5.057	3.512	2.882	2.605	2.481	2.380	2.277	2.174
20	3.303	4.384	5.228	9.062	4.811	3.493	2.884	2.516	2.391	2.295	2.387	2.236
21	3.159	4.713	5.373	9.554	4.817	3.375	2.938	2.567	2.424	2.342	2.251	2.276
22	3.424	4.709	5.447	9.829	4.700	3.362	2.869	2.606	2.262	2.379	2.304	2.257
23	3.291	4.517	5.226	9.792	4.596	3.333	2.882	2.563	2.428	2.327	2.271	2.245
24	3.298	4.297	5.504	8.065	4.791	3.385	2.898	2.667	2.423	2.322	2.257	2.242
25	3.237	4.093	5.279	8.241	4.561	3.211	2.929	2.540	2.490	2.334	2.210	2.292
26	3.238	4.274	4.986	7.910	4.616	3.246	2.869	2.548	2.413	2.406	2.246	2.266
27	3.312	4.388	5.295	8.373	4.407	3.236	2.893	2.574	2.567	2.280	2.317	2.216
28	3.212	4.426	6.361	7.694	4.422	3.231	2.899	2.926	2.467	2.324	2.247	2.193
29	3.162		6.802	8.052	4.311	3.229	2.840	2.602	2.381	2.347	2.305	2.186
30	3.271		7.310	7.874	4.245	3.223	2.824	2.606	2.460	2.297	2.287	2.213
31	3.396		11.187		4.196		2.752	2.266		2.321		2.088
Avg	3.338	3.973	5.628	9.280	5.628	3.592	2.976	2.656	2.507	2.367	2.284	2.252

2000

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.294	2.410	3.179	10.608	10.212	5.276	3.649	3.074	2.760	2.658	2.771	2.556
2	2.222	2.293	3.247	10.952	10.177	5.479	3.546	3.105	2.758	2.671	2.730	2.592
3	2.206	2.366	3.203	11.399	10.084	5.290	3.511	3.049	2.893	2.577	2.753	2.620
4	2.176	2.432	3.322	12.114	9.894	5.037	3.513	3.026	2.857	2.640	2.776	2.561
5	2.209	2.383	3.337	11.415	9.745	4.790	3.361	3.019	2.753	2.825	2.774	2.630
6	2.215	2.497	3.404	12.350	10.145	4.931	3.463	3.030	2.635	2.643	2.728	2.580
7	2.234	2.634	3.362	13.013	9.103	4.759	3.474	2.978	2.725	2.812	2.743	2.538
8	2.220	2.699	3.937	12.241	8.877	4.806	3.428	2.965	2.802	2.723	2.325	2.661
9	2.235	2.588	4.141	14.616	9.032	4.534	3.429	3.082	2.809	2.731	2.810	2.655
10	2.237	2.526	3.982	13.989	7.821	4.491	3.444	2.961	2.792	2.694	2.746	2.657
11	2.177	2.524	3.837	12.149	8.157	4.396	3.419	2.869	2.768	2.616	2.755	2.640
12	2.204	2.615	3.904	11.471	7.505	4.492	3.284	2.845	2.625	2.769	2.687	2.613
13	2.241	2.628	4.410	12.266	7.595	4.396	3.430	2.922	2.736	2.746	2.676	2.684
14	2.251	2.754	4.682	13.436	7.714	4.345	3.283	2.812	2.821	2.691	2.734	2.579
15	2.329	2.779	5.128	13.649	7.574	4.329	3.350	2.866	2.803	2.755	2.601	2.530
16	2.352	2.800	6.875	13.715	7.479	4.062	3.356	2.973	2.599	2.801	2.702	2.557
17	2.251	2.822	6.856	13.491	7.280	3.978	3.402	2.925	2.824	2.808	2.651	2.509
18	2.312	2.846	6.524	12.486	7.368	3.879	3.227	2.828	2.656	2.665	2.683	2.557
19	2.172	2.791	7.726	12.991	6.989	3.907	3.128	2.921	2.819	2.809	2.733	2.627
20	2.399	2.745	7.927	13.486	6.877	3.909	3.105	2.846	2.850	2.690	2.706	2.699
21	2.312	3.041	8.417	13.103	6.659	3.856	3.098	2.806	2.760	2.824	2.685	2.636
22	2.348	3.187	8.745	11.909	6.479	3.803	3.045	2.810	2.790	2.734	2.624	2.701
23	2.358	3.408	9.236	11.759	6.210	3.723	3.058	2.869	2.844	2.673	2.678	2.676
24	2.098	3.416	9.050	10.718	5.898	3.717	3.200	2.942	2.854	2.796	2.745	2.671
25	2.354	3.497	7.827	10.667	5.683	3.658	3.192	2.970	2.662	2.725	2.707	2.668
26	2.374	3.284	7.801	10.755	5.620	3.618	3.153	2.790	2.510	2.586	2.647	2.823
27	2.424	3.151	7.618	11.109	5.474	3.758	3.167	2.823	2.785	2.782	2.689	2.919
28	2.509	3.213	8.559	10.887	5.679	3.721	3.119	2.924	2.650	2.750	2.679	2.873
29	2.394	3.339	9.201	11.230	5.870	3.690	3.128	2.895	2.587	2.729	2.689	2.752
30	2.343		10.285	11.342	5.604	3.609	3.135	2.872	2.537	2.682	2.700	2.759
31	2.401		9.540		5.315		3.048	2.747		2.865		2.678
Avg	2.285	2.816	6.105	12.177	7.552	4.275	3.295	2.921	2.742	2.725	2.698	2.652

Table 1-5-2 Daily Spring Discharge at Figeh (2001-2002)

2001

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.888	2.778	4.343	10.793	6.296	3.623	2.868	2.644	2.449	2.242	2.360	2.574
2	2.958	2.936	4.982	10.811	6.154	3.651	2.997	2.814	2.463	2.267	2.279	2.420
3	2.977	2.985	6.479	11.205	6.141	3.492	2.954	2.731	2.372	2.202	2.326	2.364
4	2.924	2.993	5.708	11.324	5.884	3.449	3.086	2.760	2.333	2.320	2.463	2.436
5	2.905	3.015	7.206	11.568	5.982	3.404	2.611	2.493	2.345	2.234	2.409	2.421
6	2.734	2.990	11.123	11.254	5.228	3.416	3.036	2.939	2.376	2.261	2.314	2.457
7	2.977	3.023	9.151	10.926	5.637	3.365	2.769	2.830	2.489	2.230	2.479	2.574
8	2.966	3.013	9.665	10.464	5.338	3.301	2.970	2.726	2.451	2.274	2.278	2.587
9	2.966	3.047	8.978	9.568	5.497	3.275	2.716	2.816	2.402	2.243	2.396	2.554
10	2.936	3.074	8.931	9.629	5.128	3.284	2.772	2.648	2.463	2.206	2.431	2.304
11	2.916	3.189	10.074	9.333	5.122	3.181	2.757	2.624	2.541	2.203	2.484	2.707
12	3.059	3.237	10.307	9.765	5.033	3.199	2.723	2.590	2.408	2.367	2.422	2.596
13	3.106	3.221	10.666	8.765	4.932	3.248	2.743	2.692	2.438	2.180	2.505	2.472
14	3.125	3.450	11.154	9.161	4.925	2.951	2.624	2.718	2.341	2.276	2.156	2.569
15	3.080	3.589	10.601	5.803	4.508	2.898	2.923	2.654	2.437	2.262	2.559	2.582
16	3.113	3.760	10.992	7.542	4.702	2.684	2.660	2.694	2.373	2.308	2.466	2.550
17	3.062	3.923	11.118	7.908	4.766	2.899	2.697	2.414	2.363	2.310	2.358	2.573
18	3.068	3.867	10.219	8.102	4.658	3.882	2.739	2.515	2.357	2.246	2.200	2.430
19	3.053	3.870	10.044	6.483	4.559	3.511	2.474	2.498	2.396	2.352	2.343	2.511
20	3.049	3.950	10.648	8.078	4.455	3.510	2.714	2.552	2.335	2.219	2.317	2.517
21	2.982	3.842	11.009	7.973	4.463	3.520	2.521	2.491	2.284	2.378	2.400	2.548
22	2.889	4.137	12.259	7.727	4.346	3.325	2.760	2.585	2.244	2.358	2.387	2.448
23	2.928	4.077	10.819	7.467	4.146	3.172	2.644	2.707	2.291	2.359	2.373	2.438
24	2.935	3.840	11.658	7.345	4.198	3.142	2.663	2.524	2.358	2.183	2.549	2.648
25	2.868	3.809	11.810	7.454	4.182	3.161	2.804	2.500	2.389	2.345	2.546	2.564
26	2.847	3.783	10.490	7.227	4.094	3.108	2.708	2.462	2.388	2.365	2.400	2.578
27	2.885	3.889	10.701	6.935	3.995	3.059	2.707	2.524	2.380	2.302	2.418	2.583
28	2.839	4.015	10.868	6.732	3.904	2.830	2.722	2.495	2.378	2.202	2.382	2.633
29	2.755		10.687	6.615	3.891	2.995	2.463	2.515	2.287	2.207	2.369	3.044
30	2.753		11.465	6.427	3.804	2.981	2.734	2.348	2.247	2.303	2.348	3.269
31	2.712		11.382		3.764		2.685	2.511		2.306		3.040
Avg	2.944	3.475	9.856	8.680	4.830	3.251	2.750	2.613	2.379	2.274	2.391	2.580

2002

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.902	2.856	7.357	7.846	10.038	5.488	3.633	2.768	2.540	2.438	2.878	2.405
2	3.191	2.857	7.393	8.662	10.004	5.495	2.654	2.649	2.667	2.631	2.859	2.440
3	3.169	3.064	7.302	11.500	9.878	5.491	3.714	2.575	2.761	2.530	2.861	2.462
4	2.868	3.036	7.469	13.268	9.976	5.135	3.640	2.673	2.754	2.607	2.785	2.425
5	2.921	3.206	7.747	12.327	9.482	5.277	3.328	3.015	2.730	2.565	2.745	2.513
6	2.677	3.569	8.592	11.878	9.486	5.426	3.307	2.864	2.718	2.612	2.772	2.426
7	2.700	3.819	8.743	13.489	9.240	5.353	3.386	2.794	2.646	2.513	2.866	2.407
8	2.472	3.929	9.057	15.764	9.207	5.120	3.294	2.704	2.506	2.358	2.758	2.334
9	2.732	4.189	9.218	13.889	8.956	4.806	3.052	2.775	2.670	2.350	2.775	2.374
10	2.704	4.400	9.416	15.681	8.800	4.414	3.248	2.985	2.799	2.379	2.647	2.283
11	2.738	4.705	9.320	15.870	8.568	4.556	3.536	2.837	2.416	2.275	2.818	2.696
12	2.744	4.579	9.430	15.428	8.455	4.469	3.355	2.913	2.849	2.379	2.730	2.840
13	2.640	5.169	9.731	15.482	8.306	4.170	3.523	2.833	2.756	2.497	2.714	2.758
14	2.715	5.199	10.300	15.284	8.154	4.333	3.226	2.762	2.818	2.557	2.576	2.912
15	2.661	5.194	10.249	15.212	7.887	4.284	3.006	2.901	2.832	2.489	2.558	2.807
16	2.651	5.118	9.973	15.596	7.689	4.497	3.564	2.646	2.733	2.548	2.582	2.859
17	2.583	5.704	9.852	14.835	7.341	4.324	3.356	2.807	2.643	2.488	2.567	2.696
18	2.597	6.111	9.972	15.775	7.116	4.398	3.500	2.384	2.863	2.581	2.406	2.951
19	2.550	6.684	9.830	14.373	7.422	4.215	3.341	3.069	2.700	2.658	2.409	3.072
20	2.571	6.689	10.288	14.628	7.076	3.835	3.313	2.697	2.812	2.607	2.412	3.231
21	2.697	6.761	10.220	13.416	6.836	3.774	3.033	2.935	2.838	2.509	2.405	8.152
22	2.600	6.880	8.678	12.367	6.686	3.616	2.893	2.752	2.791	2.072	2.560	8.675
23	2.516	6.315	8.978	11.013	6.680	3.853	3.285	2.888	2.865	2.870	2.504	8.369
24	2.651	6.514	8.514	10.797	6.491	3.697	3.088	2.730	2.970	2.926	2.446	5.805
25	2.747	6.893	9.522	10.845	6.454	3.698	3.062	2.453	2.693	2.837	2.491	5.473
26	2.690	7.101	10.215	10.981	6.363	3.941	3.121	2.986	2.855	2.816	2.569	4.825
27	2.662	8.440	11.526	11.392	6.332	3.828	2.952	2.794	2.673	2.811	2.558	4.524
28	2.776	7.489	11.181	10.861	5.954	4.090	2.923	2.713	2.873	2.764	2.374	4.225
29	2.711		10.628	10.641	5.861	4.193	2.697	2.925	2.576	2.813	2.507	4.089
30	2.690		10.033	10.474	5.868	3.675	2.707	2.680	2.587	2.819	2.435	4.374
31	2.848		9.948		5.680		2.758	2.953		2.747		4.316
Avg	2.722	5.231	9.377	12.986	7.816	4.448	3.210	2.789	2.731	2.582	2.619	3.733

Table 1-5-3 Daily Spring Discharge at Figeh (2003)

2003

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	4.229	6.079	7.941	12.173	24.455	21.974	15.519	9.372	7.140	6.325	5.559	5.061
2	4.309	6.207	6.721	13.455	23.576	21.373	13.780	9.635	7.462	6.347	5.095	4.711
3	4.050	6.421	7.847	14.208	24.067	21.493	14.936	9.199	7.517	6.280	5.551	4.217
4	4.107	6.371	7.575	16.615	23.876	19.429	13.330	9.123	7.437	6.239	5.427	4.760
5	4.499	6.465	9.450	19.407	24.061	21.041	12.777	9.158	7.565	6.398	5.400	4.743
6	11.077	6.508	9.363	21.282	24.132	20.825	13.007	9.233	6.738	6.374	5.315	4.349
7	11.676	6.422	10.128	21.832	24.181	21.042	13.810	8.941	8.345	6.158	5.417	4.698
8	9.751	6.505	9.839	23.235	24.004	20.665	12.906	8.964	7.451	6.139	5.456	4.561
9	9.709	6.529	10.645	22.529	24.520	19.430	12.889	9.402	7.060	6.086	5.504	4.732
10	9.712	6.494	11.015	24.254	23.715	19.538	13.703	9.364	7.005	6.036	5.062	4.399
11	8.301	6.394	11.675	25.054	24.284	18.434	13.248	9.339	6.950	6.006	5.236	4.434
12	8.103	6.298	12.398	23.906	23.985	18.858	12.669	8.860	7.139	6.152	5.142	4.364
13	7.543	5.975	11.781	25.051	24.591	19.495	12.750	9.246	7.021	6.078	5.115	4.558
14	7.723	6.165	10.729	24.755	23.676	17.858	13.508	8.781	7.093	5.947	5.406	4.350
15	7.570	6.187	11.125	24.661	24.189	17.793	12.754	8.854	6.883	6.095	5.366	4.641
16	7.653	6.462	11.825	25.470	23.473	18.138	12.796	9.080	6.835	6.066	5.427	4.368
17	7.470	7.017	12.164	24.910	23.488	17.637	11.026	9.057	6.818	6.034	5.647	4.430
18	7.013	6.378	13.845	24.835	23.381	17.206	11.729	8.759	6.742	6.001	5.346	4.473
19	6.382	7.642	13.692	24.792	23.282	16.090	11.345	8.669	6.854	5.824	5.262	4.272
20	6.768	9.055	15.190	25.127	22.960	17.113	11.664	7.834	6.888	5.884	5.269	4.471
21	6.178	9.407	13.388	24.881	22.984	17.527	11.408	8.381	6.795	5.725	5.639	4.317
22	5.999	8.579	14.183	24.621	22.705	16.629	10.444	8.584	6.741	5.711	5.411	5.138
23	5.893	8.372	13.209	24.959	23.077	17.612	11.978	7.079	6.633	5.704	5.433	4.128
24	5.755	8.357	13.049	24.182	23.381	16.675	10.803	8.541	6.622	5.649	5.375	4.681
25	5.796	7.206	12.056	25.027	22.366	15.312	10.491	8.579	6.546	5.867	5.262	4.357
26	5.640	6.933	11.695	25.057	23.403	15.154	10.461	7.523	6.565	5.713	5.426	4.612
27	5.697	7.781	11.530	24.450	22.651	14.824	10.188	7.648	6.465	5.608	4.990	4.655
28	5.772	8.210	11.363	24.700	22.594	14.480	9.640	7.959	6.482	5.828	5.055	4.581
29	5.929		11.531	24.010	22.050	15.268	10.308	8.100	6.409	5.356	4.848	4.481
30	6.006		11.936	24.198	21.302	13.670	9.662	8.352	6.377	5.719	5.456	4.580
31	5.860		11.221		21.397		9.254	8.029		5.728		4.574
Avg	6.844	7.015	11.294	22.788	23.413	18.086	12.090	8.698	6.953	5.970	5.330	4.539

Table 1-6-1 Daily Discharge in Old Tunnel (2000-2004)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2000													
1	0.299	0.324	0.373	0.817	0.716	0.390	0.298	0.527	0.551	0.576	0.606	0.518	
2	0.311	0.343	0.403	0.749	0.813	0.390	0.303	0.538	0.546	0.581	0.597	0.525	
3	0.290	0.307	0.435	0.791	0.774	0.351	0.304	0.523	0.590	0.548	0.597	0.529	
4	0.292	0.372	0.425	0.831	0.806	0.342	0.309	0.524	0.590	0.557	0.591	0.518	
5	0.318	0.370	0.409	0.752	0.827	0.337	0.271	0.521	0.558	0.616	0.584	0.554	
6	0.509	0.359	0.411	0.849	0.837	0.343	0.293	0.524	0.521	0.571	0.596	0.546	
7	0.252	0.348	0.387	0.845	0.746	0.337	0.302	0.507	0.554	0.619	0.600	0.526	
8	0.283	0.386	0.416	0.715	0.836	0.341	0.293	0.511	0.571	0.589	0.513	0.548	
9	0.319	0.330	0.464	0.794	0.834	0.326	0.299	0.533	0.574	0.596	0.619	0.551	
10	0.295	0.357	0.420	0.748	0.782	0.326	0.553	0.512	0.568	0.584	0.612	0.552	
11	0.264	0.400	0.347	0.790	0.779	0.319	0.586	0.479	0.557	0.562	0.607	0.554	
12	0.293	0.368	0.426	0.787	0.784	0.357	0.548	0.472	0.518	0.598	0.587	0.546	
13	0.376	0.414	0.459	0.791	0.794	0.334	0.587	0.505	0.559	0.607	0.588	0.553	
14	0.361	0.430	0.499	0.804	0.835	0.346	0.540	0.462	0.573	0.583	0.564	0.536	
15	0.386	0.440	0.502	0.781	0.812	0.352	0.573	0.592	0.575	0.589	0.472	0.517	
16	0.396	0.447	0.819	0.846	0.802	0.304	0.577	0.634	0.525	0.611	0.503	0.557	
17	0.368	0.377	0.739	0.809	0.819	0.300	0.593	0.601	0.579	0.607	0.475	0.502	
18	0.390	0.415	0.709	0.720	0.862	0.292	0.544	0.562	0.520	0.594	0.480	0.536	
19	0.374	0.318	0.717	0.854	0.464	0.329	0.517	0.592	0.572	0.619	0.482	0.527	
20	0.315	0.401	0.672	0.816	0.427	0.329	0.517	0.575	0.583	0.572	0.490	0.553	
21	0.378	0.467	0.715	0.803	0.420	0.301	0.514	0.550	0.549	0.621	0.486	0.534	
22	0.361	0.450	0.786	0.794	0.423	0.298	0.500	0.551	0.554	0.591	0.478	0.548	
23	0.369	0.425	0.757	0.753	0.423	0.289	0.505	0.604	0.577	0.582	0.529	0.546	
24	0.474	0.404	0.690	0.719	0.432	0.287	0.552	0.597	0.581	0.609	0.554	0.549	
25	0.378	0.385	0.791	0.741	0.394	0.278	0.552	0.599	0.528	0.593	0.547	0.536	
26	0.333	0.319	0.805	0.822	0.379	0.278	0.537	0.565	0.494	0.545	0.527	0.584	
27	0.348	0.337	0.751	0.829	0.372	0.320	0.543	0.552	0.564	0.603	0.539	0.592	
28	0.410	0.316	0.818	0.845	0.383	0.317	0.533	0.593	0.567	0.593	0.541	0.585	
29	0.358	0.379	0.832	0.854	0.369	0.319	0.538	0.589	0.546	0.585	0.559	0.543	
30	0.315		0.745	0.844	0.365	0.316	0.541	0.586	0.538	0.607	0.576	0.542	
31	0.379		0.772		0.350		0.528	0.544		0.624		0.491	
Avg.	0.348	0.379	0.597	0.796	0.634	0.325	0.473	0.549	0.556	0.591	0.550	0.542	0.529
Max.	0.509	0.467	0.832	0.854	0.862	0.390	0.593	0.634	0.590	0.624	0.619	0.592	0.862
Min.	0.252	0.307	0.347	0.715	0.350	0.278	0.271	0.462	0.494	0.545	0.472	0.491	0.252
Friday	0.350	0.393	0.611	0.824	0.613	0.325	0.472	0.541	0.559	0.588	0.560	0.535	0.531

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2001													
1	0.590	0.585	0.722	0.556	0.539	0.588	0.522	0.463	0.326	0.301	0.319	0.330	
2	0.612	0.611	0.813	0.579	0.521	0.629	0.577	0.525	0.318	0.312	0.307	0.324	
3	0.615	0.626	0.640	0.593	0.530	0.599	0.524	0.471	0.350	0.285	0.314	0.318	
4	0.613	0.622	0.562	0.565	0.499	0.597	0.390	0.401	0.287	0.296	0.323	0.320	
5	0.599	0.640	0.670	0.580	0.521	0.590	0.517	0.398	0.278	0.278	0.320	0.319	
6	0.597	0.633	3.207	0.550	0.527	0.596	0.548	0.454	0.317	0.307	0.316	0.321	
7	0.630	0.637	0.537	0.561	0.574	0.585	0.412	0.456	0.328	0.331	0.390	0.329	
8	0.626	0.627	0.577	0.536	0.503	0.547	0.505	0.475	0.307	0.337	0.308	0.332	
9	0.624	0.638	0.558	0.545	0.434	0.541	0.476	0.526	0.314	0.323	0.334	0.323	
10	0.618	0.639	0.573	0.550	0.579	0.542	0.476	0.452	0.367	0.307	0.325	0.292	
11	0.607	0.691	0.603	0.576	0.639	0.560	0.435	0.397	0.367	0.294	0.323	0.342	
12	0.637	0.669	0.614	0.565	0.618	0.549	0.442	0.378	0.343	0.333	0.322	0.332	
13	0.647	0.681	0.635	0.575	0.645	0.564	0.476	0.415	0.333	0.307	0.338	0.329	
14	0.654	0.717	0.595	0.564	0.645	0.504	0.434	0.421	0.306	0.322	0.058	0.321	
15	0.644	0.739	0.584	0.323	0.578	0.477	0.604	0.431	0.330	0.354	0.338	0.331	
16	0.648	0.760	0.595	0.628	0.614	0.445	0.525	0.401	0.299	0.365	0.324	0.325	
17	0.646	0.778	0.597	0.765	0.637	0.635	0.433	0.341	0.328	0.392	0.313	0.328	
18	0.632	0.755	0.603	0.669	0.564	0.749	0.468	0.338	0.291	0.337	0.297	0.332	
19	0.644	0.770	0.601	0.633	0.555	0.619	0.433	0.335	0.306	0.337	0.312	0.321	
20	0.636	0.783	0.671	0.837	0.539	0.629	0.414	0.403	0.304	0.309	0.306	0.320	
21	0.625	0.780	0.620	0.841	0.579	0.668	0.343	0.391	0.270	0.329	0.307	0.324	
22	0.607	0.844	0.621	0.684	0.562	0.500	0.448	0.356	0.341	0.320	0.300	0.314	
23	0.620	0.810	0.685	0.591	0.633	0.548	0.389	0.389	0.321	0.319	0.308	0.318	
24	0.620	0.656	0.600	0.582	0.645	0.496	0.424	0.348	0.326	0.294	0.317	0.432	
25	0.614	0.640	0.557	0.614	0.679	0.609	0.509	0.301	0.318	0.320	0.323	0.331	
26	0.597	0.633	0.553	0.581	0.653	0.518	0.463	0.325	0.324	0.304	0.303	0.331	
27	0.609	0.662	0.539	0.562	0.615	0.535	0.460	0.337	0.352	0.297	0.310	0.330	
28	0.589	0.681	0.568	0.542	0.596	0.431	0.492	0.330	0.334	0.295	0.315	0.340	
29	0.573		0.566	0.577	0.635	0.489	0.414	0.369	0.285	0.049	0.314	0.379	
30	0.575		0.573	0.550	0.591	0.526	0.487	0.340	0.295	0.226	0.310	0.393	
31	0.585		0.577		0.578		0.449	0.306		0.313		0.371	
Avg.	0.617	0.690	0.691	0.596	0.581	0.562	0.467	0.396	0.319	0.306	0.310	0.334	0.488
Max.	0.654	0.844	3.207	0.841	0.679	0.749	0.604	0.526	0.367	0.392	0.390	0.432	3.207
Min.	0.573	0.585	0.537	0.323	0.434	0.431	0.343	0.301	0.270	0.049	0.058	0.292	0.049
Friday	0.619	0.705	0.645	0.631	0.595	0.520	0.474	0.384	0.309	0.313	0.317	0.329	0.487

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2002													
1	0.354	0.357	0.681	0.599	0.558	0.526	0.423	0.273	0.247	0.260	0.282	0.283	
2	0.396	0.362	0.679	0.608	0.572	0.516	0.401	0.266	0.134	0.273	0.283	0.282	
3	0.402	0.378	0.675	0.598	0.574	0.492	0.631	0.261	0.453	0.268	0.270	0.281	
4	0.360	0.374	0.692	0.573	0.572	0.437	0.609	0.270	0.277	0.573	0.278	0.278	
5	0.366	0.406	0.674	0.612	0.567	0.478	0.580	0.297	0.275	0.331	0.279	0.287	
6	0.342	0.450	0.675	0.591	0.528	0.501	0.560	0.281	0.272	0.270	0.456	0.280	
7	0.360	0.473	0.685	0.624	0.571	0.487	0.535	0.281	0.271	0.266	0.333	0.276	
8	0.315	0.448	0.712	0.600	0.573	0.474	0.535	0.267	0.266	0.257	0.437	0.276	
9	0.345	0.464	0.695	0.598	0.577	0.489	0.514	0.273	0.280	0.249	0.340	0.273	
10	0.352	0.483	0.691	0.606	0.553	0.482	0.513	0.286	0.278	0.249	0.481	0.260	
11	0.343	0.467	0.685	0.614	0.577	0.488	0.577	0.274	0.242	0.251	0.323	0.299	
12	0.344	0.430	0.687	0.617	0.579	0.568	0.561	0.282	0.279	0.252	0.360	0.442	
13	0.335	0.476	0.677	0.602	0.565	0.461	0.579	0.276	0.263	0.255	0.324	0.285	
14	0.348	0.475	0.689	0.860	0.593	0.449	0.536	0.260	0.271	0.268	0.262	0.318	
15	0.345	0.477	0.685	0.555	0.541	0.443	0.510	0.276	0.270	0.264	0.263	0.312	
16	0.339	0.468	0.682	0.563	0.571	0.460	0.581	0.250	0.271	0.260	0.270	0.312	
17	0.334	0.524	0.706	0.568	0.540	0.473	0.561	0.271	0.252	0.305	0.268	0.306	
18	0.337	0.552	0.679	0.567	0.581	0.480	0.569	0.279	0.266	0.353	0.434	0.326	
19	0.336	0.614	0.678	0.552	0.586	0.461	0.559	0.369	0.252	0.590	0.307	0.333	
20	0.333	0.637	0.600	0.558	0.567	0.429	0.543	0.243	0.266	0.359	0.300	0.350	
21	0.336	0.643	0.661	0.539	0.534	0.431	0.493	0.254	0.269	0.329	0.302	0.458	
22	0.330	0.655	0.602	0.557	0.573	0.419	0.494	0.235	0.267	0.494	0.328	0.458	
23	0.317	0.603	0.601	0.560	0.562	0.440	0.529	0.242	0.272	0.339	0.315	0.458	
24	0.334	0.621	0.573	0.548	0.556	0.430	0.505	0.235	0.267	0.358	0.318	0.438	
25	0.344	0.648	0.657	0.563	0.552	0.430	0.503	0.222	0.256	0.348	0.322	0.424	
26	0.338	0.597	0.558	0.558	0.548	0.454	0.328	0.375	0.363	0.300	0.338	0.389	
27	0.339	0.699	0.629	0.563	0.568	0.453	0.297	0.278	0.253	0.357	0.327	0.361	
28	0.356	0.672	0.601	0.574	0.543	0.478	0.290	0.245	0.254	0.347	0.306	0.335	
29	0.340		0.576	0.562	0.525	0.494	0.270	0.288	0.292	0.305	0.289	0.331	
30	0.336		0.573	0.561	0.545	0.438	0.271	0.284	0.273	0.386	0.277	0.351	
31	0.353		0.619		0.532		0.269	0.314		0.250		0.353	
Avg.	0.346	0.516	0.654	0.588	0.561	0.469	0.488	0.274	0.272	0.321	0.322	0.336	0.428
Max.	0.402	0.699	0.712	0.860	0.593	0.568	0.631	0.375	0.453	0.590	0.481	0.458	0.860
Min.	0.315	0.357	0.558	0.539	0.525	0.419	0.269	0.222	0.134	0.249	0.262	0.260	0.134
Friday	0.346	0.484	0.651	0.585	0.551	0.461	0.507	0.263	0.263	0.381	0.320	0.319	0.428

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2003													
1	0.337	0.467	0.550	0.424	0.570	0.452	0.585	0.597	0.576	0.420	0.304	0.321	
2	0.357	0.473	0.453	0.445	0.557	0.449	0.562	0.600	0.601	0.422	0.286	0.306	
3	0.329	0.475	0.500	0.450	0.552	0.455	0.554	0.606	0.599	0.420	0.339	0.292	
4	0.332	0.468	0.502	0.456	0.570	0.420	0.565	0.603	0.571	0.421	0.313	0.320	
5	0.356	0.462	0.470	0.454	0.569	0.442	0.572	0.609	0.617	0.463	0.320	0.306	
6	0.477	0.477	0.430	0.460	0.557	0.482	0.589	0.624	0.554	0.468	0.297	0.294	
7	0.472	0.475	0.417	0.457	0.558	0.435	0.593	0.629	0.511	0.420	0.313	0.301	
8	0.449	0.479	0.421	0.475	0.579	0.475	0.568	0.599	0.545	0.422	0.311	0.297	
9	0.476	0.483	0.421	0.444	0.584	0.444	0.553	0.615	0.537	0.418	0.331	0.324	
10	0.482	0.487	0.409	0.499	0.552	0.456	0.538	0.621	0.509	0.417	0.285	0.317	
11	0.456	0.478	0.403	0.593	0.483	0.427	0.573	0.637	0.511	0.413	0.298	0.292	
12	0.462	0.480	0.571	0.555	0.589	0.455	0.573	0.612	0.536	0.399	0.329	0.422	
13	0.476	0.459	0.565	0.595	0.597	0.507	0.591	0.620	0.511	0.294	0.327	0.390	
14	0.462	0.469	0.565	0.562	0.590	0.485	0.536	0.613	0.550	0.349	0.332	0.250	
15	0.462	0.459	0.573	0.571	0.603	0.495	0.508	0.634	0.508	0.394	0.329	0.276	
16	0.478	0.482	0.456	0.584	0.601	0.497	0.513	0.614	0.506	0.398	0.338	0.267	
17	0.338	0.425	0.473	0.555	0.582	0.505	0.558	0.619	0.507	0.401	0.349	0.250	
18	0.499	0.464	0.473	0.580	0.596	0.496	0.522	0.613	0.507	0.332	0.325	0.267	
19	0.473	0.471	0.441	0.564	0.587	0.493	0.515	0.578	0.513	0.281	0.346	0.263	
20	0.440	0.469	0.429	0.580	0.598	0.500	0.535	0.611	0.511	0.314	0.348	0.244	
21	0.468	0.508	0.461	0.568	0.585	0.490	0.530	0.585	0.512	0.281	0.364	0.234	
22	0.458	0.525	0.438	0.551	0.504	0.659	0.532	0.623	0.515	0.278	0.340	0.308	
23	0.452	0.534	0.482	0.567	0.642	0.532	0.539	0.557	0.465	0.278	0.366	0.254	
24	0.446	0.525	0.471	0.565	0.608	0.620	0.593	0.596	0.423	0.279	0.360	0.288	
25	0.438	0.466	0.467	0.580	0.596	0.496	0.505	0.613	0.422	0.316	0.325	0.304	
26	0.438	0.496	0.467	0.583	0.611	0.683	0.569	0.581	0.421	0.318	0.369	0.317	
27	0.445	0.525	0.471	0.575	0.603	0.582	0.577	0.576	0.420	0.334	0.320	0.301	
28	0.450	0.535	0.484	0.415	0.515	0.549	0.587	0.591	0.422	0.321	0.322	0.325	
29	0.458		0.497	0.555	0.809	0.563	0.601	0.597	0.421	0.287	0.312	0.314	
30	0.471		0.483	0.567	0.450	0.566	0.608	0.571	0.421	0.311	0.369	0.305	
31	0.453		0.471		0.421		0.579	0.597		0.339		0.410	
Avg.	0.438	0.483	0.475	0.528	0.575	0.504	0.559	0.605	0.507	0.362	0.329	0.302	0.472
Max.	0.499	0.535	0.573	0.595	0.809	0.683	0.608	0.637	0.617	0.468	0.369	0.422	0.809
Min.	0.329	0.425	0.403	0.415	0.421	0.420	0.505	0.557	0.420	0.278	0.285	0.234	0.234
Friday	0.409	0.497	0.482	0.552	0.567	0.518	0.541	0.610	0.522	0.371	0.333	0.327	0.477

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2004													
1	0.443	0.408	0.386	0.405	0.526	0.470	0.477	0.489	0.305	0.377	0.272		
2	0.402	0.368	0.405	0.424	0.539	0.467	0.725	0.491	0.317	0.343	0.280		
3	0.394	0.347	0.382	0.415	0.500	0.412	0.383	0.464	0.349	0.358	0.276		
4	0.406	0.386	0.399	0.408	0.527	0.472	0.734	0.478	0.323	0.380	0.277		
5	0.360	0.367	0.376	0.414	0.504	0.449	0.702	0.469	0.313	0.345	0.274		
6	0.378	0.387	0.403	0.396	0.529	0.473	0.612	0.532	0.316	0.373	0.275		
7	0.361	0.354	0.369	0.397	0.535	0.466	0.475	0.481	0.310	0.346	0.270		
8	0.350	0.407	0.385	0.407	0.537	0.462	0.657	0.485	0.322	0.347	0.268		
9	0.371	0.377	0.407	0.426	0.530	0.487	0.341	0.477	0.330	0.346	0.272		
10	0.359	0.390	0.399	0.412	0.533	0.461	0.418	0.475	0.346	0.414	0.269		
11	0.372	0.396	0.379	0.416	0.560	0.452	0.432	0.482	0.329	0.410	0.270		
12	0.361	0.355	0.409	0.401	0.525	0.479	0.454	0.494	0.320	0.285	0.269		
13	0.344	0.388	0.402	0.423	0.542	0.450	0.455	0.510	0.315	0.265	0.271		
14	0.370	0.379	0.393	0.416	0.526	0.439	0.457	0.484	0.313	0.259	0.270		
15	0.382	0.396	0.388	0.421	0.536	0.404	0.451	0.479	0.302	0.260	0.273		
16	0.362	0.356	0.372	0.402	0.542	0.399	0.453	0.477	0.298	0.269	0.269		
17	0.362	0.388	0.389	0.387	0.509	0.436	0.416	0.486	0.339	0.256	0.268		
18	0.342	0.383	0.399	0.393	0.517	0.439	0.452	0.495	0.319	0.274	0.220		
19	0.360	0.378	0.396	0.399	0.535	0.408	0.381	0.438	0.295	0.259	0.278		
20	0.400	0.392	0.395	0.404	0.518	0.452	0.453	0.415	0.289	0.272	0.279		
21	0.345	0.388	0.389	0.394	0.538	0.412	0.426	0.330	0.294	0.257	0.280		
22	0.422	0.388	0.428	0.408	0.553	0.426	0.394	0.314	0.290	0.270			
23	0.361	0.370	0.383	0.389	0.537	0.416	0.387	0.343	0.300	0.261			
24	0.378	0.375	0.410	0.408	0.541	0.859	0.382	0.326	0.337	0.258			
25	0.362	0.389	0.405	0.417	0.544	0.398	0.396	0.325	0.351	0.309			
26	0.393	0.370	0.403	0.527	0.529	0.381	0.446	0.333	0.349	0.261			
27	0.379	0.383	0.401	0.511	0.468	0.425	0.456	0.335	0.281	0.262			
28	0.381	0.402	0.412	0.521	0.452	0.314	0.475	0.314	0.331	0.259			
29	0.369	0.398	0.391	0.525	0.457	0.395	0.477	0.304	0.319	0.248			
30	0.400		0.401	0.536	0.450	0.760	0.502	0.305	0.368	0.271			
31	0.381		0.400		0.445		0.477	0.314		0.272			
Avg.	0.376	0.382	0.395	0.427	0.519	0.459	0.476	0.424	0.319	0.302	0.270		0.399
Max.	0.443	0.408	0.428	0.536	0.560	0.859	0.734	0.532	0.368	0.414	0.280		0.859
Min.	0.342	0.347	0.369	0.387	0.445	0.314	0.341	0.304	0.281	0.248	0.220		0.220
Friday	0.379	0.388	0.396	0.435	0.513	0.440	0.482	0.448	0.343	0.300	0.274	0.000	0.366

Table 1-6-2 Daily Discharge in New Tunnel (2000-2004)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2000													
1	3.355	3.461	4.192	6.676	5.978	5.828	4.193	3.491	3.156	3.030	3.121	3.086	
2	3.265	3.323	4.264	6.328	6.703	6.024	4.153	3.512	3.160	3.043	3.087	3.110	
3	3.291	3.267	4.151	6.393	6.547	5.879	4.154	3.474	3.250	2.978	3.109	3.130	
4	3.242	3.397	4.268	6.762	6.611	5.645	4.248	3.449	3.215	3.033	3.137	3.090	
5	3.283	3.377	4.303	6.257	6.798	5.397	4.036	3.445	3.144	3.157	3.144	3.123	
6	3.042	3.504	4.362	6.735	6.857	5.506	4.115	3.453	3.061	3.013	3.088	3.075	
7	3.328	3.619	4.360	6.845	6.301	5.373	4.119	3.419	3.119	3.134	3.096	3.063	
8	3.378	3.684	4.894	6.047	6.704	5.416	4.076	3.402	3.178	3.081	2.823	3.153	
9	3.324	3.622	5.004	6.740	6.781	5.154	4.075	3.496	3.181	3.084	3.237	3.147	
10	3.317	3.528	4.871	6.103	6.514	5.116	3.835	3.397	3.173	3.056	3.179	3.150	
11	3.278	3.485	4.804	6.535	6.550	5.023	3.778	3.338	3.158	3.005	3.137	3.127	
12	3.266	3.619	4.792	6.540	6.536	5.082	3.681	3.320	3.058	3.118	3.072	3.112	
13	3.261	3.583	5.270	6.466	6.619	5.007	3.787	3.365	3.122	3.089	3.130	3.180	
14	3.266	3.700	5.485	6.492	6.698	4.951	3.684	3.298	3.197	3.054	3.208	3.087	
15	3.330	3.709	5.926	6.461	6.588	4.921	3.720	3.221	3.176	3.114	3.170	3.055	
16	3.340	3.732	7.359	6.706	6.495	4.704	3.724	3.288	3.024	3.143	3.243	3.046	
17	3.270	3.816	5.993	6.561	6.945	4.621	3.769	3.269	3.182	3.154	3.183	2.982	
18	3.297	3.778	5.678	6.047	6.960	4.535	3.631	3.213	3.070	3.022	3.181	3.066	
19	3.175	3.778	6.010	6.962	6.965	4.526	3.555	3.280	3.180	3.141	3.221	3.065	
20	3.392	3.662	5.536	6.763	6.837	4.530	3.533	3.222	3.223	3.066	3.186	3.147	
21	3.264	3.883	5.988	6.476	6.756	4.502	3.528	3.208	3.150	3.153	3.174	3.151	
22	3.246	4.034	6.444	6.627	6.712	4.451	3.491	3.211	3.180	3.097	3.115	3.153	
23	3.355	4.301	6.157	6.392	6.800	4.380	3.498	3.208	3.210	3.041	3.118	3.130	
24	3.025	4.330	5.775	6.321	6.912	4.375	3.594	3.291	3.224	3.140	3.161	3.121	
25	3.381	4.420	6.362	6.282	6.709	4.327	3.589	3.316	3.083	3.087	3.130	3.103	
26	3.420	4.278	6.468	6.592	6.628	4.290	3.562	3.171	2.968	2.997	3.093	3.282	
27	3.456	4.176	6.041	6.644	6.536	4.385	3.571	3.218	3.171	3.132	3.125	3.310	
28	3.455	4.301	6.247	6.695	6.612	4.349	3.533	3.277	3.032	3.110	3.109	3.274	
29	3.423	4.333	6.651	6.925	6.449	4.322	3.533	3.253	2.989	3.101	3.178	3.177	
30	3.318		6.137	6.933	6.182	4.287	3.531	3.233	2.947	3.035	3.165	3.191	
31	3.407		6.200		5.914		3.466	3.150		3.195		3.185	
Avg.	3.305	3.783	5.484	6.543	6.619	4.897	3.767	3.319	3.133	3.084	3.137	3.131	4.183
Max.	3.456	4.420	7.359	6.962	6.965	6.024	4.248	3.512	3.250	3.195	3.243	3.310	7.359
Min.	3.025	3.267	4.151	6.047	5.914	4.287	3.466	3.150	2.947	2.978	2.823	2.982	2.823
Friday	3.328	3.770	5.398	6.627	6.732	4.910	3.716	3.329	3.136	3.075	3.158	3.125	4.192

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2001													
1	3.268	3.190	4.584	6.840	5.619	3.990	3.300	3.132	3.076	2.896	2.998	3.212	
2	3.332	3.302	5.136	6.683	5.484	3.974	3.375	3.226	3.099	2.912	2.940	3.078	
3	3.361	3.367	5.722	6.761	5.470	3.847	3.381	3.206	2.966	2.875	2.973	3.038	
4	3.313	3.370	6.190	6.600	5.235	3.805	3.273	3.289	3.001	2.983	3.097	3.107	
5	3.278	3.373	7.498	6.824	5.317	3.768	3.044	3.068	3.020	2.914	3.047	3.095	
6	3.133	3.356	6.631	6.529	5.532	3.774	3.444	3.436	3.013	2.909	2.957	3.149	
7	3.392	3.431	5.917	6.986	5.908	3.736	3.308	3.325	3.115	2.854	3.049	3.236	
8	3.383	3.385	6.388	6.518	5.610	3.708	3.417	3.193	3.099	2.896	2.927	3.218	
9	3.387	3.408	5.985	6.711	4.927	3.686	3.192	3.241	3.042	2.878	3.021	3.226	
10	3.364	3.430	6.296	6.501	4.411	3.730	3.249	3.147	3.050	2.857	3.063	2.992	
11	3.354	3.498	6.499	6.813	4.341	3.575	3.274	3.176	3.130	2.865	3.121	3.370	
12	3.466	3.614	6.722	6.765	4.278	3.605	3.233	3.162	3.020	2.991	3.058	3.300	
13	3.503	3.586	7.060	6.692	4.141	3.638	3.218	3.229	3.061	2.828	3.127	3.190	
14	3.516	3.731	6.558	6.765	4.134	3.400	3.140	3.109	2.990	2.911	3.056	3.279	
15	3.482	3.896	6.322	5.310	3.785	3.374	3.270	3.171	3.061	2.865	3.179	3.257	
16	3.507	4.016	6.548	6.744	3.948	3.190	3.087	3.248	3.019	2.901	3.102	3.226	
17	3.463	4.141	6.517	6.968	4.069	3.219	2.878	3.019	2.991	2.876	3.005	3.241	
18	3.481	4.111	6.916	6.763	3.947	4.087	3.222	3.123	3.024	2.866	2.868	3.091	
19	3.454	4.098	6.746	5.678	3.855	3.845	2.990	3.116	3.045	2.971	2.997	3.185	
20	3.457	4.165	6.722	7.147	3.769	3.834	2.652	3.104	2.983	2.865	2.973	3.195	
21	3.401	4.081	6.845	7.047	3.736	3.811	3.117	3.053	2.968	3.007	3.075	3.250	
22	3.327	4.342	7.788	6.889	3.637	3.777	3.259	3.180	2.857	2.985	3.050	3.163	
23	3.352	4.290	6.587	6.735	4.083	3.574	3.206	3.270	2.929	2.998	3.032	3.158	
24	3.361	4.172	7.051	6.621	4.160	3.596	3.190	3.127	2.987	2.847	3.194	3.253	
25	3.306	4.169	6.611	6.665	4.278	3.506	3.247	3.151	3.028	2.982	3.190	3.247	
26	3.256	4.144	6.539	6.473	4.217	3.543	3.196	3.090	3.020	3.020	3.083	3.242	
27	3.280	4.224	6.465	6.257	4.155	3.467	3.198	3.150	2.985	2.962	3.094	3.235	
28	3.250	4.339	6.748	6.051	4.086	3.352	3.179	3.116	2.999	2.871	3.033	3.330	
29	3.177		6.718	5.901	4.032	3.458	2.999	3.100	2.949	3.118	3.043	3.690	
30	3.177		6.885	5.728	3.992	3.406	3.197	2.962	2.915	3.053	3.028	3.880	
31	3.125		6.642		3.968		3.187	3.156		2.953		3.691	
Avg.	3.352	3.794	6.511	6.566	4.456	3.643	3.191	3.164	3.015	2.926	3.046	3.252	3.909
Max.	3.516	4.342	7.788	7.147	5.908	4.087	3.444	3.436	3.130	3.118	3.194	3.880	7.788
Min.	3.125	3.190	4.584	5.310	3.637	3.190	2.652	2.962	2.857	2.828	2.868	2.992	2.652
Friday	3.363	3.754	6.228	6.656	4.450	3.661	3.128	3.131	3.018	2.974	3.024	3.274	3.889

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2002													
1	3.566	3.553	6.514	5.094	5.430	5.444	4.156	3.448	3.220	3.127	3.532	3.073	
2	3.811	3.548	6.553	5.488	5.676	5.361	3.210	3.337	3.459	3.287	3.519	3.110	
3	3.789	3.741	6.468	5.377	5.799	5.122	4.048	3.269	3.241	3.190	3.538	3.136	
4	3.558	3.719	6.669	5.182	5.818	4.561	3.982	3.362	3.407	2.958	3.453	3.099	
5	3.568	3.854	6.441	5.675	5.819	5.172	3.706	3.677	3.393	3.167	3.412	3.174	
6	3.348	4.174	6.434	5.333	5.209	5.319	3.702	3.541	3.366	3.278	3.263	3.099	
7	3.366	4.401	6.596	5.958	5.841	5.256	3.807	3.470	3.302	3.185	3.486	3.081	
8	3.203	4.325	6.839	5.506	5.943	5.047	3.715	3.395	3.171	3.040	3.281	3.010	
9	3.434	4.376	6.681	5.419	5.966	4.976	3.494	3.460	3.329	3.040	3.385	3.053	
10	3.406	4.544	6.660	5.581	5.614	4.884	3.694	3.657	3.453	3.063	3.116	2.978	
11	3.406	4.390	6.545	5.737	6.019	5.016	3.913	3.521	3.113	2.963	3.445	3.351	
12	3.414	4.105	6.581	5.863	6.069	4.848	3.753	3.589	3.504	3.056	3.321	3.352	
13	3.322	4.622	6.498	5.569	5.805	4.660	3.900	3.489	3.428	3.186	3.342	3.426	
14	3.398	4.681	6.705	5.632	6.198	4.526	3.655	3.434	3.479	3.225	3.265	3.541	
15	3.348	4.673	6.644	5.300	5.488	4.482	3.428	3.556	3.509	3.166	3.244	3.443	
16	3.335	4.581	6.573	5.402	5.887	4.678	3.942	3.327	3.403	3.226	3.262	3.502	
17	3.274	5.134	6.809	5.496	5.405	4.754	3.786	3.471	3.328	3.128	3.246	3.342	
18	3.281	5.497	6.549	5.656	5.985	4.880	3.912	3.042	3.534	3.169	2.924	3.581	
19	3.255	6.026	6.603	5.303	6.173	4.716	3.739	3.635	3.387	3.007	3.053	3.695	
20	3.273	6.008	6.543	5.353	5.850	4.363	3.726	3.386	3.485	3.189	3.061	3.833	
21	3.382	6.043	7.458	5.125	5.401	4.302	3.497	3.616	3.504	3.123	3.054	5.430	
22	3.305	6.146	6.143	5.368	5.850	4.155	3.357	3.454	3.461	2.522	3.181	5.646	
23	3.256	5.645	6.796	5.410	5.854	4.373	3.714	3.580	3.533	3.475	3.135	5.610	
24	3.349	5.786	6.457	5.203	5.773	4.227	3.541	3.426	3.641	3.511	3.079	5.254	
25	3.439	6.151	7.433	5.396	5.740	4.228	3.517	3.165	3.376	3.443	3.120	4.954	
26	3.378	5.654	6.253	5.370	5.653	4.448	3.751	3.544	3.411	3.456	3.183	4.375	
27	3.360	6.695	7.115	5.441	5.944	4.333	3.611	3.454	3.357	3.398	3.184	4.107	
28	3.461	6.256	6.727	5.601	5.772	4.567	3.592	3.402	3.545	3.363	3.019	3.757	
29	3.402		6.632	5.462	5.454	4.657	3.384	3.571	3.225	3.451	3.171	3.663	
30	3.389		6.661	5.494	5.713	4.191	3.393	3.333	3.245	3.378	3.112	3.875	
31	3.550		7.145		5.557		3.445	3.573		3.443		3.848	
Avg.	3.407	4.940	6.669	5.460	5.765	4.718	3.680	3.458	3.394	3.200	3.246	3.755	4.303
Max.	3.811	6.695	7.458	5.958	6.198	5.444	4.156	3.677	3.641	3.511	3.538	5.646	7.458
Min.	3.203	3.548	6.143	5.094	5.209	4.155	3.210	3.042	3.113	2.522	2.924	2.978	2.522
Friday	3.421	4.674	6.555	5.553	5.629	4.663	3.737	3.407	3.409	3.133	3.282	3.616	4.257

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2003													
1	3.831	5.508	6.080	6.019	6.329	6.506	6.768	6.808	6.328	5.769	6.302	5.723	
2	3.895	5.633	5.662	5.981	6.216	6.389	6.661	6.942	6.662	5.770	5.793	5.382	
3	3.615	5.831	5.834	6.054	6.032	6.502	6.878	6.738	6.715	5.717	6.178	4.790	
4	3.713	5.725	5.775	6.218	6.319	6.038	6.582	6.894	6.319	5.681	6.095	5.417	
5	4.074	5.542	5.424	6.144	6.271	6.928	6.762	6.937	6.756	5.787	6.045	5.410	
6	6.047	5.853	6.358	6.247	6.162	7.041	6.845	7.106	5.976	5.757	5.995	5.066	
7	5.881	5.768	5.987	6.090	6.140	6.524	6.967	7.093	6.467	5.588	6.073	5.378	
8	5.450	5.884	6.101	6.167	6.452	6.831	6.829	6.751	6.287	5.560	6.105	5.272	
9	5.831	5.982	6.037	5.631	6.446	6.398	6.794	6.839	6.326	5.517	6.138	5.345	
10	5.971	5.899	5.758	6.174	6.180	6.605	6.420	6.982	6.300	5.498	5.584	5.086	
11	5.530	5.809	5.896	6.229	6.472	6.238	6.661	7.000	6.243	5.449	5.910	5.122	
12	5.575	5.709	5.981	5.627	6.583	6.864	6.618	6.758	6.405	5.605	5.832	4.955	
13	5.873	5.372	5.871	6.265	6.508	6.868	6.870	6.936	6.307	5.646	5.789	5.179	
14	5.429	5.518	5.893	5.747	6.367	6.375	6.452	6.792	6.349	5.449	6.062	5.041	
15	5.501	5.551	5.944	5.886	6.611	6.645	6.636	6.942	6.176	5.559	6.010	5.348	
16	5.679	5.790	6.116	6.174	6.652	6.555	6.707	6.770	6.131	5.519	6.029	5.086	
17	3.871	5.800	5.775	5.640	6.439	6.788	7.255	6.873	6.114	5.489	6.269	5.158	
18	6.335	5.745	5.726	6.024	6.552	6.400	6.804	6.788	6.075	5.774	6.030	5.079	
19	5.801	5.867	5.145	5.771	6.464	6.627	6.728	6.426	6.139	5.758	5.917	5.074	
20	5.171	5.860	5.088	6.084	6.627	6.848	6.911	6.574	6.179	5.827	5.900	5.228	
21	5.616	5.919	5.579	5.852	6.396	6.586	6.828	6.547	6.091	5.644	6.257	4.812	
22	5.481	5.734	5.101	5.606	6.694	6.178	6.889	6.900	6.023	5.556	6.071	5.708	
23	5.380	5.881	5.924	5.854	6.220	6.629	6.930	6.165	6.024	5.526	6.045	4.859	
24	5.247	5.701	5.728	5.813	6.599	6.732	6.947	6.699	6.004	5.512	6.013	5.111	
25	5.237	5.021	5.592	6.044	6.347	6.545	6.825	6.808	5.932	5.893	5.916	5.057	
26	5.141	5.337	5.680	6.067	6.620	6.785	6.892	6.434	5.944	5.878	6.048	5.302	
27	5.189	5.859	5.766	5.890	6.396	6.675	6.758	6.435	5.894	6.246	5.648	5.348	
28	5.261	5.946	5.873	5.619	6.616	6.411	6.729	6.561	5.867	6.467	5.716	5.290	
29	5.364		6.429	5.823	5.831	6.846	6.868	6.666	5.840	6.058	5.518	5.148	
30	5.425		6.033	6.039	5.547	6.603	6.971	6.360	5.795	5.856	6.069	5.271	
31	5.287		5.586		6.401		6.708	6.653		6.375		5.143	
Avg.	5.216	5.716	5.798	5.959	6.371	6.599	6.790	6.748	6.189	5.733	5.979	5.200	6.026
Max.	6.335	5.982	6.429	6.265	6.694	7.041	7.255	7.106	6.756	6.467	6.302	5.723	7.255
Min.	3.615	5.021	5.088	5.606	5.547	6.038	6.420	6.165	5.795	5.449	5.518	4.790	3.615
Friday	4.798	5.788	5.833	6.129	6.216	6.858	6.718	6.813	6.311	5.718	6.027	5.185	6.033

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2004													
1	5.392	6.023	5.715	6.023	6.019	6.385	6.657	6.060	5.568	5.739	5.262		
2	5.272	5.607	6.136	6.094	6.331	6.427	5.979	6.023	5.642	5.534	5.269		
3	5.201	5.266	5.638	6.080	5.794	5.798	6.652	5.831	5.925	5.678	5.246		
4	5.188	5.414	6.156	6.277	6.128	6.618	5.156	6.010	5.661	5.678	5.231		
5	5.090	5.338	5.732	6.197	6.005	6.134	5.583	5.817	5.761	5.553	5.255		
6	5.292	5.700	6.299	5.788	6.149	6.504	5.830	6.305	5.745	5.621	5.231		
7	5.181	5.388	5.314	5.895	6.171	6.390	5.266	5.856	5.743	5.518	5.188		
8	4.975	6.058	5.907	6.053	6.343	6.670	5.531	5.814	5.633	5.451	5.244		
9	5.221	5.810	5.761	6.227	6.134	6.551	7.403	5.824	5.709	5.517	5.262		
10	5.192	5.721	5.911	6.169	6.161	6.645	6.424	5.834	5.702	5.282	5.217		
11	5.136	5.727	5.655	6.263	6.479	6.290	6.669	5.712	5.635	5.298	5.218		
12	5.144	5.222	6.210	6.009	6.284	6.382	6.569	5.697	5.377	5.547	5.254		
13	4.903	5.897	6.022	6.269	6.149	6.420	6.573	6.136	5.309	5.596	5.230		
14	5.236	5.697	5.812	6.336	6.248	6.679	6.523	5.928	5.531	5.364	5.215		
15	5.271	5.761	5.765	6.273	6.348	6.715	6.383	5.525	5.431	5.563	5.196		
16	5.324	5.227	5.703	6.192	6.216	6.372	6.303	5.693	5.509	5.595	5.177		
17	5.402	5.732	5.776	5.918	6.007	6.671	6.391	5.584	5.523	5.521	5.156		
18	4.955	5.763	6.226	6.213	5.999	6.782	6.676	5.990	5.579	5.568	5.168		
19	5.283	5.706	5.744	5.976	6.176	6.459	6.333	5.055	5.488	5.501	5.124		
20	5.761	5.759	6.072	5.963	6.053	6.746	6.088	6.225	5.442	5.547	5.034		
21	5.116	5.682	5.829	5.945	6.118	6.225	6.249	5.859	5.398	5.544	5.136		
22	6.057	5.817	6.234	6.114	6.332	6.944	6.013	5.526	5.331	5.432			
23	5.410	5.613	5.853	5.961	6.099	6.615	6.389	6.143	5.594	5.318			
24	5.800	5.697	6.157	6.163	6.321	5.962	6.233	5.924	5.451	5.177			
25	5.540	5.756	6.121	5.796	6.308	6.600	5.945	5.884	5.474	5.229			
26	5.684	5.592	6.294	6.207	6.173	6.272	5.866	5.735	5.030	5.230			
27	5.902	5.862	6.118	5.884	6.220	6.650	6.298	5.751	5.341	5.237			
28	5.577	6.156	6.137	5.877	6.554	6.218	6.067	5.835	5.414	5.269			
29	5.703	5.794	6.005	6.375	6.335	6.949	5.968	5.473	5.312	5.316			
30	6.327		6.115	6.307	6.131	5.514	6.538	5.361	5.508	5.177			
31	5.818		6.264		6.447		6.022	5.750		5.255			
Avg.	5.398	5.682	5.957	6.095	6.201	6.453	6.212	5.812	5.526	5.447	5.205		5.835
Max.	6.327	6.156	6.299	6.375	6.554	6.949	7.403	6.305	5.925	5.739	5.269		7.403
Min.	4.903	5.222	5.314	5.788	5.794	5.514	5.156	5.055	5.030	5.177	5.034		4.903
Friday	5.511	5.804	5.995	6.156	6.273	6.572	6.522	6.104	5.650	5.500	5.211	0.000	5.442

Table 1-6-3 Daily Discharge in Two Tunnels (2000-2004)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2000													
1	3.654	3.785	4.565	7.492	6.694	6.218	4.492	4.018	3.708	3.606	3.727	3.604	
2	3.576	3.667	4.668	7.077	7.515	6.414	4.456	4.050	3.706	3.624	3.684	3.634	
3	3.580	3.575	4.586	7.184	7.321	6.229	4.458	3.997	3.840	3.525	3.706	3.659	
4	3.534	3.769	4.693	7.593	7.417	5.987	4.557	3.973	3.804	3.590	3.727	3.608	
5	3.601	3.747	4.711	7.009	7.625	5.734	4.306	3.966	3.702	3.773	3.728	3.676	
6	3.551	3.864	4.773	7.584	7.694	5.849	4.408	3.977	3.582	3.584	3.685	3.621	
7	3.580	3.967	4.747	7.690	7.047	5.710	4.420	3.926	3.673	3.753	3.696	3.589	
8	3.662	4.070	5.310	6.761	7.540	5.756	4.369	3.913	3.749	3.670	3.337	3.701	
9	3.644	3.953	5.468	7.534	7.615	5.480	4.373	4.029	3.754	3.681	3.856	3.698	
10	3.611	3.885	5.291	6.851	7.295	5.442	4.388	3.910	3.740	3.641	3.792	3.702	
11	3.542	3.884	5.152	7.325	7.329	5.342	4.364	3.817	3.716	3.567	3.744	3.680	
12	3.559	3.987	5.218	7.327	7.320	5.439	4.229	3.792	3.576	3.716	3.659	3.658	
13	3.637	3.998	5.729	7.257	7.413	5.341	4.374	3.870	3.681	3.696	3.718	3.733	
14	3.626	4.130	5.984	7.297	7.532	5.297	4.224	3.760	3.770	3.638	3.772	3.623	
15	3.716	4.150	6.429	7.242	7.399	5.272	4.293	3.812	3.751	3.704	3.642	3.572	
16	3.736	4.179	8.178	7.553	7.297	5.008	4.301	3.922	3.549	3.754	3.746	3.603	
17	3.637	4.193	6.732	7.370	7.764	4.921	4.362	3.871	3.762	3.760	3.658	3.485	
18	3.687	4.194	6.387	6.767	7.821	4.827	4.176	3.775	3.590	3.615	3.661	3.602	
19	3.549	4.096	6.727	7.816	7.429	4.855	4.072	3.871	3.752	3.760	3.703	3.592	
20	3.707	4.063	6.208	7.579	7.265	4.859	4.050	3.797	3.805	3.637	3.676	3.700	
21	3.642	4.350	6.703	7.280	7.176	4.804	4.042	3.758	3.699	3.774	3.660	3.684	
22	3.607	4.485	7.230	7.421	7.135	4.749	3.991	3.762	3.734	3.688	3.593	3.701	
23	3.724	4.726	6.914	7.145	7.223	4.669	4.003	3.811	3.787	3.623	3.647	3.676	
24	3.499	4.734	6.465	7.040	7.344	4.663	4.146	3.888	3.805	3.749	3.715	3.670	
25	3.759	4.805	7.153	7.023	7.103	4.605	4.141	3.915	3.611	3.680	3.677	3.639	
26	3.753	4.597	7.273	7.414	7.007	4.568	4.099	3.736	3.463	3.542	3.620	3.866	
27	3.803	4.513	6.791	7.474	6.908	4.705	4.114	3.770	3.734	3.735	3.664	3.902	
28	3.865	4.618	7.065	7.540	6.996	4.667	4.066	3.871	3.600	3.704	3.651	3.859	
29	3.781	4.712	7.483	7.778	6.819	4.641	4.071	3.842	3.535	3.686	3.736	3.721	
30	3.632		6.882	7.778	6.548	4.603	4.072	3.819	3.485	3.643	3.741	3.733	
31	3.786		6.971		6.264		3.995	3.694		3.819		3.676	
Avg.	3.653	4.162	6.080	7.340	7.253	5.222	4.239	3.868	3.689	3.675	3.687	3.673	4.712
Max.	3.865	4.805	8.178	7.816	7.821	6.414	4.557	4.050	3.840	3.819	3.856	3.902	8.178
Min.	3.499	3.575	4.565	6.761	6.264	4.568	3.991	3.694	3.463	3.525	3.337	3.485	3.337
Friday	3.678	4.163	6.009	7.451	7.345	5.235	4.188	3.870	3.695	3.663	3.718	3.660	4.723

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2001													
1	3.859	3.776	5.306	7.396	6.158	4.578	3.821	3.595	3.402	3.197	3.317	3.542	
2	3.945	3.914	5.950	7.262	6.005	4.603	3.951	3.750	3.416	3.224	3.247	3.402	
3	3.976	3.992	6.362	7.354	5.999	4.446	3.906	3.677	3.316	3.160	3.287	3.356	
4	3.927	3.993	6.752	7.164	5.734	4.402	3.663	3.689	3.288	3.279	3.420	3.427	
5	3.877	4.013	8.168	7.404	5.838	4.358	3.561	3.466	3.299	3.191	3.367	3.414	
6	3.731	3.989	9.838	7.079	6.059	4.371	3.992	3.890	3.330	3.216	3.273	3.470	
7	4.022	4.068	6.454	7.547	6.482	4.321	3.720	3.781	3.443	3.185	3.439	3.565	
8	4.009	4.011	6.965	7.054	6.113	4.255	3.922	3.669	3.406	3.233	3.235	3.550	
9	4.011	4.046	6.543	7.257	5.361	4.227	3.669	3.767	3.357	3.201	3.355	3.549	
10	3.981	4.069	6.869	7.051	4.990	4.273	3.725	3.599	3.417	3.164	3.388	3.283	
11	3.961	4.188	7.102	7.389	4.980	4.135	3.710	3.573	3.497	3.159	3.443	3.711	
12	4.103	4.283	7.337	7.330	4.895	4.155	3.675	3.540	3.363	3.324	3.380	3.632	
13	4.150	4.266	7.695	7.267	4.786	4.202	3.694	3.643	3.394	3.135	3.465	3.519	
14	4.170	4.449	7.153	7.329	4.779	3.904	3.574	3.529	3.296	3.233	3.114	3.600	
15	4.127	4.634	6.906	5.634	4.363	3.851	3.873	3.602	3.391	3.219	3.517	3.588	
16	4.155	4.777	7.143	7.372	4.562	3.635	3.612	3.649	3.318	3.265	3.426	3.551	
17	4.109	4.919	7.115	7.733	4.706	3.853	3.311	3.360	3.319	3.268	3.318	3.569	
18	4.113	4.866	7.519	7.431	4.510	4.836	3.690	3.460	3.315	3.203	3.166	3.423	
19	4.098	4.869	7.346	6.311	4.410	4.464	3.423	3.451	3.351	3.308	3.309	3.506	
20	4.093	4.948	7.393	7.984	4.309	4.463	3.067	3.507	3.287	3.175	3.279	3.515	
21	4.027	4.861	7.465	7.888	4.315	4.479	3.461	3.444	3.238	3.336	3.382	3.574	
22	3.934	5.185	8.409	7.573	4.199	4.277	3.707	3.537	3.198	3.306	3.350	3.477	
23	3.973	5.099	7.273	7.325	4.715	4.122	3.595	3.659	3.249	3.317	3.340	3.477	
24	3.981	4.827	7.651	7.203	4.804	4.092	3.614	3.476	3.313	3.141	3.511	3.685	
25	3.920	4.809	7.168	7.279	4.957	4.115	3.757	3.451	3.346	3.302	3.513	3.578	
26	3.853	4.777	7.092	7.054	4.870	4.061	3.658	3.415	3.344	3.323	3.387	3.573	
27	3.889	4.886	7.004	6.820	4.770	4.002	3.658	3.488	3.337	3.258	3.404	3.565	
28	3.839	5.020	7.316	6.593	4.682	3.783	3.671	3.447	3.333	3.166	3.348	3.670	
29	3.750		7.284	6.478	4.668	3.947	3.413	3.469	3.234	3.167	3.356	4.069	
30	3.752		7.458	6.279	4.583	3.931	3.684	3.302	3.210	3.279	3.338	4.273	
31	3.709		7.219		4.546		3.636	3.463		3.266		4.062	
Avg.	3.969	4.483	7.202	7.161	5.037	4.205	3.658	3.560	3.334	3.232	3.356	3.586	4.397
Max.	4.170	5.185	9.838	7.984	6.482	4.836	3.992	3.890	3.497	3.336	3.517	4.273	9.838
Min.	3.709	3.776	5.306	5.634	4.199	3.635	3.067	3.302	3.198	3.135	3.114	3.283	3.067
Friday	3.983	4.459	6.873	7.288	5.045	4.182	3.603	3.515	3.328	3.287	3.341	3.602	4.375

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2002													
1	3.920	3.910	7.196	5.692	5.988	5.970	4.580	3.722	3.468	3.387	3.814	3.356	
2	4.208	3.910	7.232	6.096	6.248	5.877	3.611	3.603	3.594	3.560	3.803	3.392	
3	4.191	4.119	7.143	5.975	6.373	5.614	4.679	3.529	3.694	3.458	3.807	3.416	
4	3.919	4.093	7.361	5.755	6.390	4.998	4.590	3.631	3.684	3.531	3.731	3.376	
5	3.934	4.261	7.115	6.287	6.386	5.650	4.286	3.973	3.667	3.498	3.691	3.460	
6	3.690	4.624	7.109	5.924	5.737	5.820	4.262	3.822	3.638	3.547	3.719	3.379	
7	3.726	4.875	7.280	6.582	6.411	5.744	4.342	3.752	3.573	3.451	3.818	3.357	
8	3.519	4.773	7.551	6.106	6.516	5.520	4.249	3.662	3.436	3.296	3.717	3.287	
9	3.779	4.840	7.376	6.017	6.543	5.465	4.009	3.733	3.609	3.289	3.726	3.325	
10	3.758	5.027	7.352	6.187	6.167	5.366	4.208	3.943	3.731	3.312	3.597	3.238	
11	3.749	4.857	7.230	6.351	6.596	5.505	4.489	3.795	3.355	3.214	3.768	3.650	
12	3.759	4.535	7.268	6.480	6.648	5.416	4.314	3.871	3.783	3.308	3.681	3.794	
13	3.657	5.098	7.175	6.171	6.370	5.121	4.480	3.765	3.691	3.440	3.666	3.712	
14	3.746	5.156	7.394	6.493	6.791	4.976	4.191	3.694	3.750	3.493	3.527	3.860	
15	3.693	5.149	7.328	5.855	6.029	4.925	3.937	3.832	3.778	3.430	3.507	3.756	
16	3.673	5.048	7.255	5.966	6.458	5.138	4.523	3.577	3.673	3.486	3.532	3.814	
17	3.608	5.659	7.515	6.064	5.945	5.227	4.347	3.741	3.580	3.433	3.514	3.648	
18	3.618	6.048	7.228	6.224	6.566	5.360	4.481	3.322	3.800	3.521	3.358	3.906	
19	3.590	6.640	7.281	5.856	6.759	5.177	4.298	4.004	3.638	3.597	3.360	4.028	
20	3.606	6.645	7.143	5.910	6.417	4.793	4.269	3.630	3.751	3.548	3.362	4.183	
21	3.719	6.687	8.120	5.664	5.934	4.733	3.990	3.870	3.773	3.452	3.356	5.888	
22	3.636	6.802	6.746	5.925	6.423	4.574	3.851	3.689	3.727	3.016	3.510	6.105	
23	3.573	6.249	7.396	5.970	6.416	4.813	4.243	3.822	3.805	3.815	3.451	6.068	
24	3.682	6.406	7.030	5.751	6.329	4.657	4.046	3.661	3.908	3.869	3.397	5.692	
25	3.783	6.799	8.090	5.959	6.293	4.659	4.020	3.387	3.633	3.791	3.442	5.378	
26	3.716	6.251	6.810	5.928	6.201	4.902	4.079	3.919	3.773	3.756	3.522	4.763	
27	3.700	7.394	7.744	6.004	6.513	4.786	3.908	3.732	3.610	3.755	3.511	4.468	
28	3.817	6.927	7.328	6.175	6.315	5.045	3.882	3.646	3.799	3.709	3.325	4.092	
29	3.742		7.208	6.024	5.979	5.151	3.654	3.859	3.517	3.756	3.460	3.994	
30	3.725		7.235	6.055	6.258	4.629	3.663	3.617	3.517	3.764	3.389	4.226	
31	3.902		7.764		6.089		3.714	3.887		3.693		4.201	
Avg.	3.753	5.456	7.323	6.048	6.325	5.187	4.168	3.732	3.665	3.522	3.569	4.091	4.732
Max.	4.208	7.394	8.120	6.582	6.791	5.970	4.679	4.004	3.908	3.869	3.818	6.105	8.120
Min.	3.519	3.910	6.746	5.664	5.737	4.574	3.611	3.322	3.355	3.016	3.325	3.238	3.016
Friday	3.767	5.158	7.206	6.138	6.180	5.124	4.244	3.671	3.672	3.514	3.602	3.935	4.684

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2003													
1	4.168	5.974	6.630	6.443	6.899	6.958	7.354	7.405	6.904	6.189	6.606	6.044	
2	4.252	6.107	6.115	6.427	6.773	6.839	7.223	7.542	7.262	6.191	6.079	5.688	
3	3.944	6.306	6.334	6.504	6.584	6.957	7.432	7.345	7.315	6.137	6.517	5.082	
4	4.045	6.193	6.277	6.675	6.889	6.458	7.146	7.497	6.890	6.102	6.408	5.737	
5	4.430	6.004	5.893	6.598	6.840	7.371	7.335	7.545	7.373	6.250	6.365	5.716	
6	6.524	6.330	6.789	6.707	6.719	7.523	7.434	7.729	6.530	6.226	6.292	5.360	
7	6.353	6.244	6.404	6.547	6.698	6.959	7.560	7.722	6.979	6.009	6.386	5.679	
8	5.899	6.363	6.521	6.642	7.031	7.305	7.397	7.350	6.831	5.982	6.416	5.569	
9	6.307	6.465	6.458	6.075	7.030	6.842	7.347	7.454	6.863	5.935	6.469	5.669	
10	6.453	6.386	6.167	6.673	6.732	7.061	6.958	7.603	6.809	5.914	5.869	5.403	
11	5.986	6.286	6.299	6.822	6.955	6.665	7.234	7.637	6.755	5.862	6.209	5.414	
12	6.037	6.189	6.552	6.182	7.172	7.318	7.191	7.371	6.941	6.004	6.161	5.377	
13	6.350	5.831	6.436	6.860	7.105	7.375	7.461	7.556	6.818	5.939	6.116	5.569	
14	5.891	5.987	6.457	6.309	6.957	6.861	6.988	7.405	6.899	5.798	6.394	5.291	
15	5.963	6.010	6.517	6.457	7.214	7.141	7.143	7.575	6.685	5.953	6.338	5.624	
16	6.156	6.271	6.571	6.757	7.253	7.053	7.219	7.384	6.637	5.918	6.367	5.353	
17	4.209	6.226	6.248	6.195	7.021	7.293	7.814	7.492	6.621	5.891	6.618	5.408	
18	6.834	6.209	6.199	6.604	7.149	6.896	7.326	7.401	6.582	6.107	6.356	5.346	
19	6.274	6.338	5.587	6.335	7.051	7.120	7.243	7.004	6.652	6.039	6.262	5.337	
20	5.610	6.329	5.517	6.663	7.225	7.349	7.446	7.185	6.689	6.141	6.248	5.472	
21	6.084	6.427	6.039	6.420	6.981	7.076	7.358	7.133	6.603	5.925	6.621	5.046	
22	5.939	6.259	5.540	6.157	7.197	6.837	7.421	7.522	6.538	5.834	6.412	6.016	
23	5.832	6.415	6.406	6.420	6.862	7.161	7.469	6.722	6.489	5.804	6.411	5.113	
24	5.693	6.226	6.199	6.377	7.208	7.352	7.540	7.295	6.427	5.792	6.373	5.399	
25	5.675	5.487	6.059	6.624	6.943	7.041	7.330	7.422	6.354	6.209	6.242	5.361	
26	5.579	5.833	6.147	6.651	7.231	7.468	7.461	7.015	6.365	6.197	6.417	5.619	
27	5.634	6.384	6.237	6.465	6.999	7.257	7.335	7.011	6.313	6.580	5.968	5.650	
28	5.712	6.482	6.357	6.035	7.131	6.960	7.317	7.152	6.289	6.787	6.038	5.615	
29	5.822		6.926	6.378	6.640	7.409	7.469	7.263	6.260	6.346	5.830	5.462	
30	5.897		6.517	6.606	5.996	7.169	7.579	6.930	6.216	6.167	6.439	5.575	
31	5.740		6.058		6.822		7.287	7.250		6.714		5.554	
Avg.	5.655	6.199	6.273	6.487	6.945	7.102	7.349	7.352	6.696	6.095	6.307	5.502	6.498
Max.	6.834	6.482	6.926	6.860	7.253	7.523	7.814	7.729	7.373	6.787	6.621	6.044	7.814
Min.	3.944	5.487	5.517	6.035	5.996	6.458	6.958	6.722	6.216	5.792	5.830	5.046	3.944
Friday	5.208	6.285	6.314	6.681	6.783	7.376	7.259	7.423	6.833	6.090	6.360	5.512	6.510

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Year 2004													
1	5.835	6.432	6.100	6.429	6.545	6.855	7.134	6.549	5.873	6.115	5.535		
2	5.674	5.974	6.540	6.518	6.870	6.895	6.703	6.515	5.960	5.877	5.548		
3	5.595	5.613	6.020	6.495	6.294	6.210	7.036	6.295	6.274	6.035	5.522		
4	5.594	5.801	6.555	6.685	6.655	7.089	5.891	6.488	5.984	6.058	5.508		
5	5.450	5.705	6.108	6.611	6.508	6.583	6.284	6.286	6.074	5.898	5.530		
6	5.670	6.087	6.702	6.184	6.678	6.977	6.442	6.838	6.060	5.994	5.506		
7	5.542	5.743	5.682	6.292	6.706	6.856	5.741	6.338	6.053	5.864	5.458		
8	5.324	6.465	6.292	6.460	6.880	7.132	6.189	6.299	5.955	5.798	5.512		
9	5.592	6.187	6.168	6.653	6.664	7.038	7.744	6.300	6.039	5.863	5.533		
10	5.551	6.111	6.310	6.582	6.694	7.106	6.842	6.309	6.048	5.696	5.486		
11	5.508	6.123	6.034	6.680	7.039	6.742	7.100	6.194	5.964	5.708	5.489		
12	5.505	5.577	6.619	6.410	6.809	6.860	7.023	6.191	5.698	5.833	5.523		
13	5.248	6.285	6.424	6.692	6.690	6.870	7.028	6.646	5.624	5.862	5.501		
14	5.606	6.076	6.205	6.752	6.774	7.118	6.980	6.412	5.844	5.623	5.485		
15	5.652	6.157	6.153	6.694	6.884	7.119	6.834	6.004	5.732	5.822	5.469		
16	5.687	5.582	6.075	6.594	6.758	6.770	6.756	6.170	5.807	5.864	5.445		
17	5.763	6.119	6.165	6.305	6.516	7.107	6.806	6.069	5.862	5.777	5.424		
18	5.296	6.146	6.625	6.606	6.516	7.221	7.128	6.485	5.898	5.842	5.389		
19	5.643	6.084	6.140	6.375	6.711	6.867	6.714	5.492	5.783	5.760	5.402		
20	6.161	6.150	6.467	6.367	6.572	7.198	6.541	6.640	5.731	5.818	5.313		
21	5.461	6.071	6.218	6.339	6.655	6.637	6.676	6.189	5.692	5.801	5.416		
22	6.479	6.205	6.662	6.523	6.885	7.370	6.407	5.839	5.622	5.702			
23	5.771	5.982	6.236	6.351	6.636	7.030	6.777	6.486	5.895	5.579			
24	6.178	6.072	6.567	6.571	6.862	6.820	6.615	6.249	5.788	5.434			
25	5.902	6.145	6.526	6.213	6.852	6.998	6.341	6.210	5.826	5.537			
26	6.077	5.962	6.697	6.734	6.702	6.653	6.313	6.068	5.378	5.490			
27	6.281	6.244	6.519	6.395	6.688	7.075	6.754	6.087	5.622	5.499			
28	5.957	6.558	6.549	6.398	7.006	6.531	6.541	6.149	5.745	5.528			
29	6.072	6.192	6.397	6.900	6.792	7.344	6.445	5.777	5.630	5.564			
30	6.727		6.516	6.843	6.582	6.274	7.040	5.666	5.875	5.448			
31	6.199		6.664		6.892		6.499	6.064		5.528			
Avg.	5.774	6.064	6.353	6.522	6.720	6.912	6.688	6.236	5.845	5.749	5.476		6.234
Max.	6.727	6.558	6.702	6.900	7.039	7.370	7.744	6.838	6.274	6.115	5.548		7.744
Min.	5.248	5.577	5.682	6.184	6.294	6.210	5.741	5.492	5.378	5.434	5.313		5.248
Friday	5.890	6.192	6.391	6.592	6.785	7.013	7.004	6.553	5.993	5.800	5.485	0.000	5.808

Table 2-1 Alternative Measures for Water Leakage Prevention of Old Tunnel Upstream

Method	**1. Panel Lining Method**				**3. Open Air Method**	
	FRP Lining		Steel Plate Lining			
Outline	FRP panels will be fixed to the tunnel inner faces with anchors after cleaning the tunnel faces. To grout the space between the panels and faces.		Steel plate panels will be installed to the tunnel inner faces with anchors and will be welded after cleaning the tunnel faces. To grout the space between the panels and faces.		Heavy equipment excavates the covering earth material above the tunnel. The tunnel will be rehabilitated in open air.	
Advantage	· Roughness coefficient of FRP is so small that tunnel can retain the design capacity · The panel can stop water leakage and intrusion of tree roots. · Easy handling the light material.		· Roughness coefficient is so small that tunnel can retain the design capacity. · Steel plate can resist external force more than FRP. · The panel can stop water leakage and intrusion of tree roots.		· Structure durability improves because the deteriorated slab can be replaced. · External reinforcement can be undertaken.	
Dis-Advantage	· The material will be affected by ultraviolet rays. · Replacement is needed when thin plate is broken during grouting.		· Panel size is small due to entrance and welding length becomes long. · Steel plate does not have flexibility due to high rigidity. · Field process is needed.		· Applicable tunnel length is short. Resident houses are closed to the tunnel. · Road widening is needed. · Excavated material shall be hauled to spoil bank.	
Construction	· Easy to bring in the material. · Electric power is needed for tools.		· Not easy to transport the heavy steel in tunnel. · Electric power is needed for welding and tools. · Plate size becomes small for transportation.		· Temporary works of road widening and spoil bank are needed. · Rock fall prevention fences are needed on slope. · Though construction cost becomes low, applicable tunnel length is short.	
Environment Impact	· No liquidation to water. · Material hardly adheres to the surface.		· Ventilation is needed due to welding work. · Periodical painting is needed.		· Measures for construction noise are needed. · Measures for land slide on slope are needed.	
Const. Period	10 m/day		7 m/day		1 m/day for direct work	
Costs	100,000 Yen/m, **15 million Yen**		150,000 Yen/m, 22 **million Yen**		50,000 Yen/m (Excavation, breaking, concreting, filling)	
Comprehensive Assess	Most effective against water leakage.	**A**	Ventilation is needed during construction. Periodical Painting is needed.	**C**	Applicable tunnel length is very short. Rehabilitation work in the tunnel is superior in this Project.	**C**

Method	**2. Bypass Tunnel Method**					
	Route-1		Route-2		Route-3	
Outline	Tunnel connecting points: TD 150 - 3,160		Tunnel connecting points: TD 150 - 1,700 (L=1,790 m) Tunnel connecting points: TD 2,300 - 3,160 (L=1,480 m)		Tunnel connecting points: TD 150 - 1,700 (L=1,790 m) Tunnel connecting points: TD 2,400 - 2,660 (L=260 m)	
Advantage	· Long durability and no water leakage. · Bypass tunnel is located far from housing area. Tunnel is not affected by then · Tunnel flow will be interrupted only when tunnel connection.		· Long durability and no water leakage. · Bypass tunnel is located far from housing area. Tunnel is not affected by the · Re-use of the old tunnel in good condition.		· Long durability and no water leakage. · Countermeasures are limited to prevention of water leakage and tree root intrusio · Re-use of the old tunnel in good condition.	
Dis-Advantage	· The non-use old tunnel shall be plugged. · Large scaled temporary works and facilities are needed.		· The non-use old tunnel shall be plugged. · Large scaled temporary works and facilities are needed.		· The non-use old tunnel shall be plugged. · Large scaled temporary works and facilities are needed.	
Construction	· Working space at the tunnel inlet is sufficient at Figeh Office. · Working space at the tunnel outlet is not sufficient at Gate 7.		· Working space at the tunnel inlet is sufficient at Figeh Office. · Working space at the other tunnel inlet/outlet is not sufficient.		· Working space at the tunnel inlet is sufficient at Figeh Office. · Rehabilitation in the tunnel from gate No.7.	
Environment Impact	· Attention shall be paid to Figeh district. · The non-use old tunnel shall be plugged not to invite collapse in future.		· Attention shall be paid to Figeh district. · The non-use old tunnel shall be plugged not to invite collapse in future.		· Attention shall be paid to Figeh district. · The non-use old tunnel shall be plugged not to invite collapse in future.	
Const. Period	30 months		30 months		25 months	
Costs	**1,500 million Yen**		**1,340 million Yen**		**780 million Yen**	
Comprehensive Assess	The alternative provides superior advantages, but costs are very high.	**C**	The alternative provides superior advantages and the old tunnel is re-used, but costs are still high.	**C**	The alternative provides superior advantages and the old tunnel is re-used, but costs are high.	**B**

Table 2-2 Alternative Measures for Structural Cracks TD300-345 of Old Tunnel

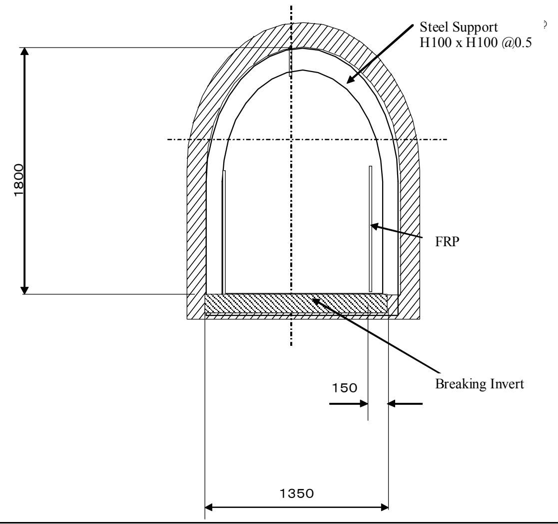
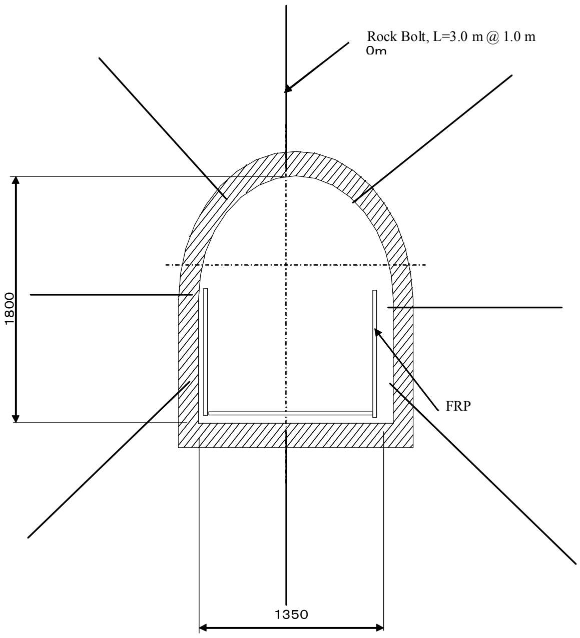
	Steel Support	**Rock Bolt**
Sketch		
Method	To install H-still in tunnel to resist external force. FRP is installed to stop water leakage.	To provide rock bolts into rock to resist external force. FRP is installed to stop water leakage.
Advantag	· This is common application as a temporary measure. · After tunnel lining loses resistance against external force, H-still resists it.	· This is common practice as a permanent measure. · External rock foundation resists deformation. It has strong resistance.
Disadva ntage	· New crack in the lining concrete is the cause of water leakage. · Flow area is reduced. Design flow capacity can not be hold. · This method is inferior against long term external force.	· It takes time to drill holes due to limited space.
Construc tion	· To transport H-steel from upstream, and to install them from downstream.	· A few drilling machine will be mobilized to expedite drilling work.
Enviro nment Impact	· Steel support will rust.	· No rust problem.
Periods	2.0 months	10 months (3 units of drill machine)
Costs	15 million Yen	18 million Yen

Table 2-3 Lining Works for Old Tunnel

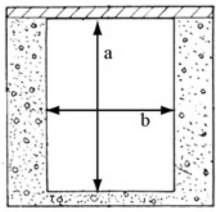
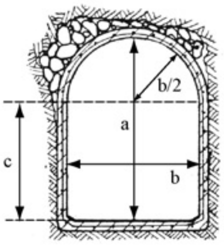
Stretch	TD (m)	Stretch Length (m)	Type of Section Profile	Type of Lining Work	Dimensions of Inner Section (mm)			Purpose of Repair	Sketch
					a	b	c		
A	290 ~355	65	II	3 faces	1,950	1,370	1,265	- Leakage prevention, - Cracking prevention	Section Type I Inside Dimensions  Section Type II Inside Dimensions 
B	1,000 ~1,100	100	II	3 faces	1,950	1,370	1,265	- Leakage prevention, - Cracking prevention	
C	1,400 ~1,440	40	I	3 faces	1,540	1,340		- Leakage prevention, - Cracking prevention	
D	1,440 ~1,680	240	I	4 faces	1,760	1,350		- Prevention of flaking and/or peeling off, - Resistance to external load	
E	2,400 ~2,550	150	I	3 faces	1,730	1,300		- Leakage prevention, - Cracking prevention, - Prevention of wooden root infiltration	
F	2,550 ~2,700	150	II	3 faces	1,900	1,340	1,230	- Leakage prevention. - Cracking prevention. - Prevention of wooden root infiltration	
G	2,910 ~3,000	90	I	1 face (crown face)	1,600	1,160		- Prevention of flaking and/or peeling off	
H	3,000 ~3,060	60	I	1 face (crown face)	1,870	1,310		- Prevention of flaking and/or peeling off	
I	7,200 ~7,330	130	II	3 faces	1,880	1,340	1,210	- Leakage prevention, - Cracking prevention	
J	8,840 ~8,860	20	II	3 faces	1,880	1,340	1,210	- Leakage prevention, - Cracking prevention, - Prevention of wooden root infiltration	
K	9,510 ~9,570	60	I	1 side (crown face)	1,770	1,370		- Prevention of flaking and/or peeling off	
L	9,750 ~10,010	260	II	3 faces	1,880	1,340	1,210	- Leakage prevention - Cracking prevention	
M	10,180 ~10,255	75	II	3 faces	1,880	1,340	1,210	- Leakage prevention - Cracking prevention	
N	10,533 ~10,579	46	I	1 face (crown face)	1,770	1,370		- Prevention of flaking and/or peeling off	
O	10,719 ~10,779	60	I	1 face (crown face)	1,780	1,310		- Prevention of flaking and/or peeling off	
	Total Length	**1,546**						-	

Table 2-4　List of Reservoirs and Tanks

No.	Name of Facility	Type of Facility	Elevation (m)		Nos. of Tanks	Volume (m^3)	Status	Remarks
			TWL	BWL				
1	Wali New	R	804	796	4	61,440		
2	Western	R	758	750	4	42,704		
3	Berze Eastern	R	753	749	2	28,240		
4	Mezze Wroud	R	776	772	2	13,000		
5	Wali Old	R	805	801	3	8,500		
6	Mezze High (new+old)	R	821	816	2	8,400		
7	Dummar High (Main)	R	905	900	2	5,862		
8	Berze Bohooth	R	836	831	2	5,862		
9	Jaramana (5)	R	672	668	2	3,360	Under Construction	
10	Akrad Low	R	790	785	2	8,200		High Water Leakage,Booster Pumps operate with a by-pass connection
11	Kassioun Middle	R	848	840	2	4,000		
12	Dummar island 23 (Ex2)	R	942	938	2	925	Under Construction	
13	Koudsayia 2	R	931	927	2	4,000		
14	Dummar island23A (Ex3)	R	994	990	2	9,000	Under Construction	
15	Barada Main Reservoir	R	1.122	1,118	2	3,000		
16	someriah	R	794	789	2	3,000		
17	Marwan Wadi	R	1,011	1,007	2	2,500		
18	Koudsayia 3	R	964	960	2	2,500		
19	Esh Al-Warwar 1	R	910	906	2	2,500		
20	Dummar island24 (Ex1)	R	899	895	2	1,000		
21	Koudsayia 1	R	909	905	2	2,500		
22	Kafar Souseh	R	706	702	2	2,500		
23	University City	R	716	712	2	2,470		
24	Jober	R	678	674	2	2,470		
25	Mazraa	R	698	694	2	6,600		
26	Oumawiyin	R	698	694	2	2,470		
27	Kadam Store	R	693	689	2	2,470		
28	Kadam Railway	R	692	688	2	2,470		
29	Ibn Assaker	R	680	676	2	2,470		
30	Kassioun High 2	R	931	926	2	800	Under Construction	
31	Takadom	R	674	670	2	2,200		
32	Jemraya	R	858	854	2	2,100		
33	Khorshead	R	819	815	2	2,000		
34	Al-Maasarani	R	809	805	2	2,000		Suppl of Research Institute only. Not supply to Network
35	Berze Village	R	835	830	1	2,500	Non-Use	
36	Dummar island22 (Ex4)	R	1,044	1,040	2	500	Under Construction	
37	Akrad High	R	885	881	2	1,872		
38	Wadi Al-Mashareh	R	824	820	2	340		
39	Kassioun High 1	R	885	881	2	3,054		
40	Akrad Middle	R	836	832	2	1,600		
41	Tishrin palace	R	781	778	2	300	Under Construction	
42	Figeh 1	R	907	903	3	1,030		
43	Tkyeh (regulation)	PBT	1,099	1,095	2	1,000		
44	Koudsayia 4	R	992	988	2	9,000		
45	Husaynieh (regulation)	PBT	949	945		1,000		
46	Yarmouk High(moukaem)	WT	702	699	1	300	Under Construction	
47	Figeh 2	R	953	948		250	Under Construction	
48	Figeh (regulation)	PBT	881	877	2	1,000		
49	Basima	R	879	875	2	1,000		Pumps have not enough capacity for lifting water up into the Reservoir
50	Kassioun Superior	R	1,000	996	3	500		
51	Kaboun High	WT	734	729	1	387	Non-Use	
52	Mezze 86	WT	867	862	1	500		
53	AbbaSiin High	WT	691	686	1	378	Non-Use	
54	Jobar High	WT	707	701	1	270	Non-Use	Not supply to Network
55	Dummar PS	R	776.50	773.25		270	Plan	
56	Dummar High (new)	R	907	904	2	350		
57	Basima PS	R	808	805	2	240		Not supply to Network
58	Jdydeh (regulation)	PBT	871	869		175		Used for Field Training of DAWSSA
59	Oumawiyin Extension	R	698	694	1	2,770	Under Construction	
60	Dummar island 16	WT	951	948	1	100		
61	Kadam High	WT	693	688	1	378	Non-Use	
62	Dummar (regulation-1)	PBT	873	870	1	100		
63	Dummar (regulation-2)	PBT	843	840	1	100		Balacing Reservoir (feeding depends on pressur in Network)
64	Dummar (regulation-3)	PBT	808	805	1	100	Non-Use	
65	Bab Musallah	WT	691	686	1	378	Non-Use	
66	KANAWAT (8) Naher Aysheh	R	689	685	3	5,160	Plan	
67	Bab Sharki	WT	686	682	1	378	Non-Use	
68	Ibn Assaker Extension	R	680	676	1	2,760	Under Construction	
69	Hai Al-Manara	R	857	855	2	78		
70	Bistan Al-Dour (6)	R	679	675	2	3,360	Plan	
71	Kassioun T.V	WT	1,158	1,155	1	50		
72	Esh Al-Warwar 2	PBT	852	849	1	200	Non-Use	
73	High Tishreen Area	WT	787	782	1	220		
74	Kudsaia Regulation (whda)	PBT	854	850	2	1,000		
75	Al Areen	R	935	931	2	1,000		
76	Street 30 (Mokhayam)	WT	660	655	1	300	Under Construction	
77	Esh AL-Waruar3	R	1,010	1,005	2	2,500	New	
78	RPO1	R	890	885	2	4,000	New	
79	RPO2	R	975	970	2	1,500	New	
80	RPO3	R	946	941	2	2,500	New	
81	RPO4	R	826	821	2	3,500	New	
82	NTR (MARABA)	R	885	880		200,000	New	
83	Inlet Tank (Alaoun ps)	R	812	806		15,000	New	
84	TR (Kutifa)	R	1,042	1,030		1,200,000	New	
85	Kudsaia Baladea	R	907	903	2	1,000	Non-Use	
86	Jober Extension	R	678	674	2	2,770	Plan	
Total volume under operation					113	264,737		

Notes:

Type of Facility "R"=Reservoir, "WT"=Water Tank, "PBT"=Pressure Break Tank

Elevation "TWL"=Top of Water Level, "BWL"=Bottom of Water Level

Status Cell blank stands for "Under Operation".

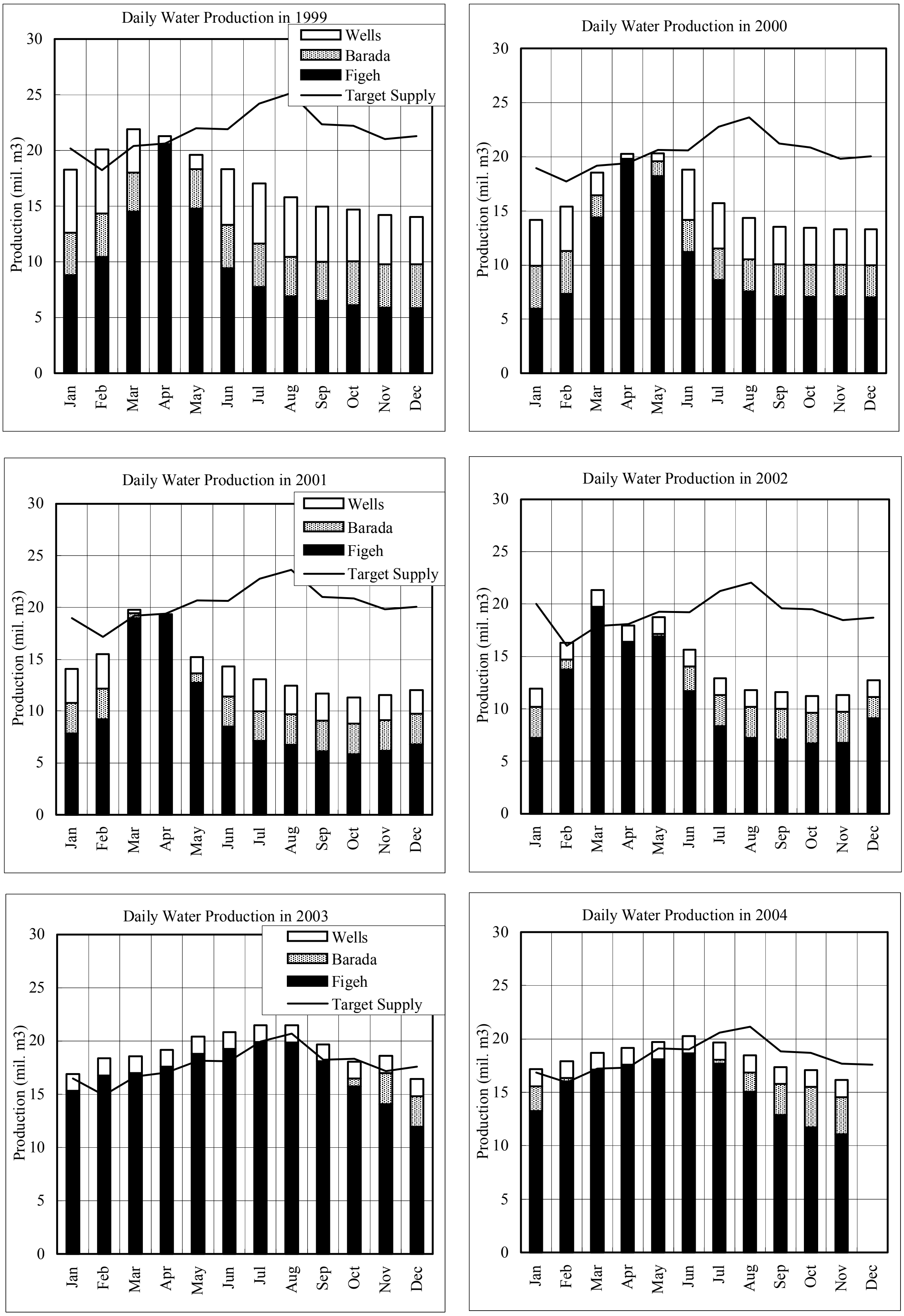
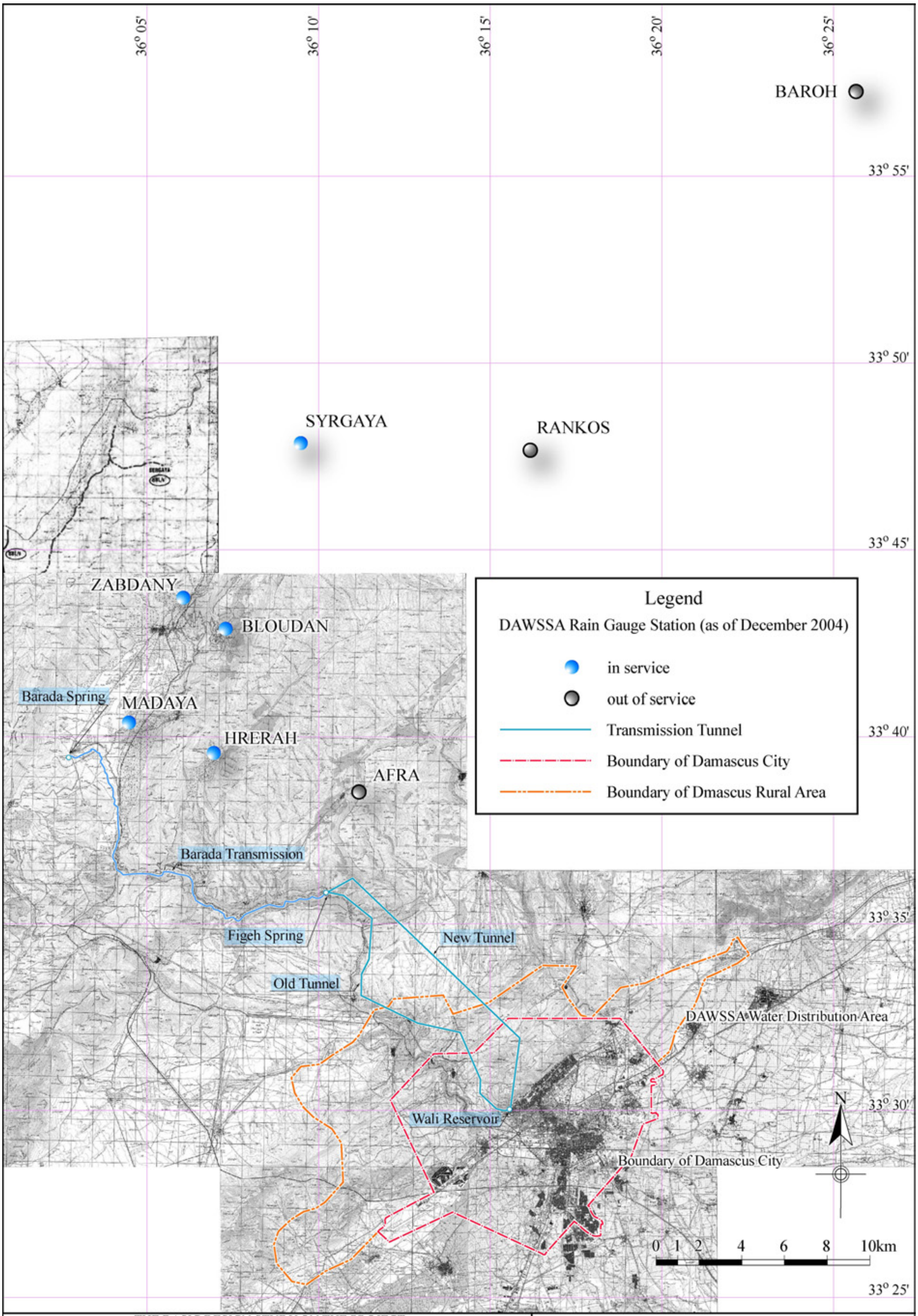


Figure 1-1 Water Consumption and Target Water Supply



THE BASIC DESIGN STUDY ON THE PROJECT
FOR REHABILITATION OF THE WATER TRANSMISSION TUNNELS IN DAMASCUS CITY
IN THE SYRIAN ARAB REPUBLIC

JICA Japan International Cooperation Agency

Figure 1-2 Location Map of DAWSSA Rainfall Stations

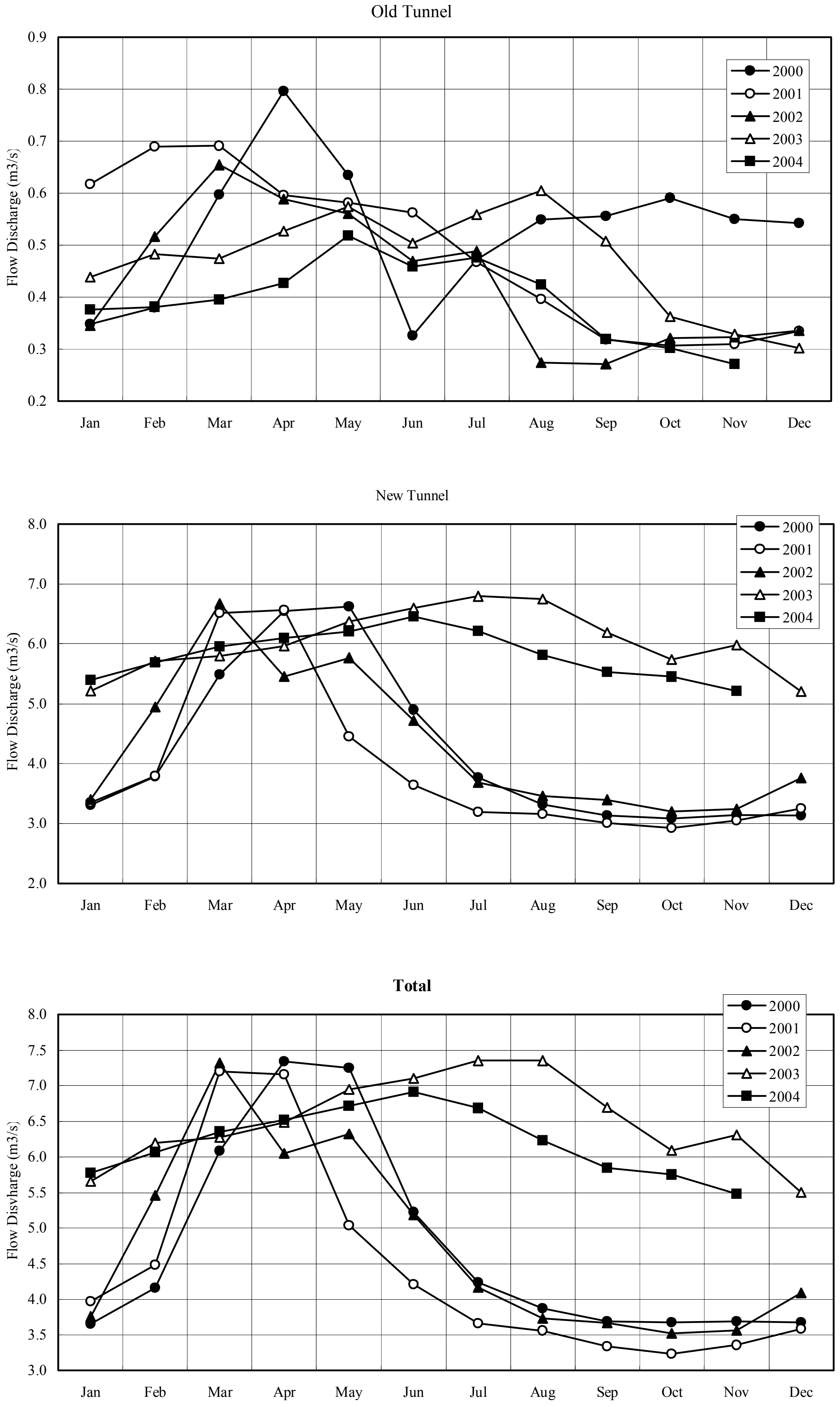


Figure 1-3　Tunnel Discharges

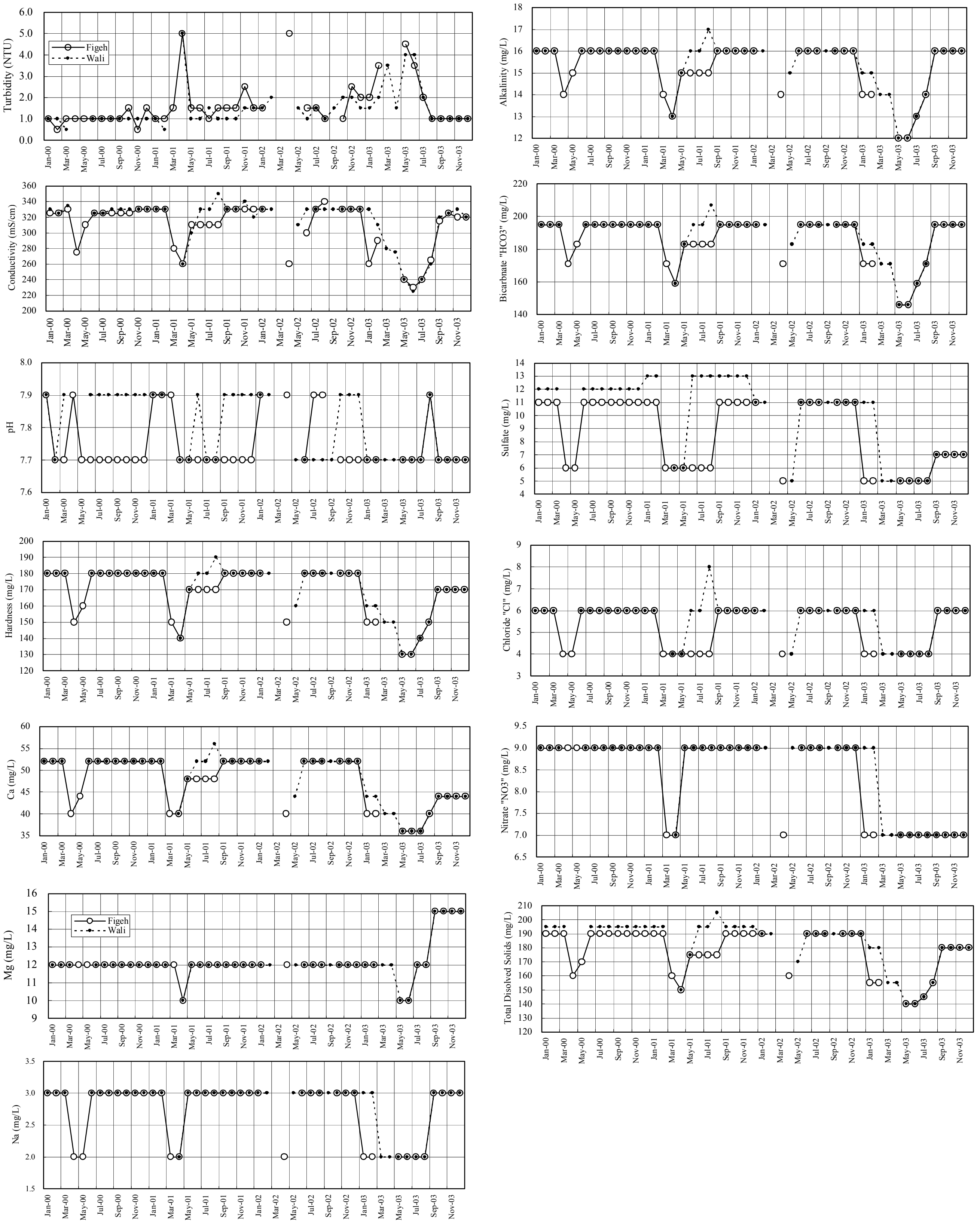
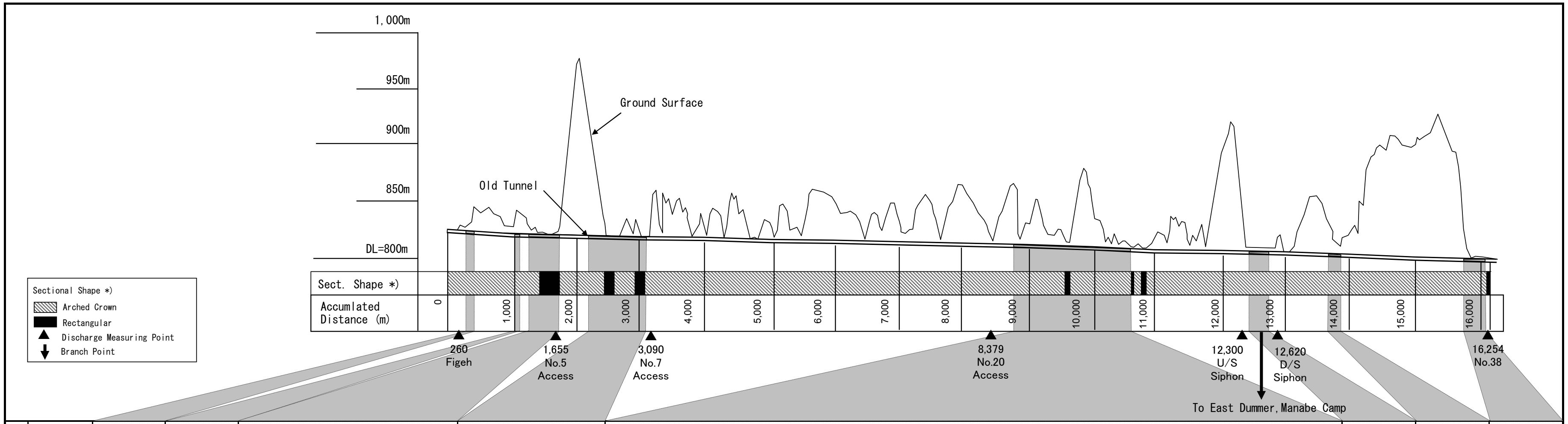
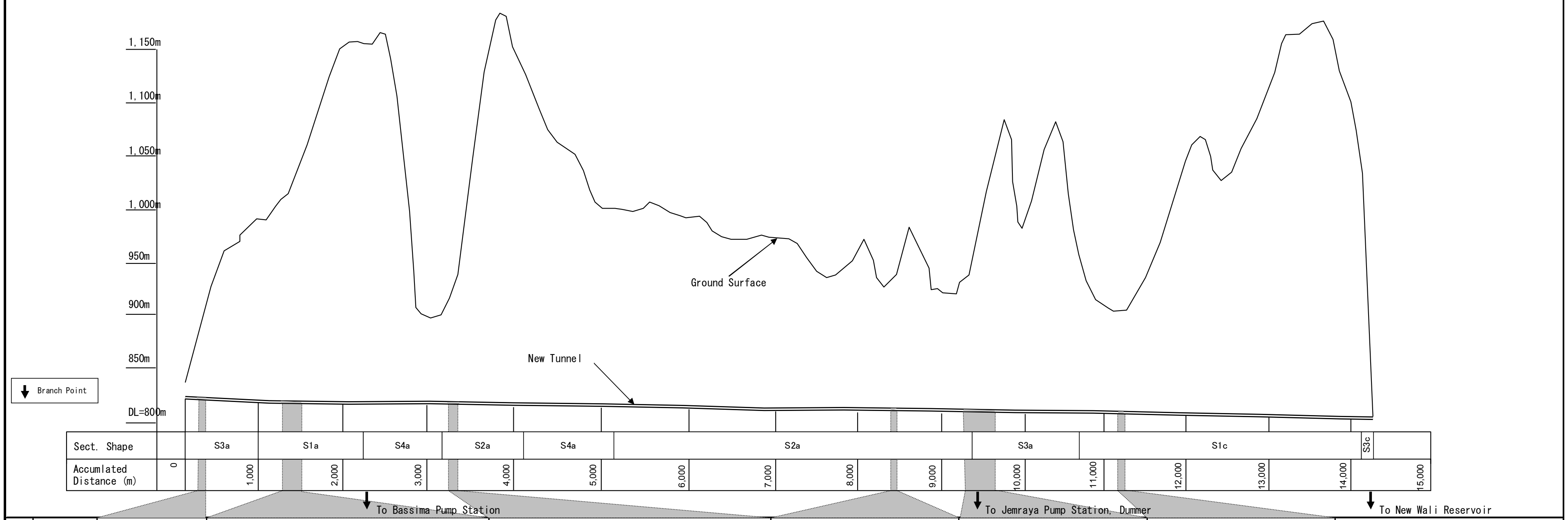


Figure 1-4 Water Quality at Tunnel Inlet and Outlet



Preliminary Study	Section No.	Out of object	Out of Object	I			II		III										IV	V	VI
				1	2	3	1	2	1	2	3	4	5	6	7	8	9	10	1	1	1
	Dist. (m)	310 ~ 318	1,000 ~ 1,025	1,216	1,400 ~ 1,440	1,465 ~ 1,670	2,394 ~ 3,018	2,471 ~ 2,642	8,843 ~ 8,849	9,555 ~ 9,561	9,548	9,641	9,764 ~ 9,841	9,929 ~ 10,254	10,549 ~ 10,590	10,549 ~ 10,599	10,735 ~ 10,780	10,747 ~ 10,770	12,325 ~ 12,745	13,740 ~ 13,938	15,721 ~ 16,071
	Present Condition	Slanting cracks (0.5mm)	No record	Intrusion of tree roots	Settlement of tunnel bed (about 5cm)	Flaking and peeling of arched concrete	Exposed re-bar, Peeling of arched concrete	Cracks (0.5-3mm) and intrusion of tree roots	Intrusion of tree roots	Exposed re-bar, Peeling of arched concrete	Intrusion of tree roots	Cracks (0.1mm)	Cracks (0.25mm)	Corrosion of steel pipe	Exposed re-bar, Peeling of arched concrete	Cracks (0.2-0.3mm)	Exposed re-bar, Peeling of arched concrete	Cracks (0.1-0.25mm)	Back-siphon	Corrosion of steel pipe	Cracks (0.1-2mm)
	Remedial Plan	By local contractor	No record	Removal of roots and protection of tunnel inside	Remedy of section	Remedy inside & outside or FRP lining	Remedy inside & outside or FRP lining	Removal of roots and protection of inside tunnel	Removal of roots and protection of inside tunnel	Remedy inside & outside or FRP lining	Removal of roots and protection of inside tunnel	Remedy of cracks	Periodic monitoring	Removal of rust and rust-proof painting	Remedy inside or FRP lining	Remedy of cracks	Remedy inside or FRP lining	Remedy of cracks	Replace of pipe	Removal of rust and rust-proof painting	Remedy of cracks and grouting
Basic Design Study	Section No.	VII	VIII	I			II		III										IV	V	VI
		1	1	1	2	3	1	2	1	2	3	4	5	6	7	8	9	10	1	1	1
	Dist. (m)	300 ~ 330	1,000 ~ 1,025	1,216	1,400 ~ 1,440	1,465 ~ 1,670	2,350 ~ 3,018	2,400 ~ 2,660	8,843 ~ 8,849	9,555 ~ 9,561	9,548	9,641	9,764 ~ 9,841	9,929 ~ 10,254	10,549 ~ 10,590	10,549 ~ 10,599	10,735 ~ 10,780	10,747 ~ 10,770	12,325 ~ 12,745	13,740 ~ 13,938	15,700 ~ 16,150
	Results of tunnel inspection	Under residential area, cracks are developing	Cracks on improved invert (0.3-0.5mm)	Partial flaking due to intrusion of tree roots	Scouring due to defective construction and narrow flow section	Continuous flaking/peeling due to road expansion	Partial flaking/peeling of arch due to defective construction	Continuous intrusion of tree roots due to residential area	Partial flaking due to intrusion of tree roots	Partial flaking/peeling of arch due to defective construction	Partial flaking due to intrusion of tree roots	Periocic investigation because of small cracks	Deterioration of waterstop at abutment of aqueduct No.1	No cracks on tunnel lining but corrosion of steel pipes	Partial flaking/peeling of arch due to defective construction	Deterioration of waterstop at abutment of aqueduct No.2	Partial flaking/peeling of arch due to defective construction	Deterioration of waterstop at abutment of aqueduct No.3	No remarkable leakage	No cracks on tunnel lining but corrosion of steel pipes	Cracks due to defferential settlement closer roads and slopes
	Inspection of tunnel cavity	TD310 ~ 330 (3 lines) and drilling (3 points)				Check thickness by drilling															TD15,700 ~ 16,150 (3 lines) and drilling (9 points)
	Examination of concrete strength	TD318 (2 locations)				By test hammer (3 locations)		By test hammer (2 locations)													TD15,810 etc.(3 points), by test hammer (9 locations)
	Survey of remedial section	TD310 ~ 340 (9 sections)				TD1,450 ~ 1,670 (26 sections)		TD2,360 ~ 2,660 (15 sections)													TD15,700 ~ 16,100 (11 sections)
	Inspection of siphon																		Visual inspection in the pipe and on ground		
	Inspection of tunnel inside	TD300 ~ 330 (exterior elevation, cross section)	TD1,000 ~ 1,025 (exterior elevation)	Confirmation of preliminary study	TD1,400 ~ 1,440 (exterior elevation)	TD1,450 ~ 1,670 (exterior elevation, cross section)	Confirmation of preliminary study	TD2,360 ~ 2,660 (exterior elevation, cross section)	Confirmation of preliminary study	Confirmation of preliminary study	Confirmation of preliminary study	Confirmation of preliminary study	Confirmation of preliminary study	Confirmation of preliminary study	Confirmation of preliminary study	Confirmation of preliminary study	Confirmation of preliminary study	Confirmation of preliminary study		Confirmation of preliminary study	TD15,700 ~ 16,150 (exterior elevation, cross section)

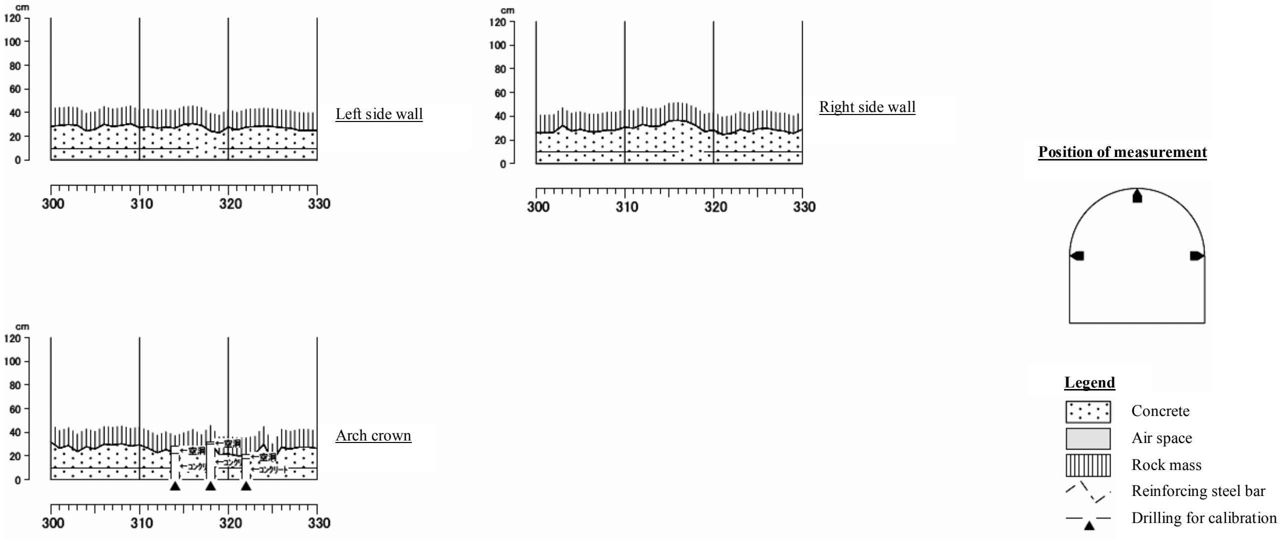
Figure 1-5 Inspection Result in Old Tunnel



Preliminary Study	Section No.	I	II			III			IV	V		VI	
		1	1	2	3	1	2	3	1	1	2	1	2
	Dist. (m)	0	1,096	1,100	1,160	3,168	3,169	3,172	8,514	9,376	9,573	11,127	11,148
	Present Condition	Roads and houses are existing above tunnel	Cracks (0.25mm)	Flaking (30×30×4cm)	Cracks (2mm)	Flaking (110×100×3cm)	Flaking (30×100×1cm)	Flaking (30×200×2cm)	Cracks (0.2mm)	Flaking (60×80×3cm)	Cracks (0.7mm)	Flaking (40×40×2cm)	Flaking (20×60×3cm)
	Remedial Plan	Grouting	Remedy of cracks	Replacement of low quality concrete with new one	Remedy of cracks	Replacement of low quality concrete with new one	Replacement of low quality concrete with new one	Replacement of low quality concrete with new one	Remedy of cracks	Replacement of low quality concrete with new one	Remedy of cracks	Replacement of low quality concrete with new one	Replacement of low quality concrete with new one
Basic Design Study	Section No.	I	II			III			IV	V		VI	
		1	1	2	3	1	2	3	1	1	2	1	2
	Dist. (m)	20～170	1,096	1,100	1,160	3,168	3,169	3,172	8,514	9,376	9,573	11,127	11,148
	Results of tunnel inspection	Less earth cover (20cm) below roads and residential area	Cracks due to defective construction at cold joint	Flaking/peeling of concrete by swelling of mixed marlstone	Devect of construction joint	Chemical corrosion of concrete (only sueface of inner)	Chemical corrosion of concrete (only sueface of inner)	Chemical corrosion of concrete (only sueface of inner)	Devect of construction joint	Chemical corrosion of concrete (only sueface of inner)	Cracks due to local fracture zone	Flaking/peeling of concrete by swelling of mixed marlstone	Flaking/peeling of concrete by swelling of mixed marlstone
	Inspection of tunnel cavity	TD20～170 (3 lines)				TD3,100～3,200 (3 lines)							
	Examination of concrete strength					TD3,166 (1 point), TD3,171 (1 point), Penetration test (by test hammer, drill impact test)							
	Survey of remedial section	TD20～170 (3 sections)				TD3,170 (1 Section), TD3,185 (1 Section)							
	Inspection of tunnel inside	Confirmation of preliminary study	Confirmation of preliminary study	Confirmation of preliminary study	Confirmation of preliminary study	TD3,165～3,172 (Exterior elevation)			Confirmation of preliminary study	Confirmation of preliminary study	Confirmation of preliminary study	Confirmation of preliminary study	Confirmation of preliminary study

Figure 1-6　Inspection Result in New Tunnel

TD 300～TD 330(L=30m)



TD 15700～TD 15800(L=100m)

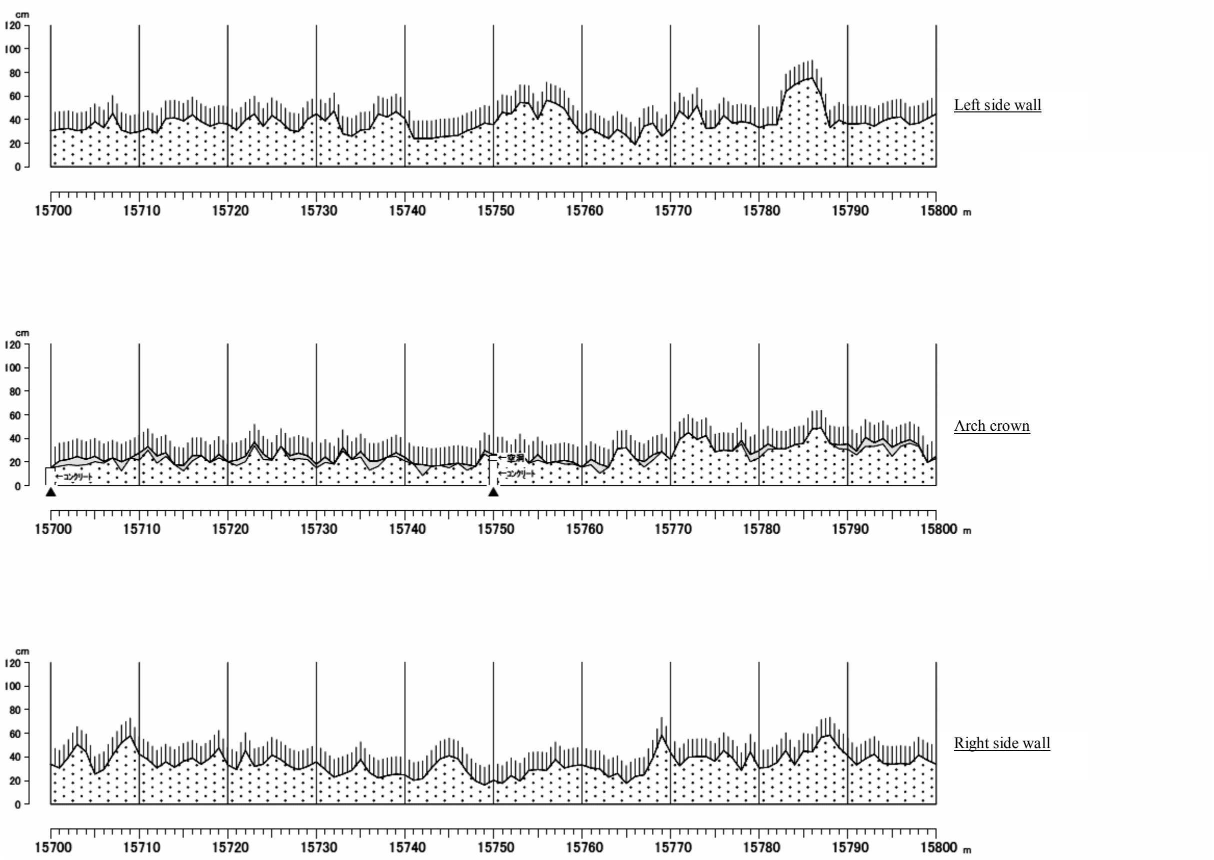


Figure 1-7-1 Investigation of Cavity behind Concrete in Old Tunnel (1)

TD 15800～TD 16000(L=200m)

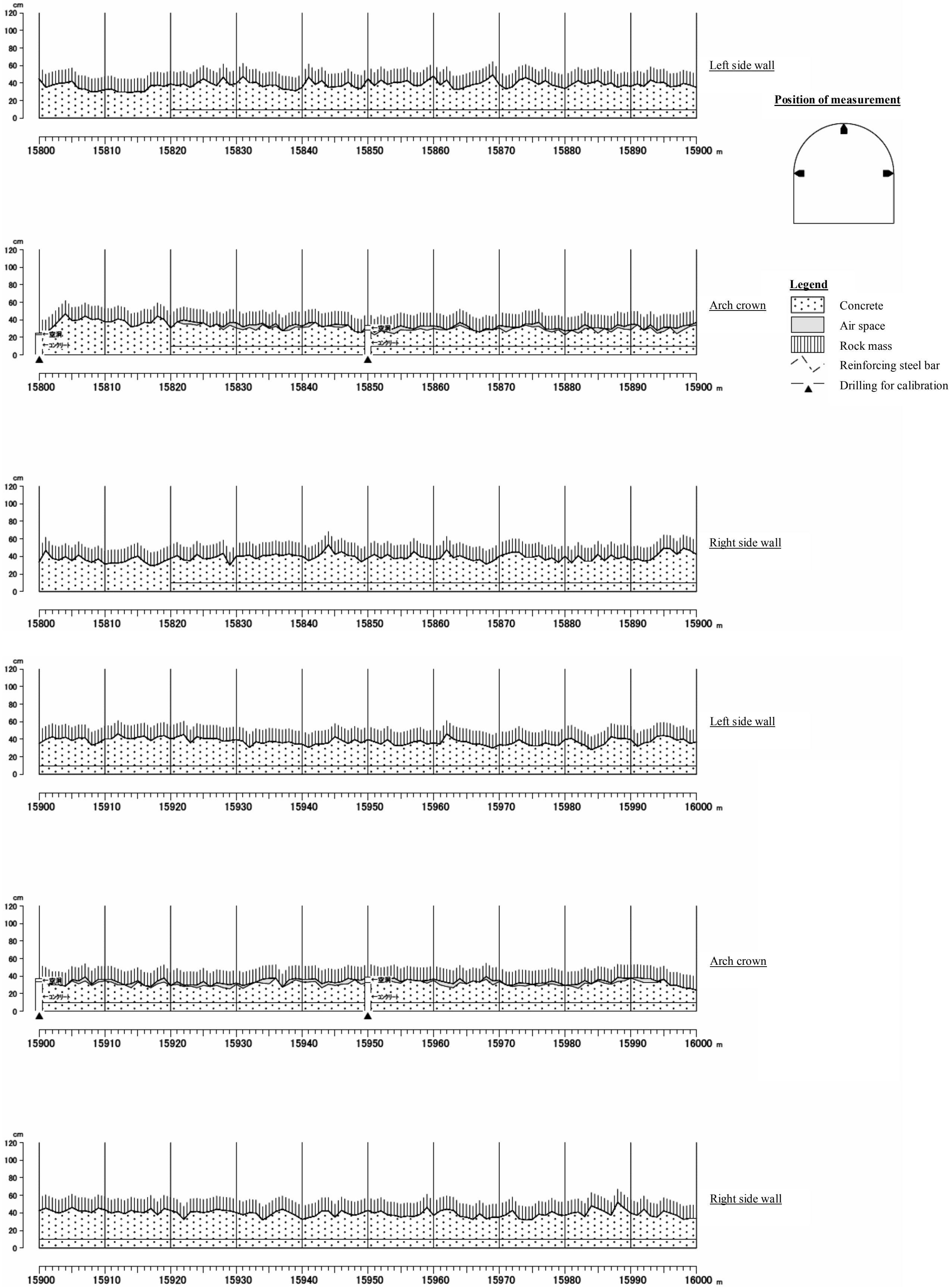


Figure 1-7-2 Investigation of Cavity behind Concrete in Old Tunnel (2)

TD 16000～TD 16150(L=150m)

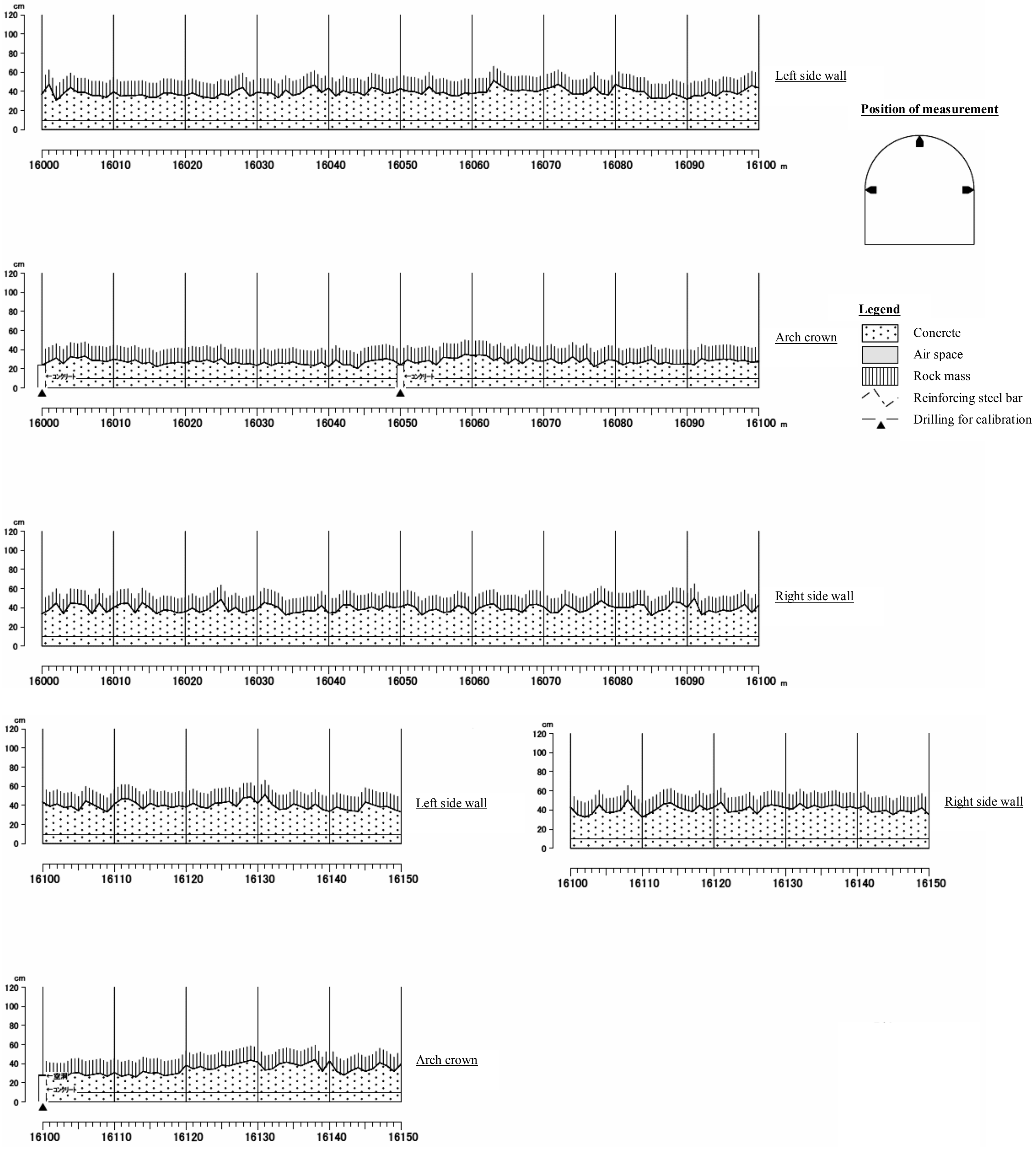


Figure 1-7-3　Investigation of Cavity behind Concrete in Old Tunnel (3)

TD 20～TD 170(L=150m)

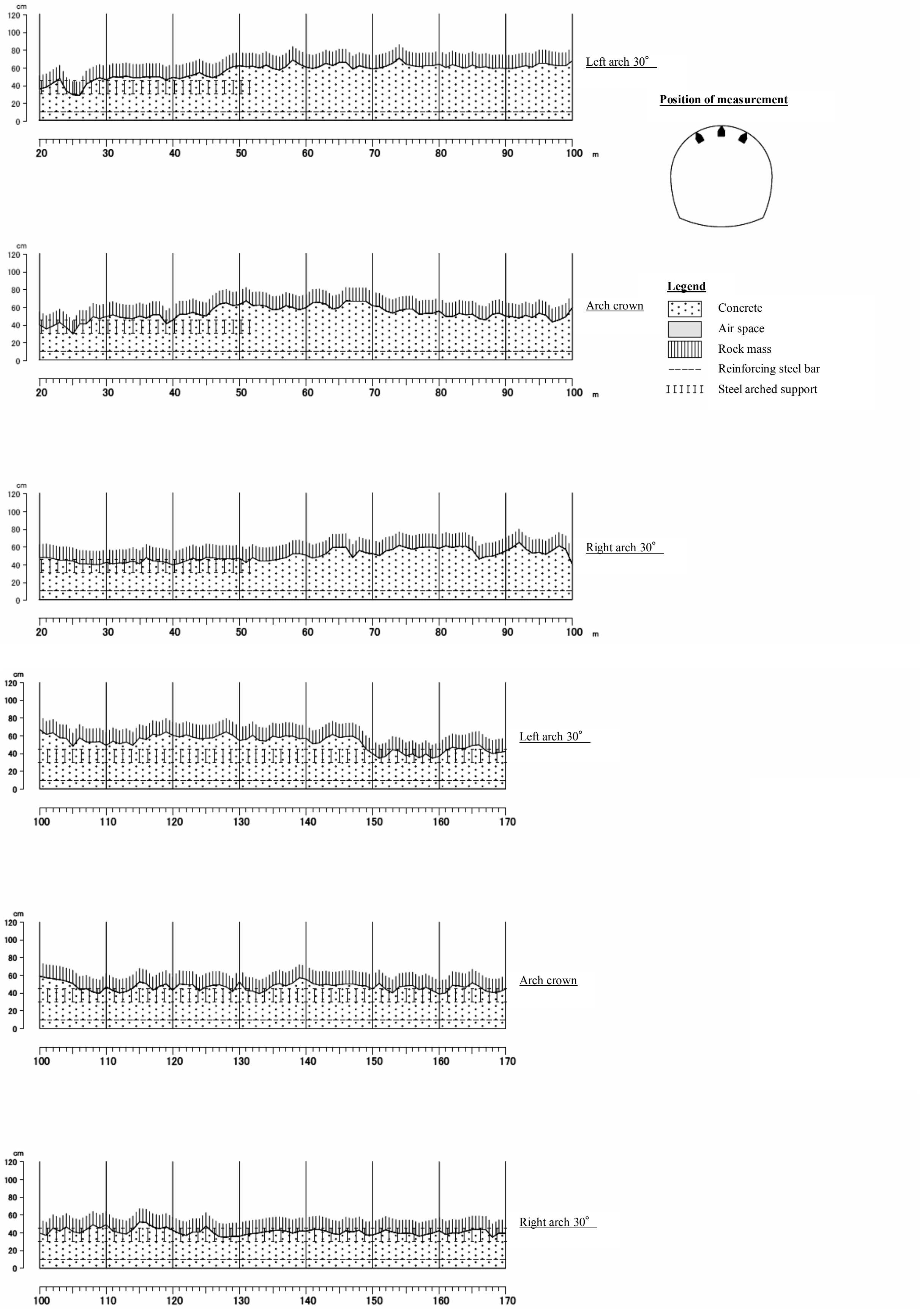


Figure 1-8-1　Investigation of Cavity behind Concrete in New Tunnel (1)

TD 3100～TD 3200(L=100m)

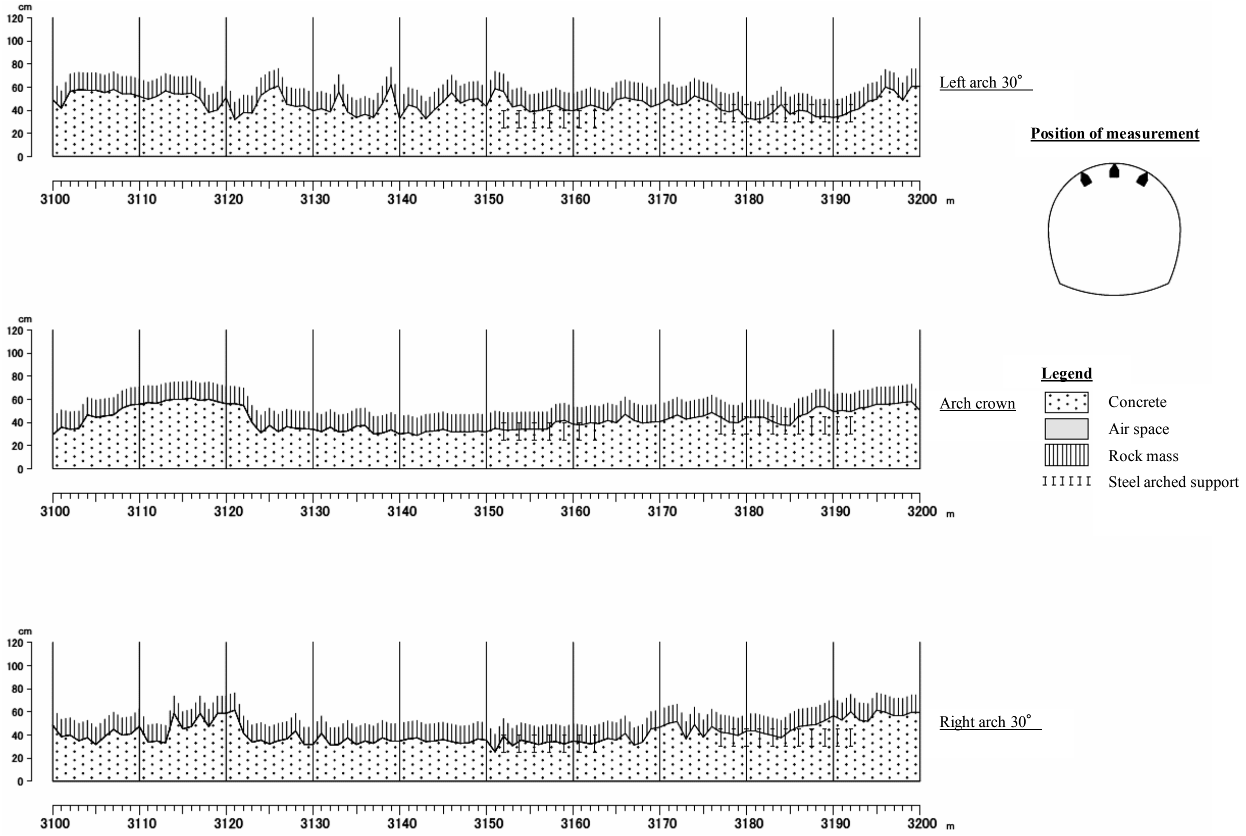


Figure 1-8-2 Investigation of Cavity behind Concrete in New Tunnel (2)

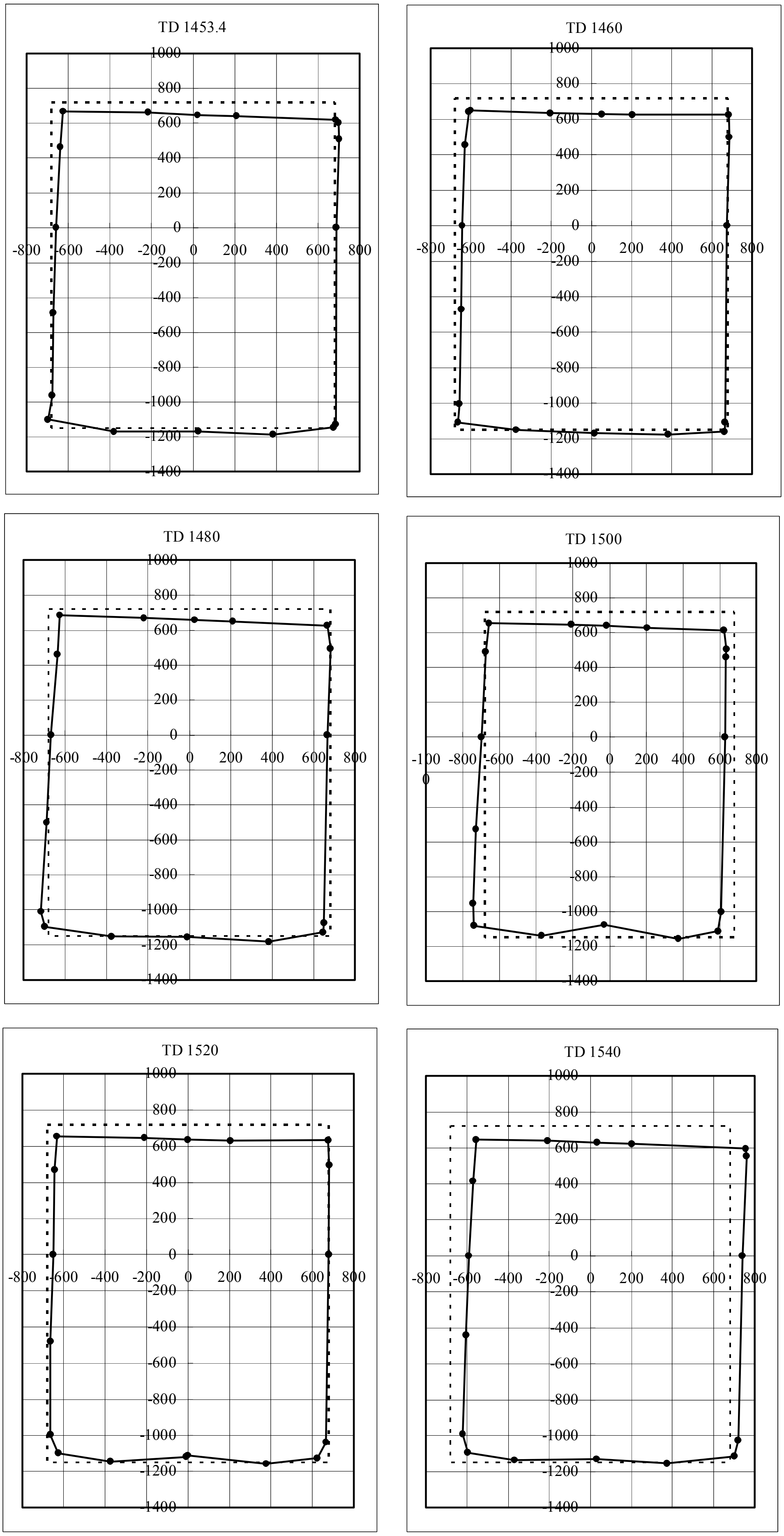


Figure 1-9-1 Survey Result of Inner Dimension in Old Tunnel (1)

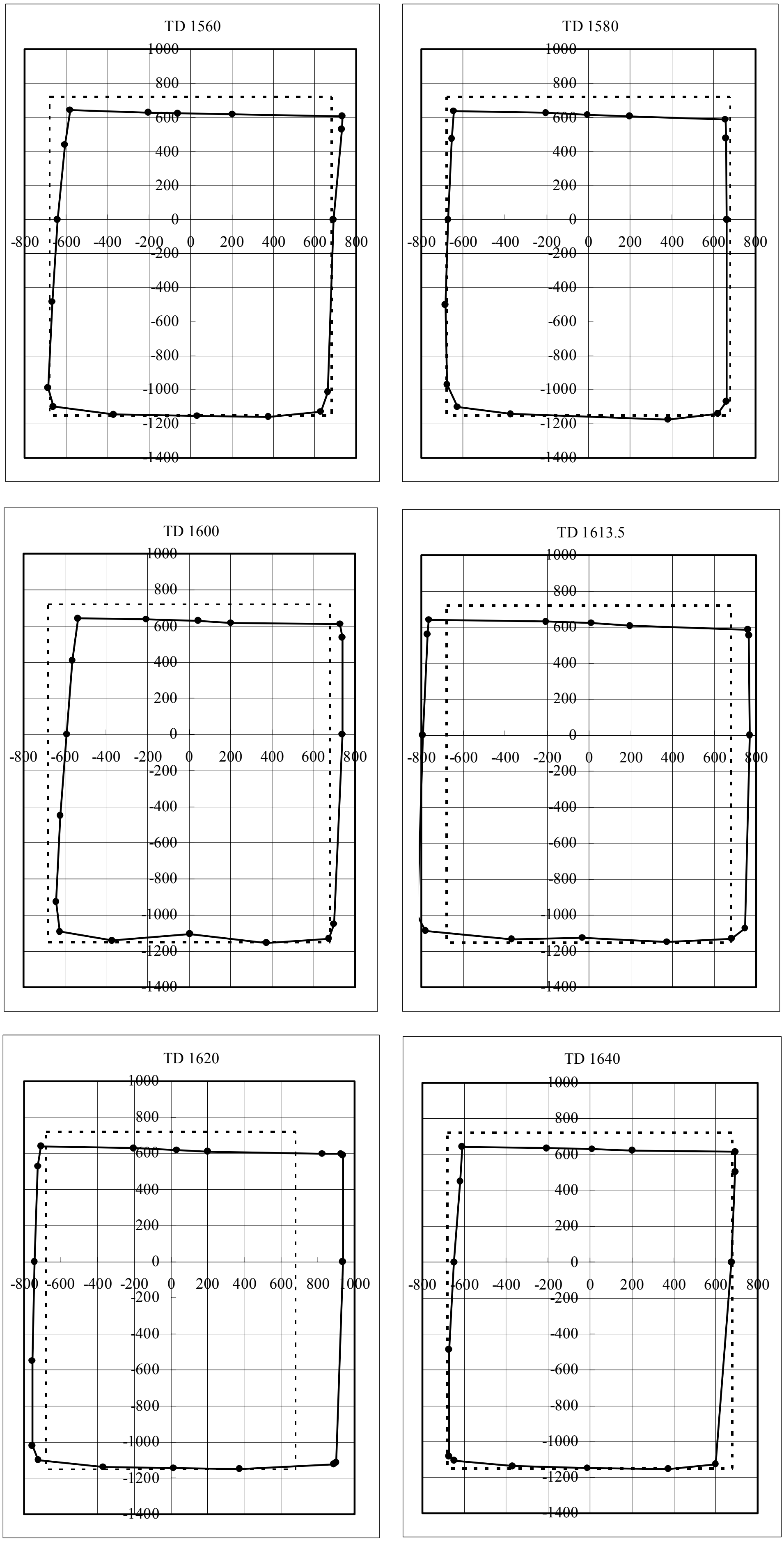


Figure 1-9-2 Survey Result of Inner Dimension in Old Tunnel (2)

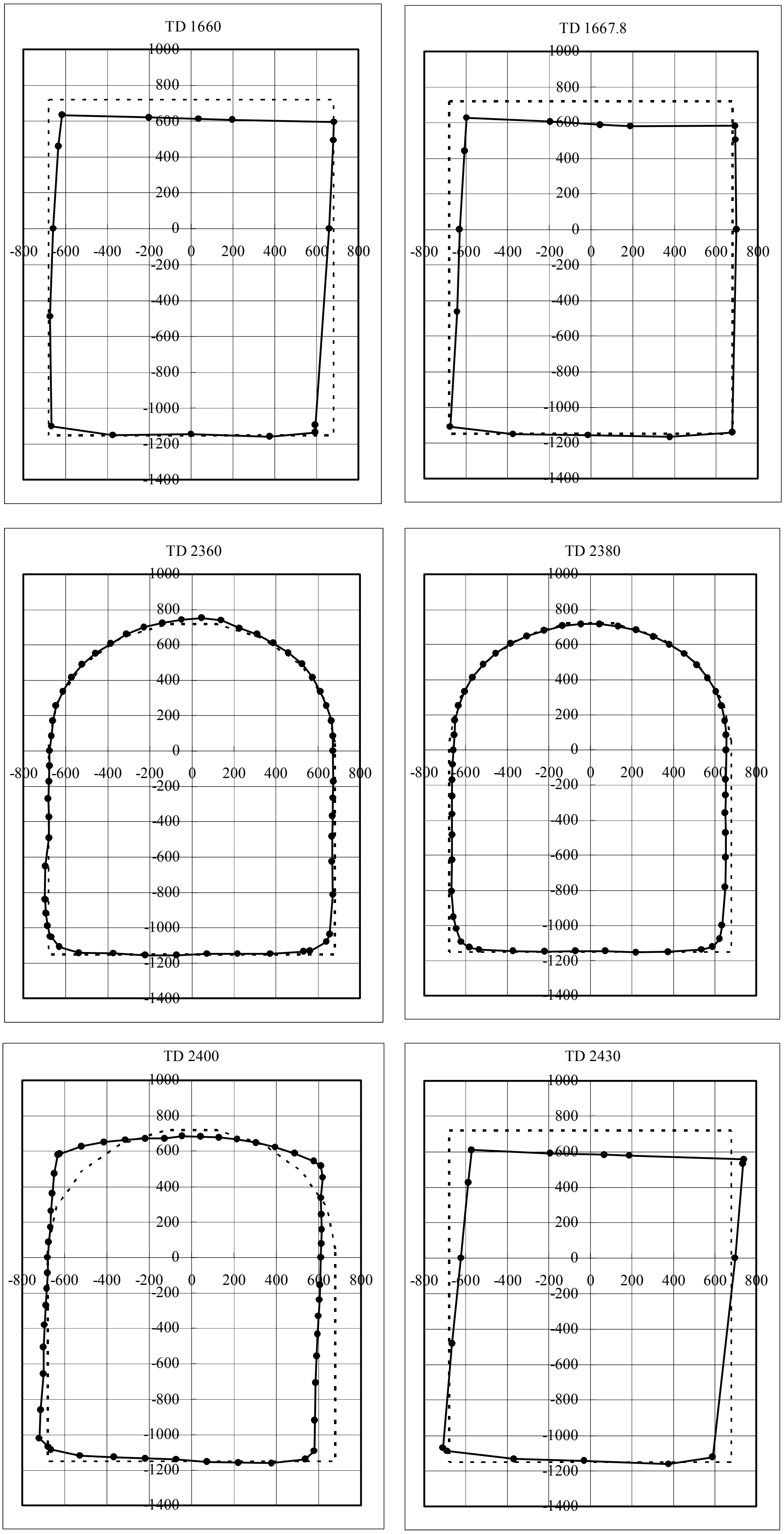


Figure 1-9-3 Survey Result of Inner Dimension in Old Tunnel (3)

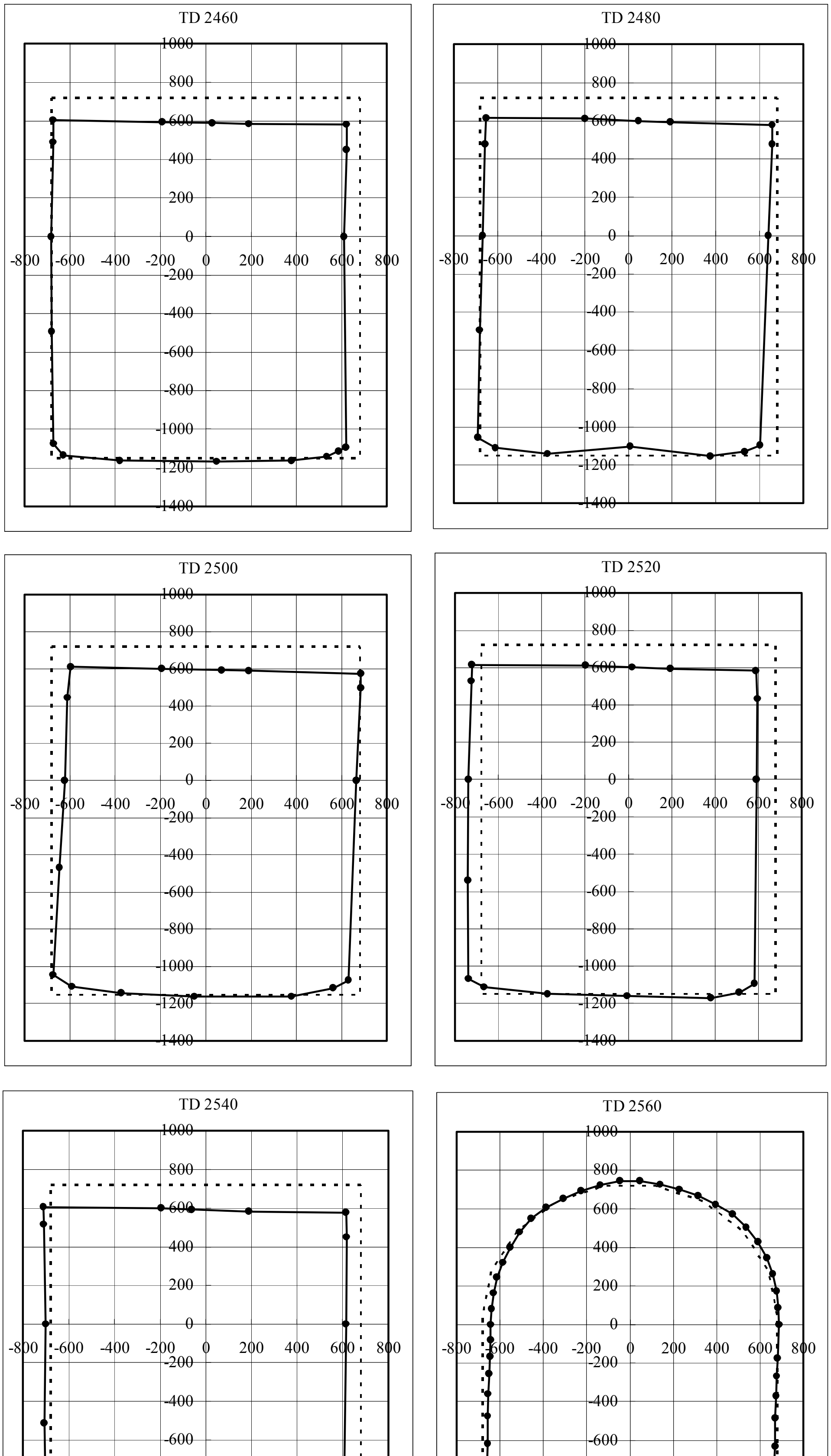


Figure 1-9-4 Survey Result of Inner Dimension in Old Tunnel (4)

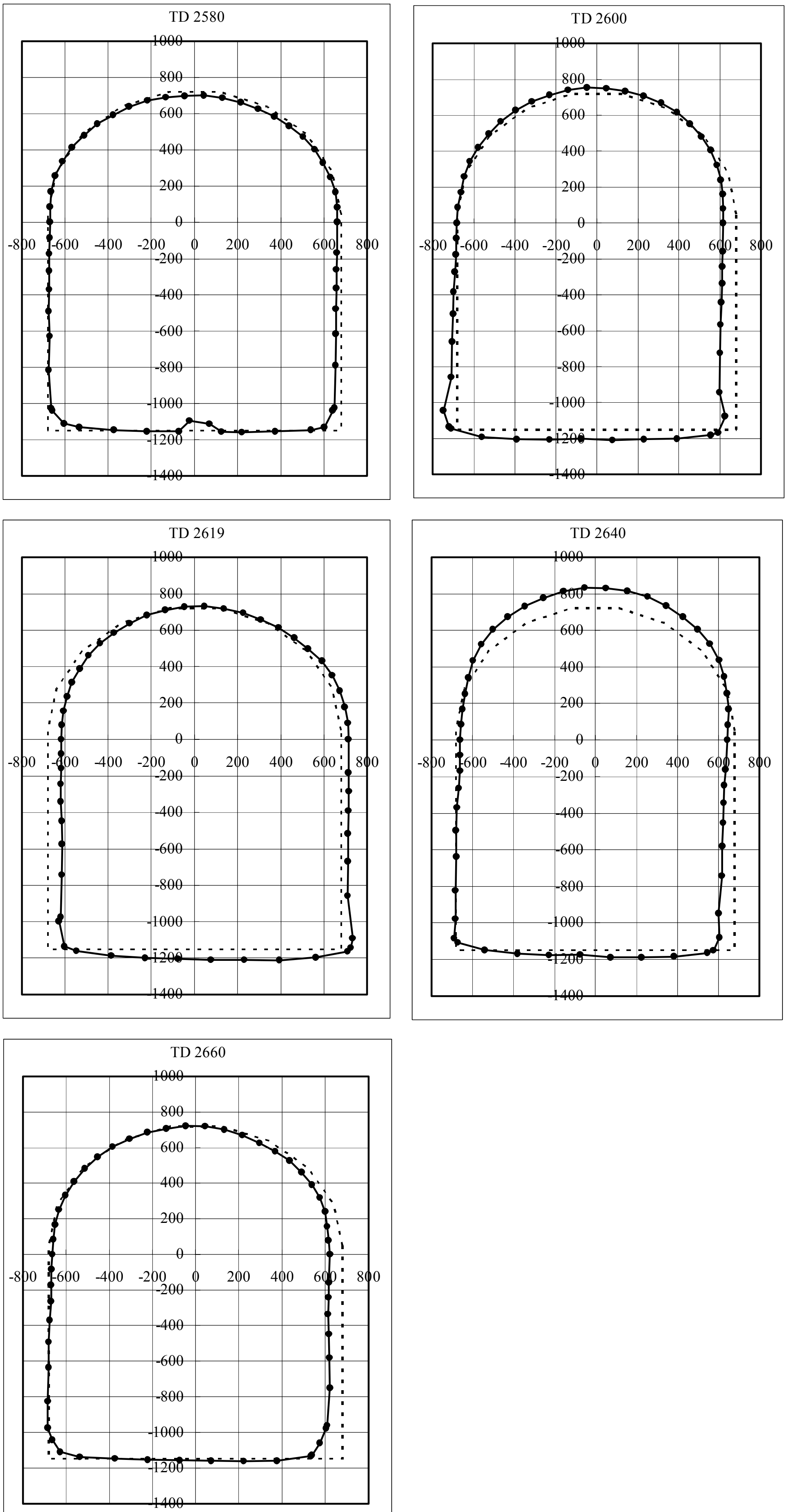


Figure 1-9-5　Survey Result of Inner Dimension in Old Tunnel (5)

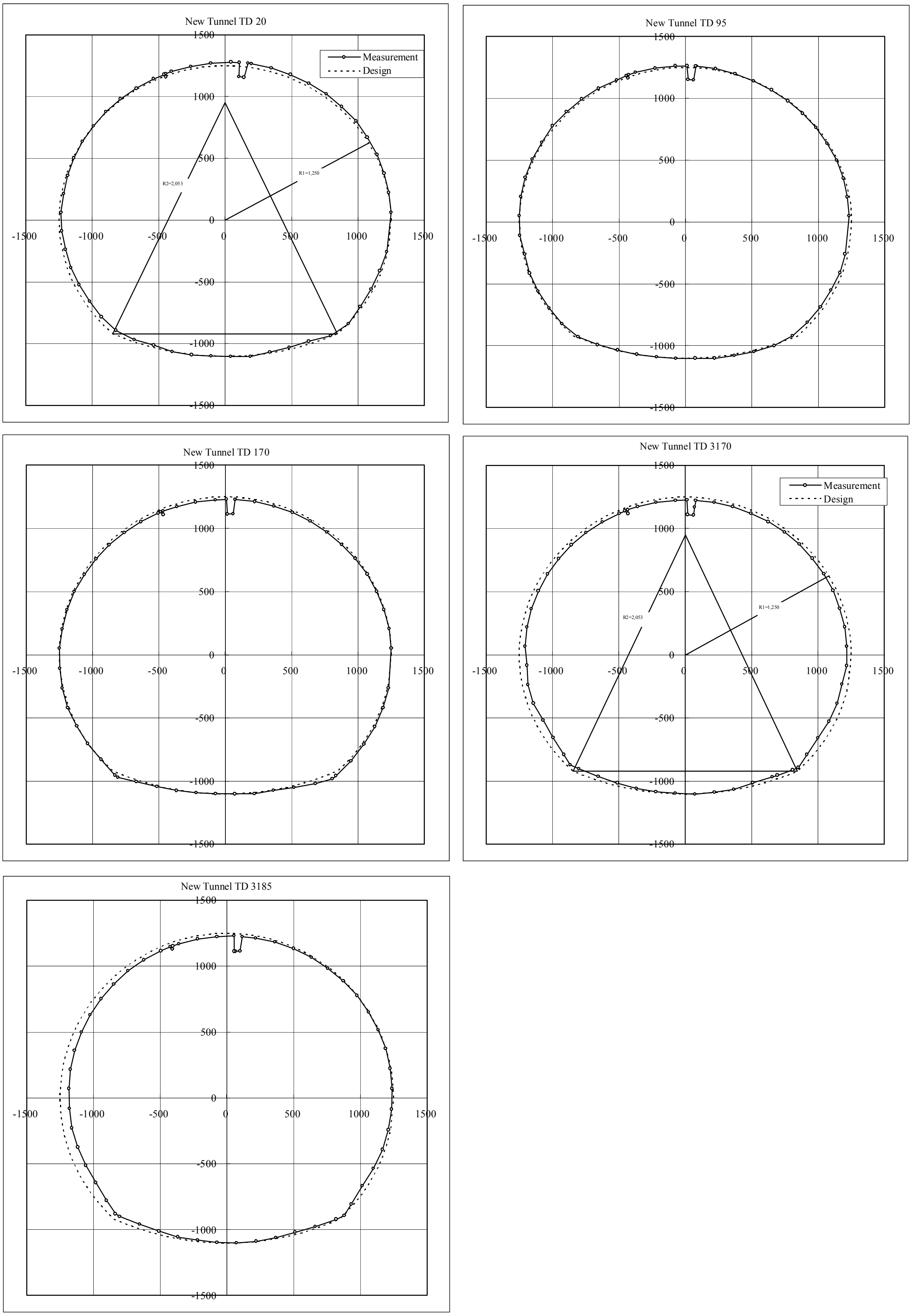


Figure 1-10 Survey Result of Inner Dimension in New Tunnel

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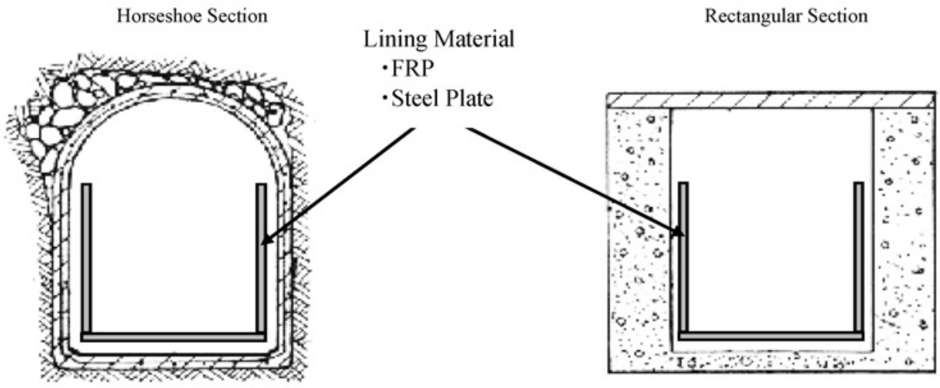
<tr><td>Linine Works</td><td>
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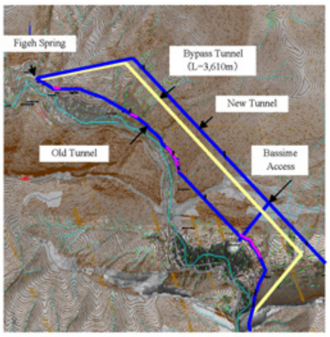
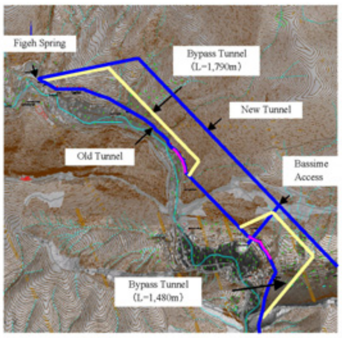
<tr><td>Bypass Tunnels</td><td>Route 1
(Total Extension L=3,610m)


Route 2
(Total Extension L=3,270m)


Route 3
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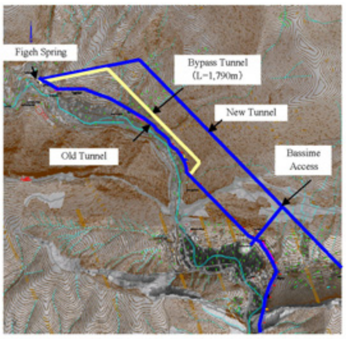
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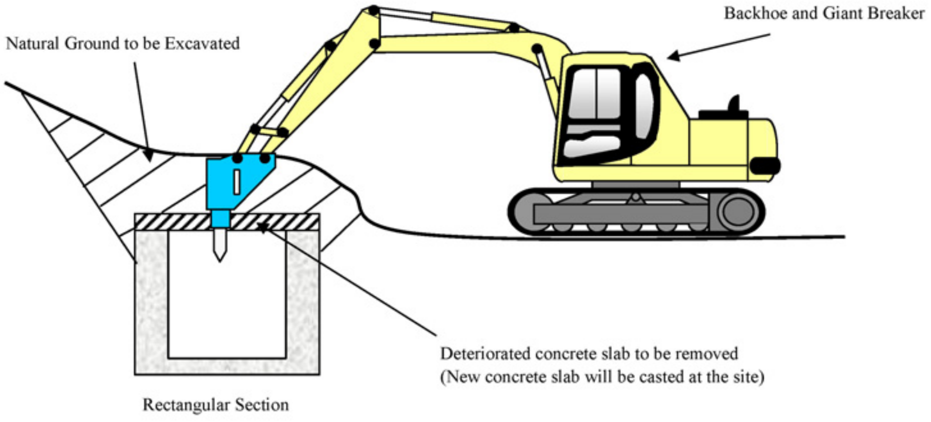
<tr><td>Open cut Works</td><td>
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Figure 2-1　Outline of Alternatives

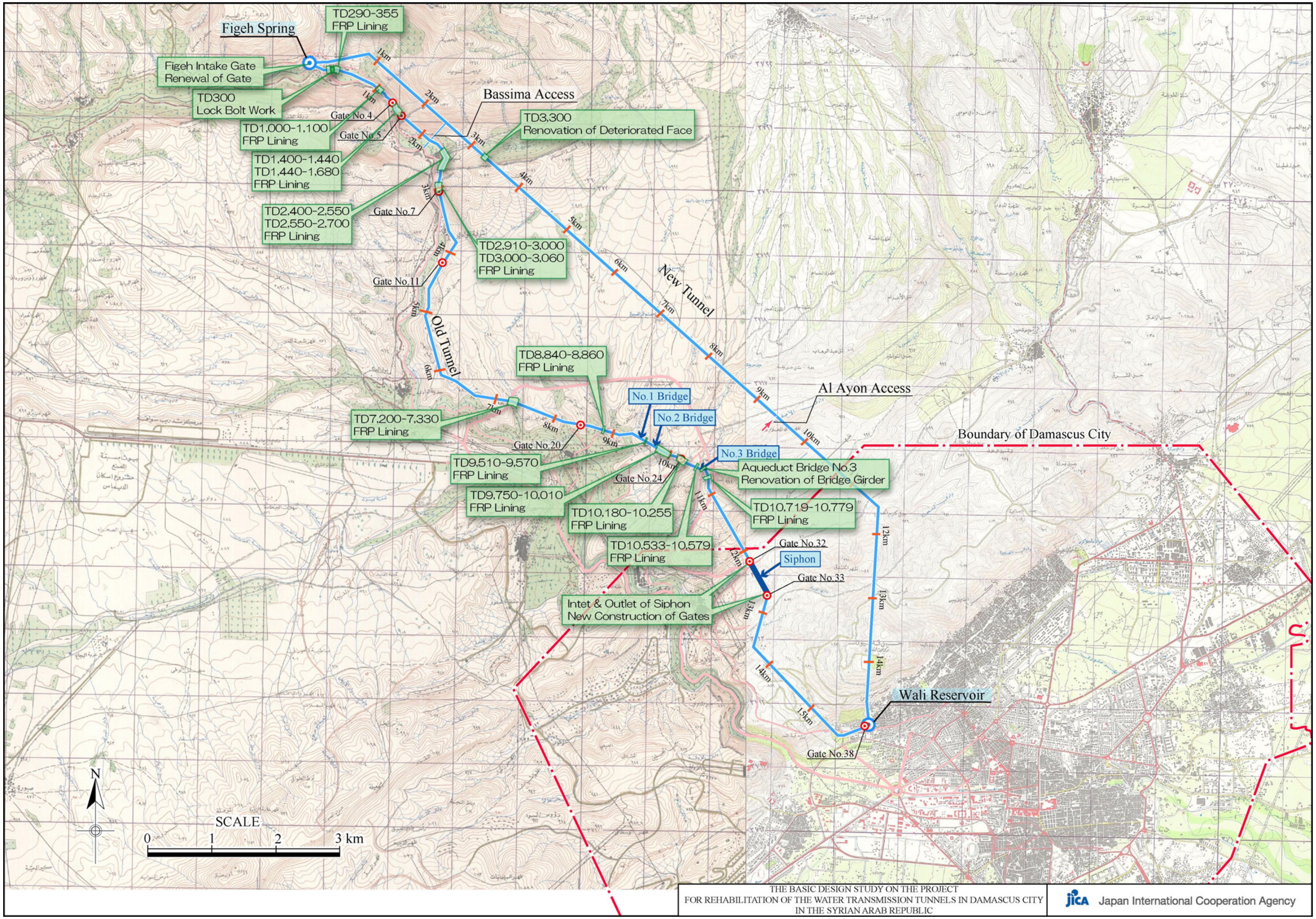

Figure 2-2 General Plan of Tunnels