TABLES

Table B-2.1 (1/3) Informal Area in The City

Zone Of Violations						Quarter			
Name And No. Of Zone	S.D.	Zone Code	Area (H)	Population 1994	Inside or outside adm. b.	Quarter & No.	Net Area	Pop. density	Population 1994
1. Kasser Labbad	10 Barze & Kaboun	1-53	21.75	5500	Inside	53. K. Labbad	104,9	252	26403
2 Kaboun Viol.	10 Barze & Kaboun	2-55	48	25900	Inside	55. Kaboun	93,3	542	50580
3 A Tdisrin Quorter	10 Barze & Kaboun	3a-56	100	35000	Inside	56. Barze Balad	375,6	198	74111
3 B Tdisrin Quorter	D.C.G.		10.62	4200	Outside				
4a Osh Alwarwar	10 Barze & Kaboun	4-56	35	7000	Inside	56. Barze Balad	375,6	198	74111
4b Osh Alwarwar	D.C.G.		65	26000	Outside				
5. Asad Eddin	1 Rukned-din	5-1	30	15000	Inside	1 Asad Eddin	92,7	510	47295
6 Nakshab-Andi	1 Rukned-din	6-2	36.90	13500	Inside	2 Nake-Shabandi	81,5	367	29886
7 Ayoubieh	1 Rukned-din	7-3	15.60	9000	Inside	3 Ayoubieh	33,6	550	18476
8 Abou Jarash	1 Rukned-din	8-4	13.75	9000	Inside	4. Abou Jarash	39,8	649	25825
9. Saflach	1 Rukned-din	9-5	20	9500	Inside	5. Saflach	47,5	478	22707
10 Shora	2 Muh-ajrin	10-6	14.40	5300	Inside	6 Shora	61,1	366	22362
11. Mastabeh	2 Muh-ajrin 2	11-7	6.90	2500	Inside	7 Mastaba	30,9	356	10986
12 Murabet	Muh-ajrin	12-8	15	4300	Inside	8 Murabeh	31,5	286	8995

Note: Number of informal Zones is related to Figure B-2.2.

(Source: Damascus Municipality)

Table B-2.1 (2/3) Informal Area in The City

13 Bostan Alroz	Dum-mar 11	13-14	50.75	13200	Inside	14 Dummar	372.1	130	48486
14 Jabal 86 Mezza	3 Mezza	14-12	82.50	37500	Inside	12 Mezza	383.2	227	86843
15 A Behind Alrazi Hosp.	3 Mezza	15A-13	41	8600	Inside	13 Mezza	100.3	209	21002
15 B Behind Alrazi Hosp.	3 Mezza	15B-23 15B-10	4	800	Inside	23 Kufur Sousa 10 Kiwan	131.1	201	26315
16 A Kufur Sousa	Mezza 3	16A-23	30	6000	Inside	23 Kufur Sousa	131.1	201	26315
16 B Kufur Sousa	3 Mezza	16B-23	5	1000	Inside	23 Kufur Sousa	131.1	201	26315
17. Lawwan	3 Mezza	17-24	33	11600	Inside	24 Lawwan	193.6	350	67823
18 Dahadil Naher Eicheh	3 Mezza	18-24	93	32500	Inside	24 Lawwan	193.6	350	67823
19. Assali	3 Mezza	91-25	36.90	12000	Inside	25 Kadam	119.9	350	62917
20 A Tadamon	M Yarm-Ouk	20A-60 20A-57	147	121700	Inside	60 Tadamon 57 Yalda	226.5	828	187510
20 B Yalda	D.C.G		16.5	13500	Outside				

The names of the districts, borders and numbers are given according to those registered by the C.S.B. for the city of Damascus for year 1994.

Population of Violating Zone inside administrative border = 508200 p. Area = 1273.20 h.

Population of Violating Zone outside administrative border = 370000 p. Area = 856.37 h.

Total: 878200 p. **Area = 2129.57 h.**

Note: Number of informal Zones is related to Figure B-2.2.

(Source: Damascus Municipality)

Table B-2.1 (3/3) Informal Area in The City

Zone Of Violations						Quarter			
Name And No Of Zone	S.D.	Zone Code	Area (H)	Population 1994	Inside Or Outside Adm. B	Quarter & No	Net Area	Pop. Density	Population 1994
21 Hajar Aswad	D.C.G.		24	19900	Outside				
22 Bustan Zohour (Daf Shouk)	6 Shagh our	22-33	33	8200	Inside	33 Bilal	186,5	249	26217
23 B.Afsour	6 Shagh our	22-33	56,25	14000	Inside	33 Bilal	186,5	249	26217
24a Kazzaz	6 Shagh our	24a-33	8	2000	Inside	33 Bilal	186,5	249	26217
24b Kazzaz	D.C.G.		38,75	15500	Outside				
25 Tabbaleh Doueilaa	6 Shagh our	25-62 + 25-62	138.7	62100	Inside	61+62 Doueilaa Tabbaleh	138.7	448	62103
26 Jobar	9 Jobar	26-48	76,50	18000	Outside	48 Jobar	213.7	236	50422
27 Zamalka	D.C.G.		42,30	16900	Outside				
28 Ebin-Hamouria	D.C.G.		113.75	45500	Outside				
29 Hazzeh - Sal bah	D.C.G.		65	26000	Outside				
30 Hazzeh - Zamalka	D.C.G.		43,50	17400	Outside				
31 Ain Tarma	D.C.G.		82,50	33000	Outside				
32 M Jaramana	D.C.G.		215	96300	Outside				
33 Sidi Mikdad	D.C.G.		50	20000	Outside				
34 Babbila - Beit Sahem	D.C.G.		6,25	2500	Outside				
35 Western Kaber Aset	D.C.G.		77	30800	Outside				
36A Kudsaya	Dum-Mar	36A-14	64	16000	Inside	14 Dommar	372.1	130	48386
36B Kudsaya	D.C.G.		6,2	2500	Outside				

Note: Number of informal Zones is related to Figure B-2.2.
(Source: Damascus Municipality)

Table B-3.1 Existing Distribution Facilities in Mezze-Razy & Kafar Souseh-Lawan area

Classification	Diameter (mm)	Type of Matrials	Pipe Length (m)	Valve (pieces)
1) Looped Pipe				
	50	GSP	570	4
	80	GSP	2,553	6
	100	DIP	3,415	19
	150	DIP	359	5
	150	CIP	1,263	0
Sub-total			8,160	34
2) Secondary				
	80	GSP		
Sub-total			0	0
3) Tertiary				
	50	GSP	1,417	17
Sub-total			1,417	17
Total			9,577	51

(Source: DAWSSA & JICA)

Remarks: GSP is a galvanized steel pipe.
DIP is a dactyl iron pipe.
CIP is a cast iron pipe.

Table B-6.1 Actual Measurement of Distribution Flow Rates of Trunk Mains by Service Areas

Service Reservoir	Service Area	Trunk Main Pipe	DMA System	Hourly Average Flow Rate (cu.m/h)	Hourly Max. Flow Rate (cu.m/h)	Hourly Peak Factor
Akrad Low (IE)	Berze medium Resid. Comm.	600 mm	B03	1,039	1,177	1.13
Eastern II (II.E)	Damas Center Low Resid. Comm. Indust.	800 mm	D08	1,585	1,926	1.22
Eastern II (II.E)	Damas Center Low Resid. Comm. Indust.	600 mm	D09	1,196	1,588	1.33
Wali Old (I.A)	Damas Center Medium Resid. Comm.	250 mm	D04	259	324	1.25
		500 mm	D04	421	522	1.24
		1,100 mm	D04	1,839	2,092	1.14
Western II (II.O)	Damas Center Low Resid. Comm. Indust.	700 mm	D05	1,234	1,775	1.44
		1,100 mm	D06	3,022	3,470	1.15
		1,100 mm	D10	7,154	8,078	1.13
Mezze (M1)	Mezze Medium Resid. Comm.	800 mm	M01	982	1,224	1.25
Mezze High (M2)	Mezze High Resid. Comm.	800 mm	M02	1,250	1,588	1.27

(Source: JICA Study Team)

- Hourly flow rates show actually measured for 24 hours monitoring
- Resid. : Resident area, Comm. : Commercial area, Indust. : Industrial area

Table B-7.1 LOOPED WATER DISTRIBUTION NETWORK (Existing)

Zone No.	Node No.	Length(m)	Dia.(m)	Q8(l/sec)	r	h8(m)	h8/Q8	@q(l/sec)	q(l/sec)	Q9(l/sec)	r	h9(m)	h9/Q9	@q(l/sec)	q(l/sec)	Q10(l/sec)
A	1-10	125	0.100	8.165	16533.920	2.267	0.278		-0.017	8.148	16533.920	2.259	0.277		-0.003	8.145
	10-11	180	0.080	3.800	70581.372	2.351	0.619		0.003	3.803	70581.372	2.355	0.619		0.006	3.809
	11-12	260	0.080	2.500	101950.871	1.565	0.626		0.003	2.503	101950.871	1.569	0.627		0.006	2.509
	12-14	215	0.080	0.700	84305.528	0.123	0.175		0.003	0.703	84305.528	0.124	0.176		0.006	0.709
	14-24	230	0.050	1.665	889630.661	6.440	3.868		-0.017	1.648	889630.661	6.318	3.834		-0.003	1.645
	24-8	340	0.050	-0.335	1315106.195	-0.490	1.462		-0.017	-0.352	1315106.195	-0.537	1.526		-0.003	-0.355
	8-4.1(4.2)	470	0.100	-6.935	62167.540	-6.302	0.909		-0.017	-6.952	62167.540	-6.331	0.911		-0.003	-6.955
	4.1(4.2)-1	359	0.169	-30.235	3687.670	-5.698	0.188		-0.017	-30.252	3687.670	-5.704	0.189		-0.003	-30.255
	Total			0.000		0.257	8.125	-0.017				0.052	8.158	-0.003		
B	10-20	375	0.100	3.465	49601.761	1.393	0.402		-0.020	3.445	49601.761	1.378	0.400		-0.009	3.436
	20-21	165	0.200	6.965	746.335	0.076	0.011		-0.020	6.945	746.335	0.076	0.011		-0.009	6.936
	21-13	95	0.080	3.865	37251.280	1.281	0.331		-0.020	3.845	37251.280	1.268	0.330		-0.009	3.836
	13-14	205	0.080	2.665	80384.340	1.389	0.521		-0.020	2.645	80384.340	1.370	0.518		-0.009	2.636
	14-12	215	0.080	-0.700	84305.528	-0.123	0.175		-0.003	-0.703	84305.528	-0.124	0.176		-0.006	-0.709
	12-11	260	0.080	-2.500	101950.871	-1.565	0.626		-0.003	-2.503	101950.871	-1.569	0.627		-0.006	-2.509
	11-10	180	0.080	-3.800	70581.372	-2.351	0.619		-0.003	-3.803	70581.372	-2.355	0.619		-0.006	-3.809
	Total					0.100	2.686	-0.020				0.045	2.681	-0.009		

(Source:JICA)

Table B-7.2 Summary of Flow Network Analysis (Existing)

Node No	Length (m)	Actual length (m)	EL of ground (m)	EL at center of pipe (m)	Height (m)	Diameter (m)	Static head (m)	Discharge (m3/sec)	Flow rate (m3/sec)	Head loss (m)	EL of Effective Head (m)	Hydraulic gradient	Effective head (m)	Velocity (m/sec)
Waff			801.27	800.17							800.17			
DOS P1			725.00	723.68	-76.50	0.25	76.50		0.0768	31.50	768.67		45.00	1.56
DOS P1			725.00	723.68							768.67			
M3 381*	2000	2000.02	715.00	713.68	-10.00	0.25	28.57		0.0768	26.42	742.25	0.0132	28.57	1.56
M3 381*			715.00	713.68							742.25			
1.1	130	130.01	713.80	712.52	-1.16	0.17	29.73		0.0303	2.07	740.18	0.0159	27.66	1.35
1.1			713.80	712.52			29.73				740.18			
4.1	359	359.02	711.15	709.87	-3.81	0.17	32.38	0.0006	0.0303	5.70	736.54	0.0159	26.68	1.35
4.1			711.15	709.87							736.54			
4.2	50	50.07	711.15	709.87	-2.65	0.17	32.38	0.0000	0.0303	0.80	739.38	0.0159	29.52	1.35
4.1			711.15	709.87			32.38				736.54			
8	470	470.02	707.00	705.75	-4.12	0.10	36.50	0.0046	0.0070	6.33	730.21	0.0135	24.46	0.89
8			707.00	705.75			36.50				730.21			
9	700	700.01	703.07	701.82	-3.93	0.10	40.43	0.0020	0.0020	0.92	729.30	0.0013	27.48	0.25
8			707.00	705.75			36.50				730.21			
24	340	340.01	704.70	703.48	-2.27	0.05	38.77	0.0020	0.0004	0.55	729.67	0.0016	26.19	0.18
24			704.70	703.48			38.77				729.67			
14	230	230.01	706.63	705.41	1.93	0.05	36.84	0.0017	0.0016	6.30	723.37	0.0274	17.97	0.84
M3 381			715.00	713.68							742.25			
1.2	130	130.01	713.80	712.52	-1.16	0.17	29.73	0.0016	0.0303	2.07	740.18	0.0159	27.66	1.35
1.2			713.80	712.55			29.70				740.18			
10	125	125.02	711.70	710.45	-2.10	0.10	31.80	0.0009	0.0081	2.26	737.92	0.0181	27.47	1.04
10			711.70	710.45			31.80				737.92			
16	205	205.00	710.36	709.11	-1.34	0.10	33.14	0.0019	0.0034	0.75	737.17	0.0037	28.06	0.44
16			710.36	709.11			33.14				737.17			
20	170	170.00	710.00	708.75	0.36	0.10	33.50	0.0021	0.0015	0.14	737.03	0.0008	28.28	0.20
20			710.00	708.75			33.50				737.03			
23	555	555.03	704.00	702.75	-6.00	0.10	39.50	0.0031	0.0031	1.68	735.35	0.0030	32.60	0.40
20			710.00	708.75			33.50				737.03			
19	225	225.00	709.07	707.85	0.90	0.05	34.40	0.0034	0.0034	23.22	713.81	0.1032	5.97	1.72
10			711.70	710.45			31.80				737.92			
11	180	180.01	710.01	708.77	-1.68	0.08	33.48	0.0043	0.0038	2.36	735.56	0.0131	26.79	0.76
11			710.01	708.77			33.48				735.56			
12	260	260.01	708.01	706.77	-2.00	0.08	35.49	0.0018	0.0025	1.58	733.99	0.0061	27.22	0.50
12			708.01	706.77			35.48				733.99			
14	215	215.00	706.63	705.39	-1.38	0.08	36.86	0.0017	0.0007	0.13	733.85	0.0006	28.47	0.14
14			706.63	705.39			36.86				733.86			
13	205	205.01	708.85	707.61	2.22	0.08	34.64	0.0012	0.0026	1.36	732.50	0.0066	24.89	0.52
13			708.85	707.61			34.64				732.50			
21	95	95.00	709.08	707.84	0.23	0.08	34.41	0.0002	0.0038	1.26	731.24	0.0133	23.40	0.76
M3 381**			715.00	713.68							742.25			
3	200	200.01	712.90	711.65	-2.02	0.10	30.60	0.0000	0.0110	6.34	735.90	0.0317	24.25	1.41
3			712.90	707.84			34.41				731.24			
15	120	120.03	712.00	710.55	2.71	0.50	31.70	0.0014	0.0014	0.00	731.24	0.0000	20.69	0.01
3			712.90	711.65			30.60				735.90			
17	105	105.03	710.50	709.25	-2.40	0.10	33.00	0.0021	0.0097	2.61	733.29	0.0249	24.04	1.23
17			710.50	709.25			33.00				733.29			
20	200	200.00	710.09	708.84	-0.41	0.10	33.41	0.0021	0.0076	3.19	730.10	0.0159	21.26	0.97
20			710.09	708.84			33.41				733.29			
19	220	220.00	709.07	707.82	-1.02	0.10	34.43	0.0034	0.0034	0.76	732.52	0.0035	24.70	0.43
20			710.09	708.84			33.41				730.10			
21	165	165.00	709.08	707.83	-1.01	0.10	34.42	0.0002	0.0069	2.21	727.89	0.0134	20.06	0.88
M3 381			715.00	713.60							742.25			
2	240	240.00	713.80	712.52	-1.28	0.17	29.73	0.0005	0.0303	3.81	738.43	0.0159	25.92	1.35
2			713.80	712.52			29.73				738.43			
1.2	200	200.00	712.90	711.62	0.90	0.17	30.63	0.0016	0.0303	3.18	735.25	0.0159	23.64	1.35
2			713.80	712.52			29.73				738.43			
4.2	150	150.02	711.15	709.87	-2.65	0.17	32.38	0.0000	0.0303	2.38	736.05	0.0159	26.18	1.35
4.2			711.15	709.87			32.38				736.05			
4.3	60	60.00	711.15	709.91	0.04	0.08	32.34	0.0014	0.0233	22.45	713.60	0.3741	3.69	4.64
4.3			711.15	709.87			32.38				736.05			
5.1	425	425.00	711.25	710.01	0.14	0.08	32.24	0.0026	0.0219	141.82	594.23	0.3337	-115.78	4.36
5.1			711.25	710.01			32.24				594.23			
5.2	433	433.00	710.00	708.76	-1.25	0.08	33.49	0.0039	0.0193	113.93	480.30	0.2631	-228.46	3.83
5.2			710.00	708.76			33.49				480.30			
6	390	390.02	706.41	705.17	-3.59	0.08	37.08	0.0010	0.0091	25.74	454.56	0.0660	-250.61	1.82
5.1			711.25	710.01			32.24				594.23			
7	505	505.02	706.24	704.99	-5.02	0.10	37.26	0.0063	0.0063	5.61	588.62	0.0111	-116.37	0.80
6			706.41	705.17							454.56			
25	165	165.00	706.11	704.87	-0.30	0.08	37.38	0.0047	0.0081	8.78	445.78	0.0532	-259.09	1.62
25			706.11	704.87			37.38				445.78			
28	230	230.00	705.04	703.80	-1.07	0.08	38.45	0.0000	0.0034	2.51	443.27	0.0109	-260.53	0.69
28			705.04	703.80			38.45				443.27			
29	95	95.01	704.06	702.81	-0.99	0.10	39.44	0.0000	0.0034	0.35	442.92	0.0037	-259.89	0.44
29			704.06	702.81			39.43				442.92			
30	165	165.00	704.23	702.98	0.17	0.10	39.27	0.0014	0.0034	0.61	442.31	0.0037	-260.67	0.44
30			704.23	702.98			39.27				442.31			
31	75	75.00	704.16	702.91	-0.07	0.10	39.34	0.0015	0.0020	0.10	442.21	0.0014	-260.70	0.26
Wester S.R.				755.00							755.00			
A			700.00	698.73	-56.28	0.15	56.28		0.0150		744.23		45.50	
A			700.00	698.73							744.23			
B	3030	3030.00	702.85	701.58	2.85	0.15	53.43		0.0150	23.58	720.65	0.0076	19.07	0.85
8			702.85	701.58							720.65			
26		1.72	701.13	699.86	-1.72	0.15	55.15	0.0019	0.0150	0.01	720.63	0.0076	20.78	0.85
26			701.13	699.86			55.15				720.63			
27	85	85.00	701.11	699.84	-0.02	0.15	55.17	0.0016	0.0032	0.04	720.60	0.0004	20.76	0.18
27			701.11	699.84							720.60			
37	300	300.03	705.50	704.23	4.39	0.15	50.78			0.00	720.60	0.0000	16.37	0.00
26			701.13	699.86							720.63			
32	500	500.02	696.64	695.39	-4.47	0.10	59.61	0.0051	0.0100	13.15	707.49	0.0263	12.10	1.27
32			696.64	695.39							707.49			
33	115	115.01	698.04	696.79	1.40	0.10	58.21	0.0015	0.0049	0.80	706.68	0.0070	9.89	0.62
33			698.04	696.79							706.68			
35	185	185.00	698.08	696.83	0.04	0.10	58.17	0.0018	0.0053	1.50	705.19	0.0081	8.36	0.67
35			698.08	696.83							705.19			
36	190	190.00	698.70	697.45	0.62	0.10	57.55	0.0016	0.0016	0.17	705.02	0.0009	7.57	0.20
27			701.13	699.84							720.60			
34	540	540.00	701.84	700.59	0.75	0.10	54.41	0.0016	0.0016	0.48	720.12	0.0009	19.53	0.20

Table B-7.3 Looped Water Distribution Network Analysis (Proposed)

Zone No.	Node No.	Length(m)	Dia.(m)	Q2(l/sec)	r	h2(m)	h2/Q2	Δq(l/sec)	q(l/sec)	Q(l/sec)	V(m/sec)
O	17-18	225	0.100	5.091	29761.057	1.703	0.335		0.000	5.091	0.65
	18-19	200	0.100	1.315	26454.273	0.124	0.094		0.000	1.315	0.17
	19-20	225	0.100	-3.886	29761.057	-1.034	0.266		0.000	-3.887	-0.50
	20-17	200	0.250	-40.053	306.160	-0.793	0.020		0.000	-40.052	-0.82
	Total	850				0.000	0.714	0.000			
I	3-17(D100/250)	105	0.300	49.846	65.929	0.257	0.005		0.000	49.846	0.71
	17-20(D100/250)	200	0.250	40.053	306.160	0.793	0.020		0.000	40.052	0.82
	20-16(D100)	170	0.100	-1.522	22486.132	-0.138	0.091		0.001	-1.521	-0.19
	16-15	400	0.100	-1.311	52908.545	-0.246	0.185		0.000	-1.312	-0.17
	15-3	120	0.100	-4.304	15872.564	-0.666	0.155		0.000	-4.304	-0.55
	Total	995				0.000	0.458	0.000			
II	10-16(D100)	205	0.100	4.486	27115.629	1.228	0.274		-0.001	4.484	0.57
	16-20(D100)	170	0.100	1.522	22486.132	0.138	0.091		-0.001	1.521	0.19
	20-21(D100*2/250)	165	0.250	32.986	251.757	0.457	0.014		-0.001	32.985	0.67
	21-13	95	0.100	6.047	12565.779	0.989	0.163		0.000	6.046	0.77
	13-14	205	0.100	3.339	27115.629	0.711	0.213		0.000	3.339	0.43
	14-12	215	0.150	-8.536	3947.661	-0.588	0.069		0.000	-8.536	-0.48
	12-11	260	0.150	-12.526	4773.916	-1.445	0.115		0.000	-12.526	-0.71
	11-10	180	0.150	-15.519	3305.019	-1.487	0.096		0.000	-15.518	-0.88
	Total	1,495				0.003	1.035	-0.001			
III	21-22(D100*2/200)	215	0.200	26.369	972.497	1.167	0.044		-0.001	26.368	0.84
	22-23(D100/150)	105	0.150	12.119	1927.927	0.549	0.045		-0.001	12.118	0.69
	23-37	195	0.150	8.628	3580.437	0.544	0.063		-0.001	8.627	0.49
	37-24	270	0.100	0.149	35713.268	0.003	0.020		-0.001	0.148	0.02
	24-14(D50)	230	0.150	-8.028	4223.079	-0.561	0.070		0.001	-8.027	-0.45
	14-13(D80)	205	0.100	-3.339	27115.629	-0.711	0.213		0.000	-3.339	-0.43
	13-21(D80)	95	0.100	-6.047	12565.779	-0.989	0.163		0.000	-6.046	-0.77
	Total	1,315				0.001	0.619	-0.001			
IV	1-10(D100/200)	125	0.200	22.142	565.405	0.491	0.022		-0.002	22.140	0.71
	10-11(D80)	180	0.150	15.519	3305.019	1.487	0.096		0.000	15.518	0.88
	11-12(D80)	260	0.150	12.526	4773.916	1.445	0.115		0.000	12.526	0.71
	12-14(D80)	215	0.150	8.536	3947.661	0.588	0.069		0.000	8.536	0.48
	14-24(D50)	230	0.150	8.028	4223.079	0.561	0.070		-0.001	8.027	0.45
	24-8(D80)	340	0.150	-1.370	6242.813	-0.032	0.023		-0.002	-1.372	-0.08
	8-4(D100/200)	470	0.200	-28.838	2125.923	-3.009	0.104		0.004	-28.835	-0.92
	4-2(D150/400)	150	0.500	-165.388	7.827	-0.280	0.002		-0.002	-165.390	-0.84
	2-1(D150/200)	200	0.200	-28.445	904.648	-1.249	0.044		-0.002	-28.447	-0.91
	Total	2,170				0.002	0.545	-0.002			
V	4-8(D100/200)	470	0.200	28.838	2125.923	3.009	0.104		-0.004	28.835	0.92
	8-9(D100/200)	700	0.200	17.065	3166.269	1.698	0.100		-0.005	17.060	0.54
	9-38	80	0.200	15.640	361.859	0.165	0.011		-0.005	15.635	0.50
	38-39	270	0.150	-7.247	4957.528	-0.545	0.075		-0.001	-7.247	-0.41
	39-40	95	0.150	-8.244	1744.315	-0.243	0.030		-0.001	-8.245	-0.47
	40-41	175	0.150	-9.242	3213.212	-0.554	0.060		-0.001	-9.242	-0.52
	41-7	220	0.150	-9.831	4039.467	-0.781	0.079		0.000	-9.831	-0.56
	7-5.1(D100/100)	500	0.200	-16.814	2284.237	-1.192	0.071		0.000	-16.814	-0.54
	5.1-4	425	0.400	-131.990	65.739	-1.552	0.012		-0.006	-131.995	-1.05
	Total	2,010				0.005	0.541	-0.005			
VI	5.1-7(D100/100)	500	0.200	16.814	2284.237	1.192	0.071		0.000	16.814	0.54
	7-41	220	0.150	9.831	4039.467	0.781	0.079		0.000	9.831	0.56
	41-42	195	0.150	-6.393	3580.437	-0.312	0.049		-0.001	-6.394	-0.36
	42-5.2(D80)	245	0.400	-101.997	37.897	-0.545	0.005		-0.006	-101.003	-0.80
	5.2-5.1	433	0.400	-109.191	66.976	1.113	0.010		-0.006	-109.197	-0.87
	Total	1,595				0.002	0.215	-0.006			
VII	42-41	195	0.150	6.393	3580.437	0.312	0.049		0.001	6.394	0.36
	41-40	175	0.150	9.242	3213.212	0.554	0.060		0.001	9.242	0.52
	40-39	95	0.150	8.244	1744.315	0.243	0.030		0.001	8.245	0.47
	39-38	270	0.150	7.247	4957.528	0.545	0.075		0.001	7.247	0.41
	38-43	205	0.200	21.889	927.264	0.788	0.036		-0.005	21.885	0.70
	43-48(D150)	560	0.200	19.182	2533.015	1.687	0.088		-0.005	19.177	0.61
	18-26(D150)	110	0.200	16.474	497.557	0.250	0.015		-0.005	16.470	0.52
	26-27(D150)	85	0.100	0.955	11243.066	-0.029	0.030		0.001	0.956	-0.12
	27-28(D150)	385	0.150	-14.423	7124.151	-2.799	0.194		0.008	-14.414	-0.82
	28-25(D80)	230	0.300	-69.738	144.415	-1.047	0.015		-0.005	69.743	-0.99
	25-6(D80)	165	0.400	-76.436	25.522	-0.219	0.003		-0.005	-76.490	-0.61
	5-42(D80)	168	0.400	86.411	25.986	0.280	0.003		-0.005	86.415	-0.69
	Total	2,640				0.005	0.598	-0.005			
VIII	26-46(D100/150)	160	0.169	17.429	1765.162	0.951	0.055		-0.003	17.426	0.78
	46-32(D100/150)	330	0.169	14.579	3389.780	1.359	0.093		-0.003	14.576	0.65
	32-33(D100/150)	115	0.169	8.879	1181.287	0.189	0.021		-0.003	8.876	0.40
	33-35(D100/150)	185	0.169	5.459	1900.331	0.124	0.023		0.003	5.456	0.24
	35-36(D100/150)	190	0.169	-14.919	1951.692	-0.816	0.055		-0.003	-14.922	-0.67
	36-45	80	0.250	-38.004	131.219	-0.310	0.008		-0.003	-38.007	-0.77
	45-34	355	0.150	-8.124	6518.231	-0.886	0.109		0.010	-8.115	-0.46
	34-27	177	0.150	-9.906	3249.935	-0.637	0.064		0.010	-9.896	-0.56
	27-26(D150)	85	0.100	0.955	11243.066	0.029	0.030		0.001	0.956	0.12
	Total	1,695				0.003	0.458	-0.003			
IX	27-34(D50)	180	0.150	9.906	3305.019	0.648	0.065		-0.010	9.896	0.56
	34-45	355	0.150	8.124	6518.231	0.886	0.109		0.010	8.115	0.46
	45-44	225	0.200	-31.660	1008.683	-1.697	0.054		-0.013	-31.673	-1.01
	44-31	120	0.100	-3.591	16930.734	-0.508	0.141		-0.007	-3.598	-0.46
	31-30	78	0.100	-4.624	10317.166	-0.494	0.107		-0.007	-4.631	-0.59
	30-29	80	0.100	-5.657	10581.709	-0.736	0.130		-0.007	-5.661	-0.72
	29-28	95	0.100	-5.657	12565.779	-0.874	0.154		-0.007	-5.664	-0.72
	28-27(D150)	385	0.150	14.423	7124.151	2.799	0.194		-0.018	14.414	0.82
	Total	1,527				0.023	0.955	-0.013			
X	28-29(D100)	95	0.100	5.657	12565.779	0.874	0.154		0.007	5.664	0.72
	29-30(D100)	80	0.100	5.657	10581.709	0.736	0.130		0.007	5.664	0.72
	30-31(D100)	78	0.100	4.624	10317.166	0.494	0.107		0.007	4.631	0.59
	31-44	128	0.100	3.591	16930.734	0.508	0.141		0.007	3.598	0.46
	44-54	125	0.200	-29.102	565.405	-0.814	0.028		-0.006	-29.109	-0.93
	54-53	275	0.250	-39.897	419.595	-1.063	0.027		-0.006	-39.903	-0.81
	53-28(D150)	120	0.250	-49.658	183.096	0.706	0.014		-0.006	49.664	-1.01
	Total	901				0.007	0.602	-0.006			

(Source: JICA)

Remarks: The network is analyzed by the Hazen Williams' equation

h = r*Q^1.85

where, h: Friction head loss (m)

r: Coefficient of pipe diameter

Q: Allocated flow (l/sec)

Table B-7.4 (1/2) Summary of Flow Network Analysis (Tentative)

Node No	Length (m)	Actual length (m)	EL of ground (m)	EL at center of pipe (m)	Height (m)	Diameter (m)	Static head (m)	Discharge (m3/sec)	Flow rate (m3/sec)	Head loss (m)	EL of Effective Head (m)	Hydraulic gradient	Effective head (m)	Velocity (m/sec)
Wali			801.27	800.17							800.170			
D05-P1			725.00	723.55	-76.62	0.50	76.62		0.2505	31.500	768.670	0.0040	45.12	1.28
D05-P1			725.00	723.55							768.670			
M3-381*	2000	2000.02	715.00	713.55	-10.00	0.50	47.06		0.2505	8.058	760.612	0.0040	47.06	1.28
M3-381*			715.00	713.55		0.50					760.612			
1	130	130.00	713.80	712.52	-1.03	0.17	48.10		0.0380	3.149	757.463	0.0242	44.95	1.69
1			713.80	712.55			48.06				757.463			
2	200	200.01	711.72	710.42	-2.13	0.20	50.19	0.0009	0.0276	1.184	756.279	0.0059	45.86	0.88
1			713.80	712.55			48.06				757.463			
10	125	125.02	711.70	710.40	-2.15	0.20	50.21	0.0015	0.0229	0.524	756.938	0.0042	46.54	0.73
10			711.70	710.40			50.21				756.938			
16	205	205.00	710.36	709.11	-1.29	0.10	51.50	0.0030	0.0048	1.394	755.544	0.0068	46.43	0.61
16			710.36	709.11			51.50				755.544			
20	170	170.00	710.00	708.75	-0.36	0.10	51.86	0.0033	0.0010	0.061	755.483	0.0004	46.73	0.12
10			711.70	710.40							755.483			
11	180	180.01	710.01	708.74	-1.67	0.15	51.88	0.0021	0.0160	1.574	753.909	0.0087	45.17	0.91
11			710.01	708.74			51.88				753.909			
12	260	260.01	708.01	706.74	-2.00	0.15	53.88	0.0028	0.0130	1.550	752.359	0.0060	45.62	0.74
12			708.01	706.74			53.88				752.359			
14	215	215.00	706.63	705.36	-1.38	0.15	55.26	0.0027	0.0090	0.651	751.708	0.0030	46.35	0.51
14			706.63	705.38			55.23				751.708			
13	205	205.01	708.85	707.60	2.22	0.10	53.01	0.0019	0.0036	0.800	750.907	0.0039	43.31	0.45
13			708.85	707.60			53.01				750.907			
21	95	95.00	709.08	707.83	0.23	0.10	52.78	0.0004	0.0063	1.056	749.852	0.0111	42.02	0.56
14			706.63	705.38							751.708			
24	340	340.00	705.24	703.97	-1.41	0.15	56.65	0.0032	0.0087	0.969	750.738	0.0029	46.77	0.49
M3-381**			715.00	713.55		0.50					760.612			
3	200	200.01	712.90	711.58	-1.98	0.25	49.04	0.0000	0.0551	1.431	759.181	0.0072	47.61	1.12
3			712.90	711.58			49.04				759.181			
15	120	120.00	712.00	710.75	-0.82	0.10	49.86	0.0021	0.0034	0.426	758.754	0.0036	48.00	0.43
15			712.00	710.75							758.754			
16	400	400.00	710.36	709.14	-1.62	0.05	51.48	0.0030	0.0005	0.995	757.759	0.0025	48.62	0.23
3			712.90	711.58			49.04				759.181			
17	105	105.03	710.50	709.18	-2.40	0.25	51.44	0.0033	0.0507	0.644	758.536	0.0061	49.36	1.03
17			710.50	709.18			51.44				758.536			
20	200	200.00	710.09	708.77	-0.41	0.25	51.85	0.0033	0.0416	0.851	757.686	0.0043	48.92	0.85
20			710.09	708.84			51.77				758.536			
19	220	220.00	709.07	707.82	-1.02	0.10	52.79	0.0053	0.0046	1.362	757.174	0.0062	49.35	0.58
19			709.07	707.85			52.77				757.686			
18	200	200.00	709.64	708.42	0.57	0.05	52.20	0.0053	0.0006	0.938	756.747	0.0047	48.33	0.32
18			709.64	708.39			52.22				757.174			
17	225	225.00	710.50	709.25	0.86	0.10	51.36	0.0053	0.0044	1.306	755.869	0.0058	46.62	0.56
20			710.09	708.77			51.85				757.686			
21	165	165.00	709.08	707.76	-1.01	0.25	52.86	0.0004	0.0333	0.465	757.221	0.0028	49.47	0.68
21			709.08	707.76			52.86				757.221			
22	215	215.01	707.24	705.94	-1.81	0.20	54.67	0.0170	0.0365	1.175	756.046	0.0055	50.11	0.84
22			707.24	705.94			54.67				756.046			
23	105	105.00	707.24	705.97	0.02	0.15	54.65	0.0049	0.0122	0.557	755.489	0.0053	49.52	0.69
23			707.24	705.97			54.65				755.489			
37	195	195.02	704.56	703.29	-2.68	0.15	57.33	0.0049	0.0087	0.555	754.933	0.0028	51.65	0.49
37			704.56	703.29			57.33				754.933			
24	340	340.00	705.24	704.02	0.73	0.05	56.60	0.0032	0.0002	0.283	754.650	0.0008	50.64	0.13
24			705.24	704.02			56.60				754.650			
8	340	340.01	708.01	706.71	2.70	0.20	53.90	0.0073	0.0077	0.190	754.460	0.0006	47.75	0.25
M3-381			715.00	713.55		0.50					760.612			
2	240	240.00	713.80	712.43	-1.13	0.35	48.19	0.0009	0.0970	0.950	759.662	0.0040	47.24	1.01
2			713.80	712.43			48.19				759.662			
4	150	150.02	711.15	709.75	-2.67	0.40	50.86	0.0032	0.1646	0.824	758.838	0.0055	49.09	1.31
4			711.15	709.75			50.56				758.838			
8	470	470.01	705.01	706.71	-3.04	0.20	53.90	0.0073	0.0285	2.941	755.897	0.0063	49.19	0.91
8			708.01	706.71			53.90				755.897			
9	700	700.02	703.07	701.77	-4.94	0.20	58.84	0.0031	0.0175	1.781	754.116	0.0025	52.35	0.56
9			703.07	701.77			58.84				754.116			
38	50	50.01	702.00	700.70	-1.07	0.20	59.91	0.0007	0.0161	0.174	753.942	0.0022	53.24	0.51
38			702.00	700.73			59.89				753.942			
39	270	270.00	703.61	702.34	1.61	0.15	58.28	0.0007	0.0081	0.670	753.272	0.0025	50.94	0.46
39			703.61	702.34			58.28				753.272			
40	95	95.00	704.00	702.73	0.39	0.15	57.89	0.0007	0.0091	0.292	752.980	0.0031	50.26	0.52
40			704.00	702.73			57.89				752.980			
41	700	700.00	705.76	704.49	1.76	0.15	56.13	0.0042	0.0101	2.610	750.370	0.0037	45.59	0.57

Table B-7.4 (2/2) Summary of Flow Network Analysis (Tentative)

Node No	Length (m)	Actual length (m)	EL of ground (m)	EL at center of pipe (m)	Height (m)	Diameter (m)	Static head (m)	Discharge (m3/sec)	Flow rate (m3/sec)	Head loss (m)	EL of Effective Head (m)	Hydraulic gradient	Effective head (m)	Velocity (m/sec)
4			711.15	709.75			50.86				758.838			
5.1	425	425.00	711.25	709.85	0.10	0.40	50.76	0.0042	0.1315	1.542	757.296	0.0036	47.45	1.05
5.1			711.25	709.85			50.76				757.296			
7	505	505.02	706.24	704.94	-4.91	0.20	55.67	0.0049	0.0204	1.697	755.599	0.0034	50.66	0.65
7			710.00	708.63			51.99				755.305			
41	220	220.04	705.76	704.49	-4.14	0.15	56.13	0.0049	0.0020	0.039	755.266	0.0002	50.78	0.11
41			710.00	708.63			51.99				754.336			
42	195	195.04	705.76	704.49	-4.14	0.15	56.13	0.0058	0.0046	0.169	754.166	0.0009	49.68	0.26
5.1			711.25	709.85			50.76				757.296			
5.2	433	433.00	710.00	708.63	-1.23	0.35	51.99	0.0058	0.1052	1.991	755.305	0.0046	46.68	1.09
5.2			710.00	708.63			51.99				755.305			
42	245	245.00	710.00	708.63	0.00	0.35	51.99	0.0058	0.0970	0.970	754.336	0.0040	45.71	1.01
42			710.00	708.63			51.99				754.336			
6	390	390.02	706.41	705.04	-3.59	0.35	55.58	0.0070	0.0551	1.212	753.124	0.0031	48.09	0.89
6			706.41	705.04							753.124			
25	165	165.00	706.11	704.74	-0.30	0.35	55.88	0.0047	0.0751	0.407	752.717	0.0025	47.98	0.78
25			706.11	704.74			55.88				752.717			
28	230	230.00	705.04	703.69	-1.05	0.30	56.92	0.0000	0.0684	1.011	751.706	0.0044	48.02	0.97
28			705.04	703.69			56.92				751.706			
29	95	95.00	704.06	702.81	-0.88	0.10	57.80	0.0000	0.0061	0.993	750.713	0.0105	47.90	0.77
29			704.06	702.81			57.80				750.713			
30	80	80.00	704.23	702.98	0.17	0.10	57.63	0.0007	0.0061	0.836	749.877	0.0105	46.90	0.77
30			704.23	702.98			57.63				749.877			
31	78	78.00	704.16	702.91	-0.07	0.10	57.70	0.0007	0.0050	0.577	749.300	0.0074	46.39	0.64
31			704.16	702.91			57.70				749.300			
44	128	128.00	704.53	703.28	0.37	0.10	57.33	0.0007	0.0004	0.010	749.290	0.0001	46.01	0.05
28			705.04	703.69			56.92				751.706			
53	120	120.01	706.80	705.48	1.78	0.25	55.14	0.0137	0.0479	0.663	751.043	0.0055	45.57	0.98
53			706.80	705.48			55.14				751.043			
54	275	275.00	706.20	704.88	-0.60	0.25	55.74	0.0007	0.0382	0.997	750.045	0.0036	45.17	0.78
54			706.20	704.88			55.74				750.045			
44	125	125.01	704.53	703.23	-1.64	0.20	57.38	0.0007	0.0274	0.727	749.318	0.0058	46.09	0.87
44			704.53	703.23			57.38				749.318			
45	223	223.03	701.07	699.77	-3.46	0.20	60.84	0.0013	0.0303	1.568	747.751	0.0070	47.98	0.97
45			701.07	699.77			60.84				747.751			
36	86	86.01	699.70	698.38	-1.40	0.25	62.24	0.0162	0.0375	0.302	747.449	0.0035	49.07	0.76
36			699.70	698.38			62.24				747.449			
35	190	190.01	698.08	696.80	-1.58	0.17	63.82	0.0150	0.0144	0.763	746.686	0.0040	49.89	0.64
38			702.00	700.73			59.89				753.942			
43	203	203.01	703.59	702.29	1.57	0.20	58.32	0.0019	0.0232	0.869	753.074	0.0043	50.78	0.74
43			703.59	702.29			58.32				753.074			
48	560	560.01	700.38	699.08	-3.21	0.20	61.53	0.0019	0.0205	1.904	751.169	0.0034	52.09	0.65
48			700.38	699.08			61.53				751.169			
26	110	110.00	701.13	699.83	0.75	0.20	60.78	0.0011	0.0178	0.288	750.882	0.0026	51.05	0.57
26			701.13	699.83			60.78				750.882			
27	85	85.00	701.11	699.89	0.05	0.05	60.73	0.0025	0.0002	0.042	750.840	0.0005	50.95	0.10
27			701.11	699.89			60.73				750.840			
28	388	388.02	705.04	703.77	3.88	0.15	56.85	0.0000	0.0141	2.808	748.032	0.0072	44.27	0.82
26			701.13	699.83			60.78				750.882			
46	166	166.01	699.40	698.12	-1.71	0.17	62.50	0.0020	0.0180	1.006	749.876	0.0061	51.76	0.80
46			699.40	698.12			62.50				749.876			
32	330	330.01	696.64	695.36	-2.76	0.17	65.26	0.0040	0.0151	1.452	748.424	0.0044	53.07	0.67
32			696.64	695.36			65.26				748.424			
33	115	115.01	698.04	696.76	1.40	0.17	63.86	0.0024	0.0094	0.211	748.213	0.0018	51.46	0.42
33			698.04	696.76			63.86				748.213			
35	185	185.00	698.08	696.80	0.04	0.17	63.82	0.0150	0.0060	0.147	748.066	0.0008	51.27	0.27
27			701.11	699.89			60.73				750.840			
34	180	150.00	701.84	700.57	0.68	0.15	60.05	0.0013	0.0107	0.747	750.093	0.0042	49.53	0.61
34		-	701.84	700.57			60.05				750.093			
45	355	355.00	701.07	699.80	-0.77	0.15	60.82	0.0013	0.0059	1.052	749.041	0.0030	49.25	0.50
Wester S.R.				755.00							755.000			
A			700.00	698.63	-56.38	0.35	56.38	0.0108	0.0750		744.125		45.50	
A			700.00	698.63							744.125			
B	3030	3030.00	702.85	701.48	2.85	0.35	53.53	0.0628	0.0642	5.588	738.537	0.0018	37.06	0.67

(Source: DAWSSA & JICA)

Table B-7.5 (1/2) Summary of Flow Network Analysis (Alternative 2)

Node No	Length (m)	Actual length (m)	EL of ground (m)	EL at center of pipe (m)	Height (m)	Diameter (m)	Static head (m)	Discharge (m3/sec)	Flow rate (m3/sec)	Head loss (m)	EL of Effective Head (m)	Hydraulic gradient	Effective head (m)	Velocity (m/sec)
Mezze			772.25	770.25		0.60					770.250			
M3-351	1600	1600.89	715.00	713.50	-56.75	0.60	56.75		0.2505	2.986	767.264	0.0017	53.76	0.89
M3-381*			715.00	713.60		0.40					767.264			
1	250	250.00	713.80	712.52	-1.08	0.17	54.75		0.0380	6.056	761.208	0.0242	48.69	1.69
1			713.80	712.55			54.71				761.208			
2	200	200.01	711.72	710.42	-2.13	0.20	56.84	0.0009	0.0276	1.184	760.024	0.0059	49.60	0.88
1			713.80	712.55			54.71				761.208			
10	125	125.02	711.70	710.40	-2.15	0.20	56.86	0.0015	0.0229	0.524	760.684	0.0042	50.28	0.73
10			711.70	710.40			56.86				760.684			
16	205	205.00	710.36	709.11	-1.29	0.10	58.15	0.0030	0.0048	1.394	759.290	0.0068	50.18	0.61
16			710.36	709.11			58.15				759.290			
20	170	170.00	710.00	708.75	-0.36	0.10	58.51	0.0033	0.0010	0.061	759.229	0.0004	50.48	0.12
10			711.70	710.40							759.229			
11	180	180.01	710.01	708.74	-1.67	0.15	58.53	0.0021	0.0160	1.574	757.655	0.0087	48.92	0.91
11			710.01	708.74			58.53				757.655			
12	260	260.01	708.01	706.74	-2.00	0.15	60.53	0.0028	0.0130	1.550	756.104	0.0060	49.37	0.74
12			708.01	706.74			60.53				756.104			
14	215	215.00	706.63	705.36	-1.38	0.15	61.91	0.0027	0.0090	0.651	755.453	0.0030	50.10	0.51
14			706.63	705.38			61.88				755.453			
13	205	205.01	708.85	707.60	2.22	0.10	59.66	0.0019	0.0036	0.800	754.653	0.0039	47.05	0.45
13			708.85	707.60			59.66				754.653			
21	95	95.00	709.08	707.83	0.23	0.10	59.43	0.0004	0.0063	1.056	753.597	0.0111	45.77	0.80
14			706.63	705.38							755.453			
24	340	340.00	705.24	703.97	-1.41	0.15	63.30	0.0032	0.0087	0.969	754.484	0.0029	50.52	0.49
M3-381**			715.00	713.60		0.40					767.264			
3	30	30.07	712.90	711.58	-2.03	0.25	55.69	0.0000	0.0551	0.215	767.049	0.0072	55.47	1.12
3			712.90	703.97			63.30				767.049			
15	120	120.19	712.00	710.75	6.78	0.10	56.51	0.0021	0.0034	0.427	766.622	0.0036	55.87	0.43
15			712.00	710.75							766.622			
16	400	400.00	710.36	709.14	-1.62	0.05	58.13	0.0030	0.0005	0.995	765.627	0.0025	56.49	0.23
3			712.90	711.58			55.69				767.049			
17	105	105.03	710.50	709.18	-2.40	0.25	58.09	0.0033	0.0507	0.644	766.404	0.0061	57.23	1.03
17			710.50	709.18			58.09				766.404			
20	200	200.00	710.09	708.77	-0.41	0.25	58.50	0.0033	0.0416	0.851	765.554	0.0043	56.79	0.85
20			710.09	708.84			58.42				766.404			
19	220	220.00	709.07	707.82	-1.02	0.10	59.41	0.0053	0.0046	1.362	765.043	0.0062	57.22	0.58
19			709.07	707.82			59.44				765.554			
18	200	200.00	709.64	708.39	0.57	0.10	58.87	0.0053	0.0006	0.032	765.522	0.0002	57.13	0.08
18			709.64	708.39			58.87				765.043			
17	225	225.00	710.50	709.25	0.86	0.10	58.01	0.0053	0.0044	1.306	763.737	0.0058	54.49	0.56
20			710.09	708.77			58.50				765.554			
21	165	165.00	709.08	707.76	-1.01	0.25	59.51	0.0004	0.0333	0.465	765.059	0.0028	57.33	0.68
21			709.08	707.76			59.51				765.059			
22	215	215.01	707.24	705.94	-1.81	0.20	61.32	0.0170	0.0265	1.175	763.914	0.0055	57.97	0.84
22			707.24	705.94			61.32				763.914			
23	105	105.00	707.24	705.97	0.02	0.15	61.30	0.0049	0.0122	0.557	763.357	0.0053	57.39	0.69
23			707.24	705.97			61.30				763.357			
37	195	195.02	704.56	703.29	-2.68	0.15	63.98	0.0049	0.0087	0.555	762.801	0.0028	59.52	0.49
37			704.56	703.29			63.98				762.801			
24	340	340.00	705.24	704.02	0.73	0.05	63.25	0.0032	0.0002	0.283	762.518	0.0008	58.50	0.13
24			705.24	704.02			63.25				762.518			
8	340	340.01	708.01	706.71	2.70	0.20	60.55	0.0073	0.0077	0.190	762.328	0.0006	55.62	0.25
M3-381			715.00	713.60		0.40					767.264			
2	250	250.00	713.80	712.45	-1.15	0.30	54.81	0.0009	0.0970	2.096	765.168	0.0084	52.72	1.37
2			713.80	712.45			54.81				765.168			
4	150	150.02	711.15	709.75	-2.70	0.40	57.51	0.0032	0.1646	0.824	764.344	0.0055	51.59	1.31
4			711.15	709.75			57.51				764.344			
8	470	470.01	708.01	706.71	-3.04	0.20	60.55	0.0073	0.0285	2.941	761.404	0.0063	54.69	0.91
8			708.01	706.71			60.55				761.404			
9	700	700.02	703.07	701.77	-4.94	0.20	65.49	0.0031	0.0175	1.781	759.623	0.0025	57.85	0.56
9			703.07	701.77			65.49				759.623			
38	80	80.01	702.00	700.70	-1.07	0.20	66.56	0.0007	0.0161	0.174	759.449	0.0022	55.75	0.51
38			702.00	700.73			66.54				759.449			
39	270	270.00	703.61	702.34	1.61	0.15	64.93	0.0007	0.0081	0.670	758.779	0.0025	56.44	0.46
39			703.61	702.34			64.93				758.779			
40	95	95.00	704.00	702.73	0.39	0.15	64.54	0.0007	0.0091	0.292	758.486	0.0031	55.76	0.52
40			704.00	702.73			64.54				758.486			
41	700	700.00	705.76	704.49	1.76	0.15	62.78	0.0049	0.0101	2.610	755.876	0.0037	51.39	0.57
4			711.15	709.75			57.51				764.344			
5.1	425	425.00	711.25	709.85	0.10	0.40	57.41	0.0042	0.1315	1.542	762.803	0.0036	52.95	1.05
5.1			711.25	709.85			57.41				762.803			
7	505	505.02	706.24	704.94	-4.91	0.20	62.32	0.0049	0.0204	1.697	761.106	0.0034	56.17	0.65
7			710.00	708.65			58.61				758.585			
41	220	220.04	705.76	704.49	-4.16	0.15	62.78	0.0049	0.0020	0.039	758.545	0.0002	54.06	0.11
41			710.00	708.65			58.61				756.531			
42	195	195.04	705.76	704.49	-4.16	0.15	62.78	0.0058	0.0046	0.169	756.361	0.0009	51.88	0.26

Table B-7.5 (2/2) Summary of Flow Network Analysis (Alternative 2)

Node No	Length (m)	Actual length (m)	EL of ground (m)	EL at center of pipe (m)	Height (m)	Diameter (m)	Static head (m)	Discharge (m3/sec)	Flow rate (m3/sec)	Head loss (m)	EL of Effective Head (m)	Hydraulic gradient	Effective head (m)	Velocity (m/sec)
5.1			711.25	709.85			57.41				762.803			
5.2	433	433.00	710.00	708.65	-1.20	0.30	58.61	0.0058	0.1052	4.218	758.585	0.0097	49.93	1.49
5.2			710.00	708.65			58.61				758.585			
42	245	245.00	710.00	708.65	0.00	0.30	58.61	0.0058	0.0970	2.054	756.531	0.0084	47.88	1.37
42			710.00	708.65			58.61				756.531			
6	390	390.02	706.41	705.06	-3.59	0.30	62.20	0.0070	0.0851	2.567	753.964	0.0066	48.90	1.20
6			706.41	705.06							753.964			
25	165	165.00	706.11	704.76	-0.30	0.30	62.50	0.0047	0.0751	0.862	753.102	0.0052	48.34	1.06
25			706.11	704.76			62.50				753.102			
28	230	230.00	705.04	703.69	-1.07	0.30	63.57	0.0000	0.0684	1.011	752.091	0.0044	48.40	0.97
28			705.04	703.69			63.57				752.091			
29	95	95.00	704.06	702.81	-0.88	0.10	64.45	0.0000	0.0061	0.993	751.098	0.0105	48.29	0.77
29			704.06	702.81			64.45				751.098			
30	80	80.00	704.23	702.98	0.17	0.10	64.28	0.0007	0.0061	0.836	750.262	0.0105	47.28	0.77
30			704.23	702.98			64.28				750.262			
31	78	78.00	704.16	702.91	-0.07	0.10	64.35	0.0007	0.0050	0.577	749.685	0.0074	46.77	0.64
31			704.16	702.91			64.35				749.685			
44	128	128.00	704.53	703.28	0.37	0.10	63.98	0.0007	0.0004	0.010	749.675	0.0001	46.40	0.05
28			705.04	703.69			63.57				752.091			
53	120	120.01	706.80	705.48	1.78	0.25	61.79	0.0137	0.0479	0.663	751.427	0.0055	45.95	0.98
53			706.80	705.48			61.79				751.427			
54	275	275.00	706.20	704.88	-0.60	0.25	62.39	0.0007	0.0382	0.997	750.430	0.0036	45.55	0.78
54			706.20	704.88			62.39				750.430			
44	125	125.01	704.53	703.23	-1.64	0.20	64.03	0.0007	0.0274	0.727	749.703	0.0058	46.47	0.87
44			704.53	703.23			64.03				749.703			
45	223	223.03	701.07	699.77	-3.46	0.20	67.49	0.0013	0.0303	1.568	748.135	0.0070	48.37	0.97
45			701.07	699.77			67.49				748.135			
36	86	86.01	699.70	698.38	-1.40	0.25	68.89	0.0162	0.0375	0.302	747.834	0.0035	49.46	0.76
36			699.70	698.38			68.89				747.834			
35	190	190.01	698.08	696.50	-1.58	0.17	70.47	0.0150	0.0144	0.763	747.071	0.0040	50.28	0.61
38			702.00	700.73			66.54				759.449			
43	203	203.01	703.59	702.29	1.57	0.20	64.97	0.0019	0.0232	0.869	758.580	0.0043	56.29	0.74
43			703.59	702.29			64.97				758.580			
48	560	560.01	700.38	699.08	-3.21	0.20	68.18	0.0019	0.0205	1.904	756.676	0.0034	57.60	0.65
48			700.38	699.08			68.18				756.676			
26	110	110.00	701.13	699.83	0.75	0.20	67.43	0.0011	0.0178	0.288	756.388	0.0026	56.56	0.57
26			701.13	699.83			67.43				756.388			
27	85	85.00	701.11	699.86	0.03	0.10	67.40	0.0025	0.0002	0.001	756.387	0.0000	56.53	0.02
27			701.11	699.86			67.40				756.387			
28	388	388.02	705.04	703.77	3.90	0.15	63.50	0.0000	0.0144	2.808	753.579	0.0072	49.81	0.82
26			701.13	699.83			67.43				756.388			
46	166	166.01	699.40	698.12	-1.71	0.17	69.15	0.0020	0.0180	1.006	755.382	0.0061	57.27	0.80
46			699.40	698.12			69.15				755.382			
32	330	330.01	696.64	695.36	-2.76	0.17	71.91	0.0040	0.0151	1.452	753.930	0.0044	58.57	0.67
32			696.64	695.36			71.91				753.930			
33	115	115.01	698.04	696.76	1.40	0.17	70.51	0.0024	0.0094	0.211	753.720	0.0018	56.96	0.42
33			698.04	696.76			70.51				753.720			
35	185	185.00	698.08	696.50	0.04	0.17	70.47	0.0150	0.0060	0.147	753.572	0.0008	56.78	0.27
27			701.11	699.86			67.40				756.387			
34	150	150.00	701.84	700.57	0.71	0.15	66.70	0.0013	0.0107	0.747	755.640	0.0042	55.07	0.61
34			701.84	700.57			66.70				755.640			
45	355	355.00	701.07	699.80	-0.77	0.15	67.47	0.0013	0.0059	1.052	754.588	0.0030	54.79	0.50
Wester S.R.*				755.00							755.000			
A			700.00	698.60	-56.40	0.40	56.40	0.0108	0.0750		744.100		45.50	
A			700.00	698.60							744.100			
B	3030	3030.00	702.85	701.45	2.85	0.40	53.55	0.0628	0.0642	2.916	741.184	0.0010	39.73	0.51

(Source: DAWSSA & JICA) *Western S.R improvement exludes from the porosed project.

Table B-7.6 (1/2) Summary of Flow Network Analysis (Proposed: Alternative 1)

Node No	Length (m)	Actual length (m)	EL of ground (m)	EL at center of pipe (m)	Height (m)	Diameter (m)	Static head (m)	Discharge (m3/sec)	Flow rate (m3/sec)	Head loss (m)	EL of Effective Head (m)	Hydraulic gradient	Effective head (m)	Velocity (m/sec)
Wali			796.00	796.00							796.000			
N508			714.90	713.30	-82.70	0.80	82.70		0.3574	21.700	763.300	0.0008	50.00	0.71
N508			714.90	713.30							763.300			
N508-1	550	550.00	715.17	713.67	0.37	0.60	82.33	0.1982	0.2488	0.900	762.400	0.0016	48.73	0.88
N508-1			715.17	713.97							762.400			
1	250	250.00	713.80	712.49	-1.48	0.23	83.51		0.0506	2.551	759.849	0.0102	47.36	1.27
1			713.80	712.55			83.45				759.849			
2	200	200.01	711.72	710.42	-2.13	0.20	85.58	0.0009	0.0284	1.249	758.600	0.0062	48.18	0.91
1			713.80	712.55			83.45				759.849			
10	125	125.02	711.70	710.40	-2.15	0.20	85.60	0.0015	0.0221	0.491	759.358	0.0039	48.96	0.71
10			711.70	710.40			85.60				759.358			
16	205	205.00	710.36	709.11	-1.29	0.10	86.89	0.0030	0.0045	1.227	758.131	0.0060	49.02	0.57
16			710.36	709.11			86.89				758.131			
20	170	170.00	710.00	708.75	-0.36	0.10	87.25	0.0033	0.0015	0.138	757.993	0.0008	49.24	0.19
10			711.70	710.40							759.358			
11	180	180.01	710.01	708.74	-1.67	0.15	87.27	0.0021	0.0155	1.487	757.871	0.0083	49.14	0.88
11			710.01	708.74			87.27				757.871			
12	260	260.01	708.01	706.74	-2.00	0.15	89.27	0.0028	0.0125	1.445	756.426	0.0056	49.69	0.71
12			708.01	706.74			89.27				756.426			
14	215	215.00	706.63	705.36	-1.38	0.15	90.65	0.0027	0.0085	0.588	755.839	0.0027	50.48	0.45
14			706.63	705.38			90.62				755.839			
13	205	205.01	709.85	707.60	2.22	0.10	88.40	0.0019	0.0033	0.711	755.128	0.0035	47.53	0.43
13			708.85	707.60			88.40				755.128			
21	95	95.00	709.08	707.83	0.23	0.10	88.17	0.0004	0.0060	0.988	754.140	0.0104	46.31	0.77
14			706.63	705.38							755.839			
24	340	340.00	705.24	703.97	-1.41	0.15	92.04	0.0032	0.0080	0.829	755.009	0.0024	51.04	0.45
N508			714.90	713.30							763.300			
N508-3	250	250.01	712.20	710.75	-2.55	0.50	85.25	0.0545	0.1087	0.215	763.085	0.0009	52.34	0.55
N508 3			712.20	711.00							763.085			
3	30	30.01	712.90	711.55	0.55	0.30	84.45	0.0000	0.0542	0.086	763.000	0.0029	51.45	0.77
3			712.90	703.97							763.000			
15	120	120.19	712.00	710.75	6.78	0.10	85.25	0.0021	0.0043	0.667	762.333	0.0055	51.58	0.55
15			712.00	710.75							762.333			
16	400	400.00	710.36	709.11	-1.64	0.10	86.89	0.0030	0.0013	0.246	762.086	0.0006	52.98	0.17
3			712.90	711.55			84.45				763.000			
17	105	105.03	710.50	709.15	-2.40	0.30	86.85	0.0033	0.0498	0.257	762.743	0.0024	53.59	0.71
17			710.50	709.15			86.85				762.743			
20	200	200.00	710.09	708.77	-0.38	0.25	87.24	0.0033	0.0401	0.793	761.950	0.0040	53.18	0.82
20			710.09	708.84			87.16				761.950			
19	220	220.00	709.07	707.82	-1.02	0.10	88.18	0.0053	0.0039	1.011	760.939	0.0046	53.12	0.50
19			709.07	707.82			88.18				760.939			
18	200	200.00	709.64	708.39	0.57	0.10	87.61	0.0053	0.0013	0.124	760.815	0.0006	52.43	0.17
18			709.64	708.39			87.61				760.815			
17	225	225.00	710.50	709.25	0.86	0.10	86.75	0.0053	0.0051	1.703	759.112	0.0076	49.86	0.65
20			710.09	708.77			87.24				761.950			
21	165	165.00	709.08	707.76	-1.01	0.25	88.25	0.0004	0.0330	0.457	761.493	0.0028	53.74	0.67
21			709.08	707.76			88.25				761.493			
22	215	215.01	707.24	705.94	-1.81	0.20	90.06	0.0170	0.0261	1.166	760.326	0.0054	54.39	0.81
22			707.24	705.94			90.06				760.326			
23	105	105.00	707.24	705.97	0.02	0.15	90.04	0.0049	0.0121	0.549	759.778	0.0052	53.81	0.69
23			707.24	705.97			90.04				759.778			
37	195	195.02	704.56	703.29	-2.68	0.15	92.72	0.0049	0.0086	0.544	759.234	0.0028	55.95	0.49
37			704.56	703.29			92.72				759.234			
24	340	340.00	705.24	703.99	0.71	0.10	92.01	0.0032	0.0001	0.004	759.230	0.0000	55.24	0.02
24			705.24	703.99			92.01				759.230			
8	340	340.01	708.01	706.71	2.72	0.20	89.29	0.0073	0.0014	0.008	759.222	0.0000	52.51	0.04
N508-1			715.17	713.67							762.400			
N508-2	150	150.00	715.00	713.50	-0.17	0.60	82.50	0.0545	0.1932	0.161	762.239	0.0011	48.74	0.70
N508-2			715.00	713.80			82.50				762.239			
2	250	250.00	713.80	712.35	-1.45	0.50	83.65	0.0009	0.1437	0.360	761.878	0.0014	49.53	0.73
2			713.80	712.35			83.65				761.878			
4	150	150.02	711.15	709.70	-2.65	0.50	86.30	0.0032	0.1654	0.280	761.598	0.0019	51.90	0.84
4			711.15	709.70			86.30				761.598			
5	470	470.01	708.01	706.71	-2.99	0.20	89.29	0.0073	0.0288	3.009	758.589	0.0064	51.88	0.92
5			708.01	706.71			89.29				758.589			
9	700	700.02	703.07	701.77	-4.94	0.20	94.23	0.0031	0.0171	1.697	756.892	0.0024	55.12	0.54
9			703.07	701.77			94.23				756.892			
38	80	80.01	702.00	700.70	-1.07	0.20	95.30	0.0007	0.0156	0.165	756.727	0.0021	56.03	0.50
38			702.00	700.73			95.28				756.727			
39	270	270.00	703.61	702.34	1.61	0.15	93.67	0.0007	0.0072	0.545	756.182	0.0020	53.85	0.41
39			703.61	702.34			93.67				756.182			
40	95	95.00	704.00	702.73	0.39	0.15	93.28	0.0007	0.0082	0.244	755.939	0.0026	53.21	0.47
40			704.00	702.73			93.28				755.939			
41	700	700.00	705.76	704.49	1.76	0.15	91.52	0.0049	0.0092	2.216	753.722	0.0032	49.24	0.52
4			711.15	709.70			86.30				761.598			
5.1	425	425.00	711.25	709.80	0.10	0.50	86.20	0.0042	0.1320	0.523	761.075	0.0012	51.27	0.67
5.1			711.25	709.80			86.20				761.075			
7	505	505.02	706.24	704.94	-4.86	0.20	91.06	0.0049	0.0168	1.192	759.883	0.0024	54.94	0.54
7			710.00	708.60			87.40				759.883			
41	220	220.04	705.76	704.49	-4.12	0.15	91.52	0.0049	0.0098	0.781	759.102	0.0035	54.62	0.56
41			710.00	708.60			87.40				759.102			
42	195	195.04	705.76	704.49	-4.12	0.15	91.52	0.0058	0.0061	0.312	758.789	0.0016	54.30	0.36

Table B-7.6 (2/2) Summary of Flow Network Analysis (Proposed: Alternative 1)

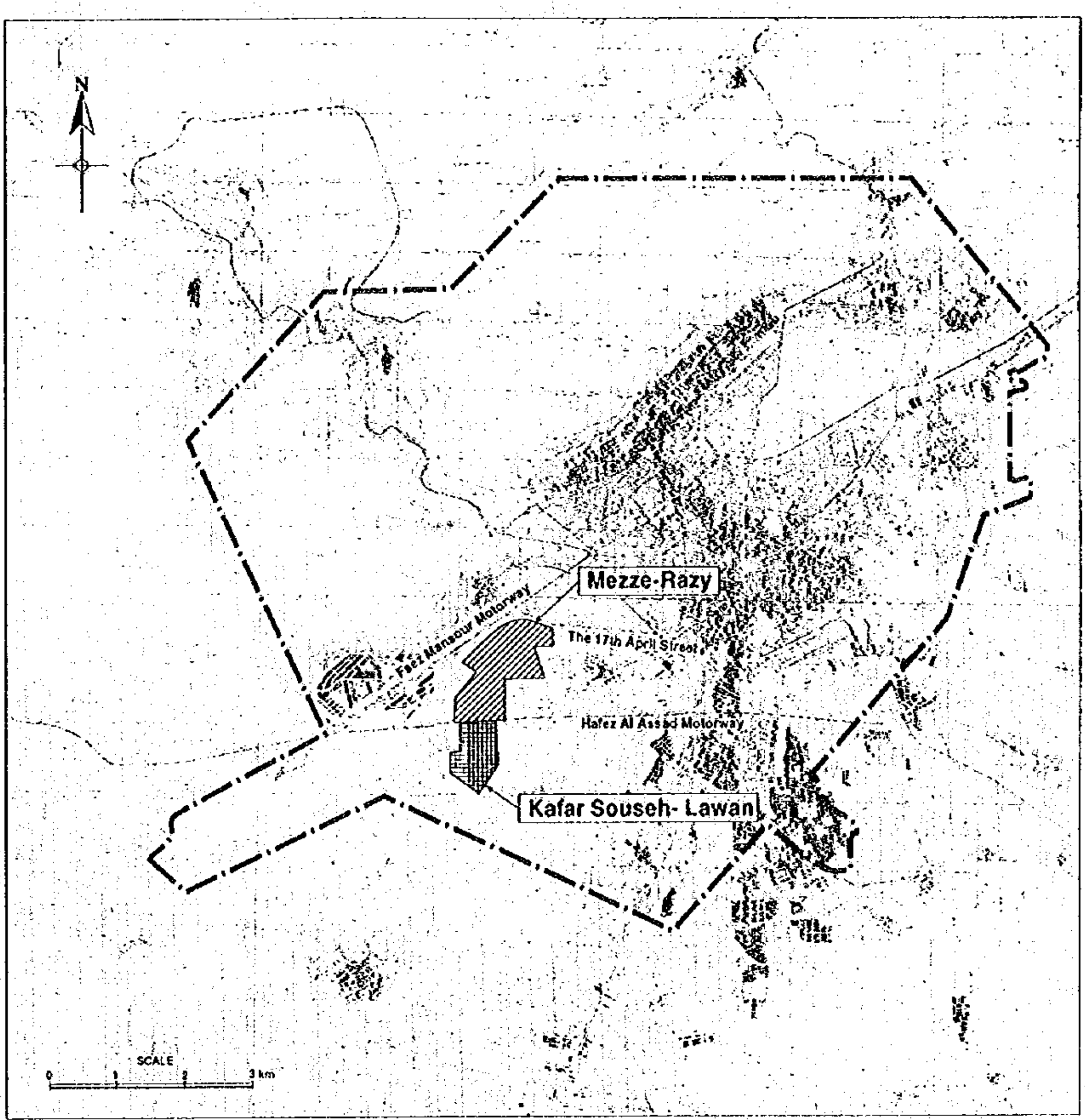
Node No	Length (m)	Actual length (m)	EL of ground (m)	EL at center of pipe (m)	Height (m)	Diameter (m)	Static head (m)	Discharge (m3/sec)	Flow rate (m3/sec)	Head loss (m)	EL of Effective Head (m)	Hydraulic gradient	Effective head (m)	Velocity (m/sec)
5.1			711.25	709.80			86.20				761.075			
5.2	433	433.00	710.00	708.60	-1.20	0.40	87.40	0.0058	0.1092	1.113	759.961	0.0026	51.36	0.87
5.2			710.00	708.60			87.40				759.961			
42	245	245.00	710.00	708.60	0.00	0.40	87.40	0.0058	0.1010	0.545	759.416	0.0022	50.82	0.80
42			710.00	708.60			87.40				759.416			
6	390	390.02	706.41	705.01	-3.59	0.40	90.99	0.0070	0.0864	0.650	758.765	0.0017	53.76	0.69
6			706.41	705.01			90.99				758.766			
25	165	165.00	706.11	704.71	-0.30	0.40	91.29	0.0047	0.0764	0.219	758.547	0.0013	53.84	0.61
25			706.11	704.71			91.29				758.547			
28	230	230.00	705.04	703.69	-1.02	0.30	92.31	0.0000	0.0697	1.047	757.499	0.0046	53.81	0.99
28			705.04	703.69			92.31				757.499			
29	95	95.00	704.06	702.81	-0.88	0.10	93.19	0.0000	0.0057	0.876	756.623	0.0092	53.81	0.72
29			704.06	702.81			93.19				756.623			
30	80	80.00	704.23	702.98	0.17	0.10	93.02	0.0007	0.0057	0.738	755.886	0.0092	52.91	0.72
30			704.23	702.98			93.02				755.886			
31	78	78.00	704.16	702.91	-0.07	0.10	93.09	0.0007	0.0046	0.495	755.390	0.0064	52.48	0.59
31			704.16	702.91			93.09				755.390			
44	128	128.00	704.53	703.28	0.37	0.10	92.72	0.0007	0.0036	0.510	754.881	0.0040	51.60	0.46
28			705.04	703.69			92.31				757.499			
53	120	120.01	706.80	705.48	1.78	0.25	90.53	0.0137	0.0497	0.709	756.791	0.0059	51.32	1.01
53			706.80	705.48			90.53				756.791			
54	275	275.00	706.20	704.88	-0.60	0.25	91.13	0.0007	0.0399	1.083	755.708	0.0039	50.83	0.81
54			706.20	704.88			91.13				755.708			
44	125	125.01	704.53	703.23	-1.64	0.20	92.77	0.0007	0.0291	0.814	754.893	0.0065	51.66	0.93
44			704.53	703.23			92.77				754.893			
45	223	223.03	701.07	699.77	-3.46	0.20	96.23	0.0013	0.0317	1.698	753.195	0.0076	53.42	1.01
45			701.07	699.77			96.23				753.195			
36	86	86.01	699.70	698.38	-1.40	0.25	97.63	0.0162	0.0380	0.310	752.885	0.0036	54.51	0.77
36			699.70	698.38			97.63				752.885			
35	190	190.01	698.08	696.80	-1.58	0.17	99.20	0.0150	0.0149	0.817	752.069	0.0043	55.27	0.67
38			702.00	700.73			95.28				756.727			
43	203	203.01	703.59	702.29	1.57	0.20	93.71	0.0019	0.0219	0.780	755.947	0.0038	53.66	0.70
43			703.59	702.29			93.71				755.947			
48	560	560.01	700.38	699.08	-3.21	0.20	96.92	0.0019	0.0192	1.686	754.262	0.0030	55.18	0.61
48			700.38	699.08			96.92				754.262			
26	110	110.00	701.13	699.83	0.75	0.20	96.17	0.0011	0.0165	0.250	754.012	0.0023	54.18	0.52
26			701.13	699.83			96.17				754.012			
27	85	85.00	701.11	699.86	0.03	0.10	96.14	0.0025	0.0010	0.029	753.983	0.0003	54.12	0.12
27			701.11	699.86			96.14				753.983			
28	388	388.02	705.04	703.77	3.90	0.15	92.24	0.0000	0.0144	2.796	751.187	0.0072	47.42	0.82
26			701.13	699.83			96.17				754.012			
46	166	166.01	699.40	698.12	-1.71	0.17	97.88	0.0020	0.0174	0.951	753.061	0.0057	54.95	0.78
46			699.40	698.12			97.88				753.061			
32	330	330.01	696.64	695.36	-2.76	0.17	100.64	0.0040	0.0146	1.358	751.703	0.0041	56.35	0.65
32			696.64	695.36			100.64				751.703			
33	115	115.01	698.04	696.76	1.40	0.17	99.24	0.0024	[illegible]	[illegible]	751.514	[illegible]	54.76	0.40
33			698.04	696.76			99.24				751.514			
35	185	185.00	698.08	[illegible]	[illegible]	0.17	[illegible]	0.0150	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27			701.11	[illegible]			[illegible]				[illegible]			
34	150	150.00	701.84	[illegible]	[illegible]	0.15	95.43	0.0013	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
34			701.84	700.57			95.43				[illegible]			
45	355	355.00	701.07	699.80	-0.77	0.15	96.20	0.0013	[illegible]	[illegible]	752.452	0.0025	52.66	0.46

(Source: DAWSSA & JICA)

Table B-8.1 Distribution Facilities for Mezze-Razy & Kafar Souseh-Lawan Area

Items	Description	Unit	Quantity	Remarks
1. Distribution Pipeline				
Ductile iron pipe	ND600 mm, push-on joint	m	700	from N508 branch point
"	ND500 mm, "	m	1,200	
"	ND400 mm, "	m	1,400	
"	ND300 mm, "	m	400	
"	ND250 mm, "	m	1,000	
"	ND200 mm, "	m	4,500	
"	ND150 mm, "	m	4,700	
"	ND100 mm, "	m	1,700	
Polyethylene pipe	ND 65 mm,	m	4,600	
"	ND 50 mm,	m	16,100	
Total Length		m	36,300	
2. Valve and Fire-hydrant				
Butterfly valve	ND600 mm, flange joint	nr	1	
"	ND500 mm, "	nr	1	
"	ND400 mm, "	nr	2	
Gate valve	ND300 mm, "	nr	2	
"	ND250 mm, "	nr	2	
"	ND200 mm, "	nr	12	
"	ND150 mm, "	nr	8	
"	ND100 mm, "	nr	7	
"	ND 80 mm, "	nr	50	
"	ND 50 mm, "	nr	196	
Fire-hydrants	ND100 mm, underground type	nr	25	
3. Flow Meter				
Ultrasonic type flow meter	ND600 mm, including Sensor	nr	1	
Flow meter sensor	ND400 mm,	nr	1	
"	ND200 mm	nr	1	
4. Service Meter				
Water meter	ND 13 mm, multi-jet type	nr	5,400	

FIGURES

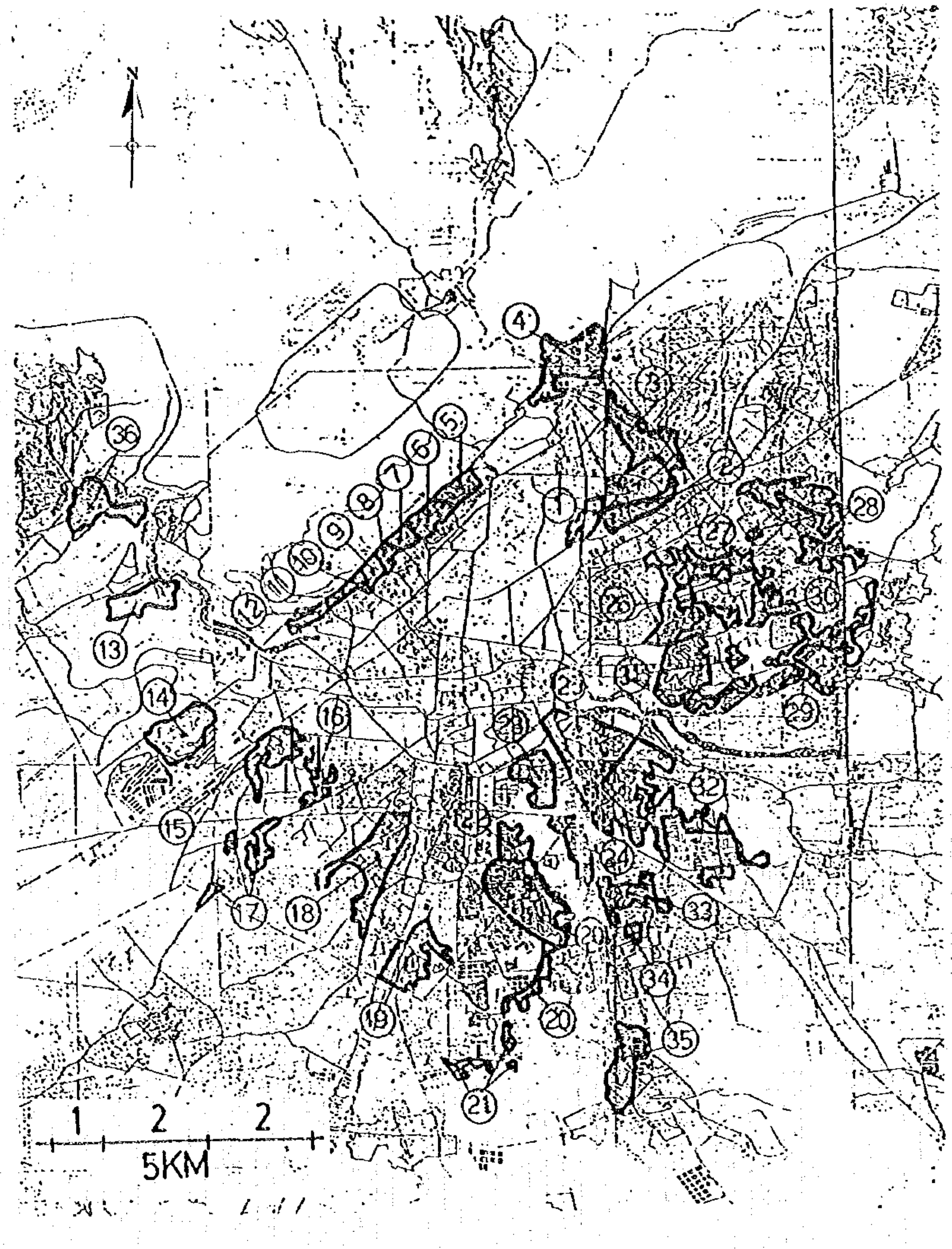


JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY

Figure B-2.1 Location Map

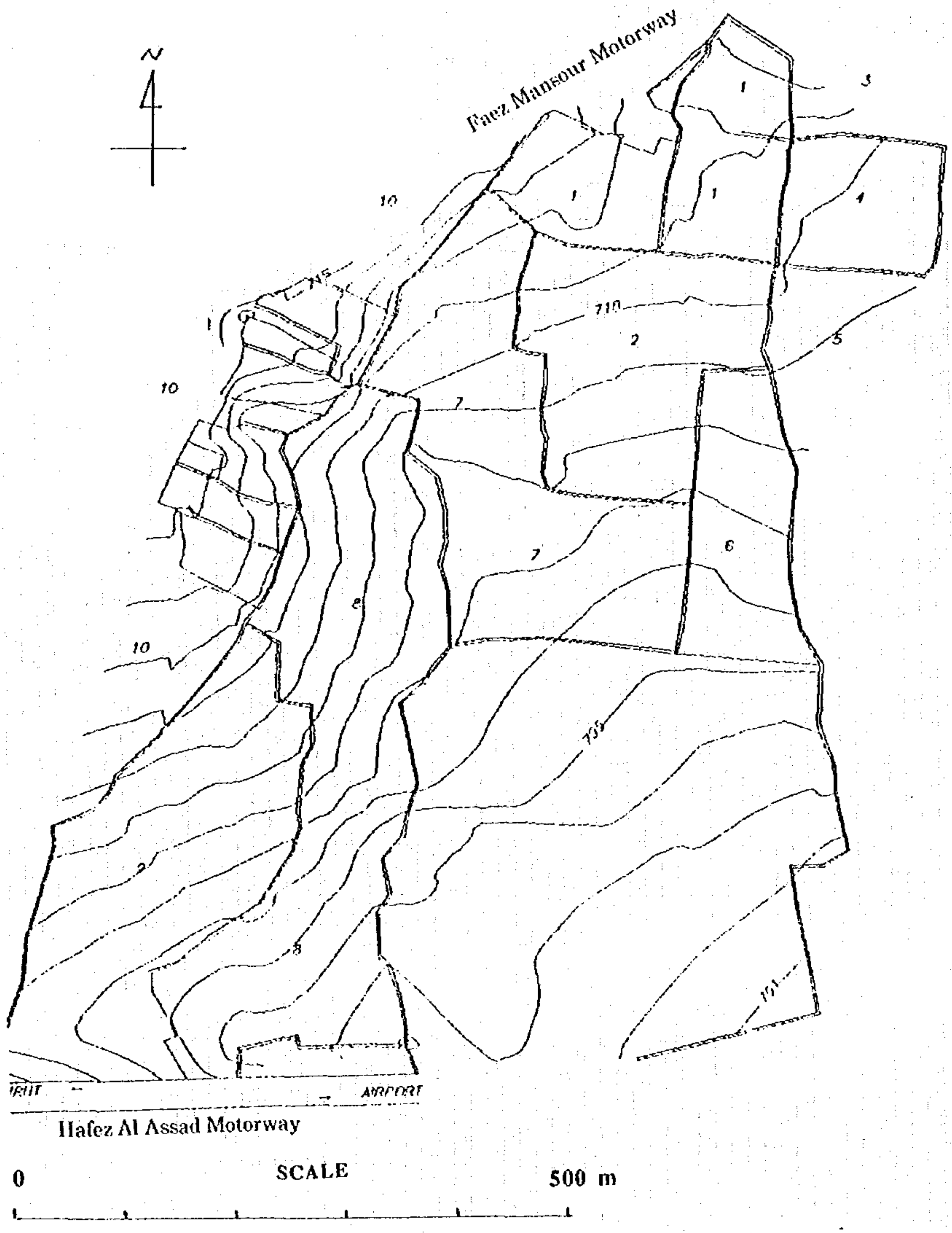
NIPPON KOEI CO., LTD.



Legend

1-36: Number of informal Zones (see Table B-2.1)

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY
Figure B-2.2 Loation of Informal Areas in The City
NIPPON KOEI CO., LTD.



Legend

1 – 10: Block Number

710: Elevation

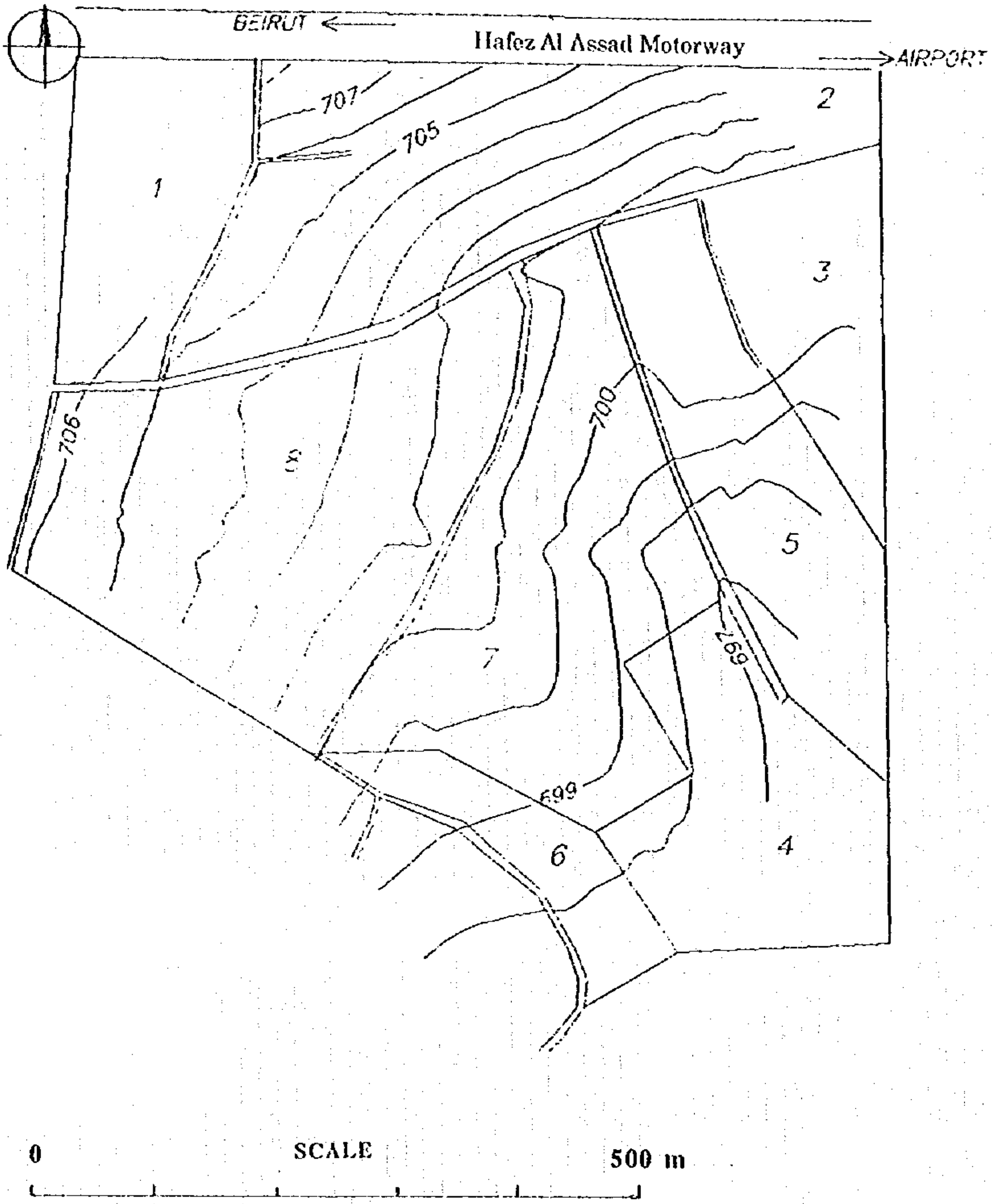
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY

Figure B-3.1

Topographic Map (Mezze-Razy)

NIPPON KOEI CO., LTD.



Legend

1 – 8: Block Number

705: Elevation

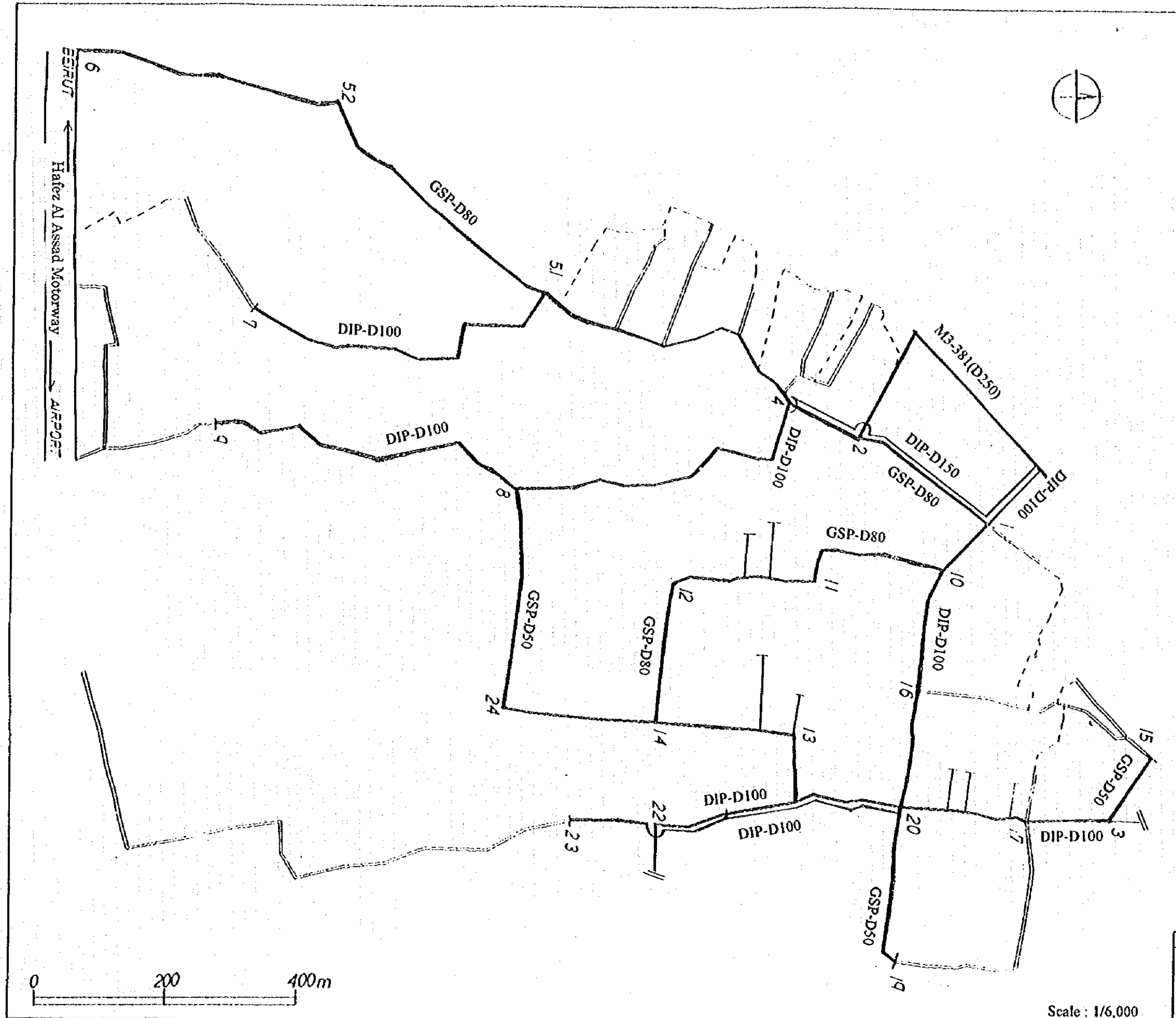
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY

Figure B-3.2

Topographic Map(Kafar Souseh-Lawan)

NIPPON KOEI CO., LTD.



Legend

1-23: Node Number

▬ : Water Main

DIP: Ductile Iron Pipe

GSP: Galvanized Steel Pipe

D100: Diameter of Pipe

M3-381: Name of Network Analyzed Point

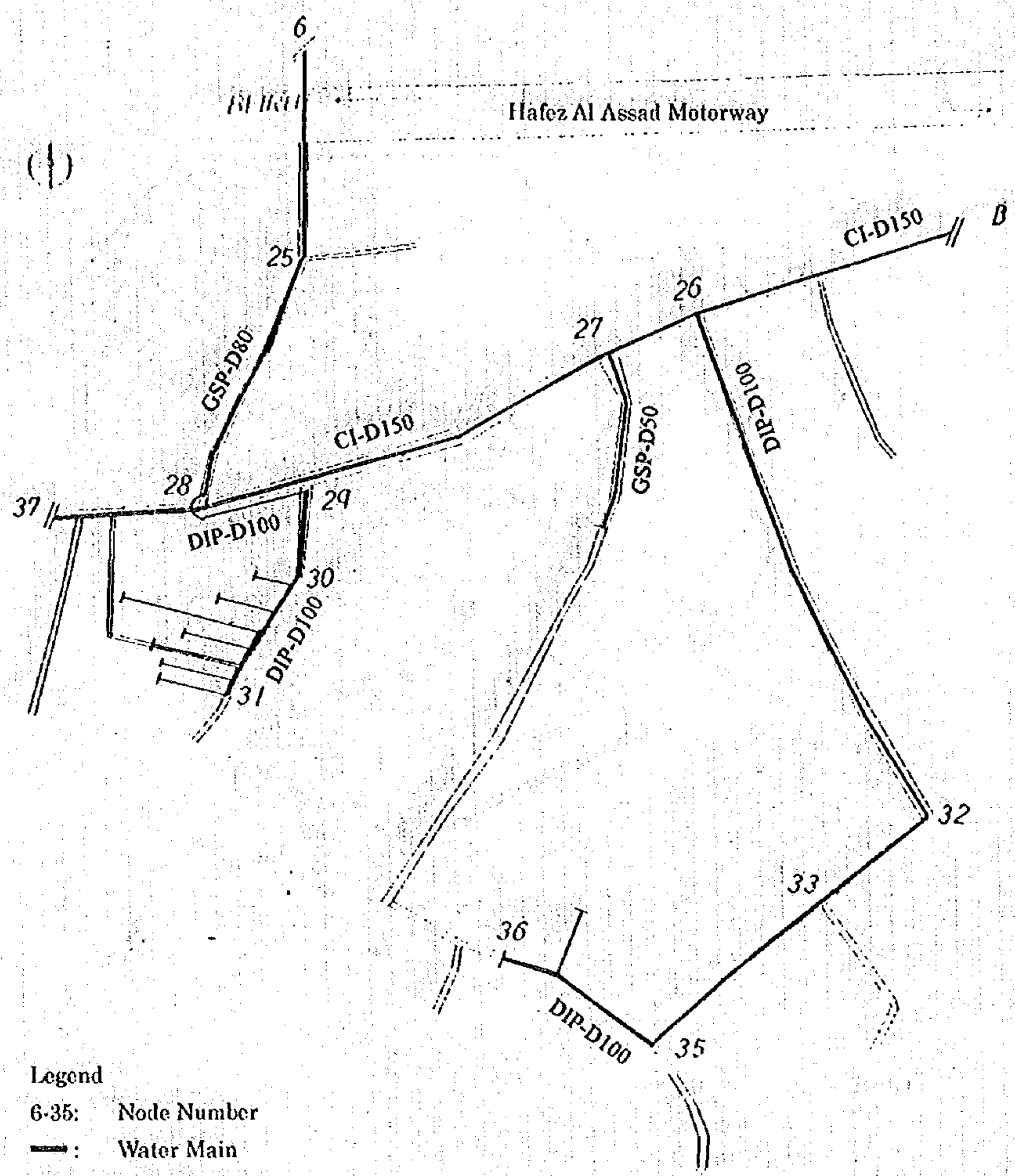
Scale : 1/6,000

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY

Figure B-3.3
Existing Water Supply (Mezze-Razzy)

NIPPON KOEI CO., LTD.



Legend

6-35:	Node Number
▬ :	Water Main
DIP:	Ductile Iron Pipe
GSP:	Galvanized Steel Pipe
CI:	Cast Iron Pipe
D100:	Diameter of Pipe

0 200 400m

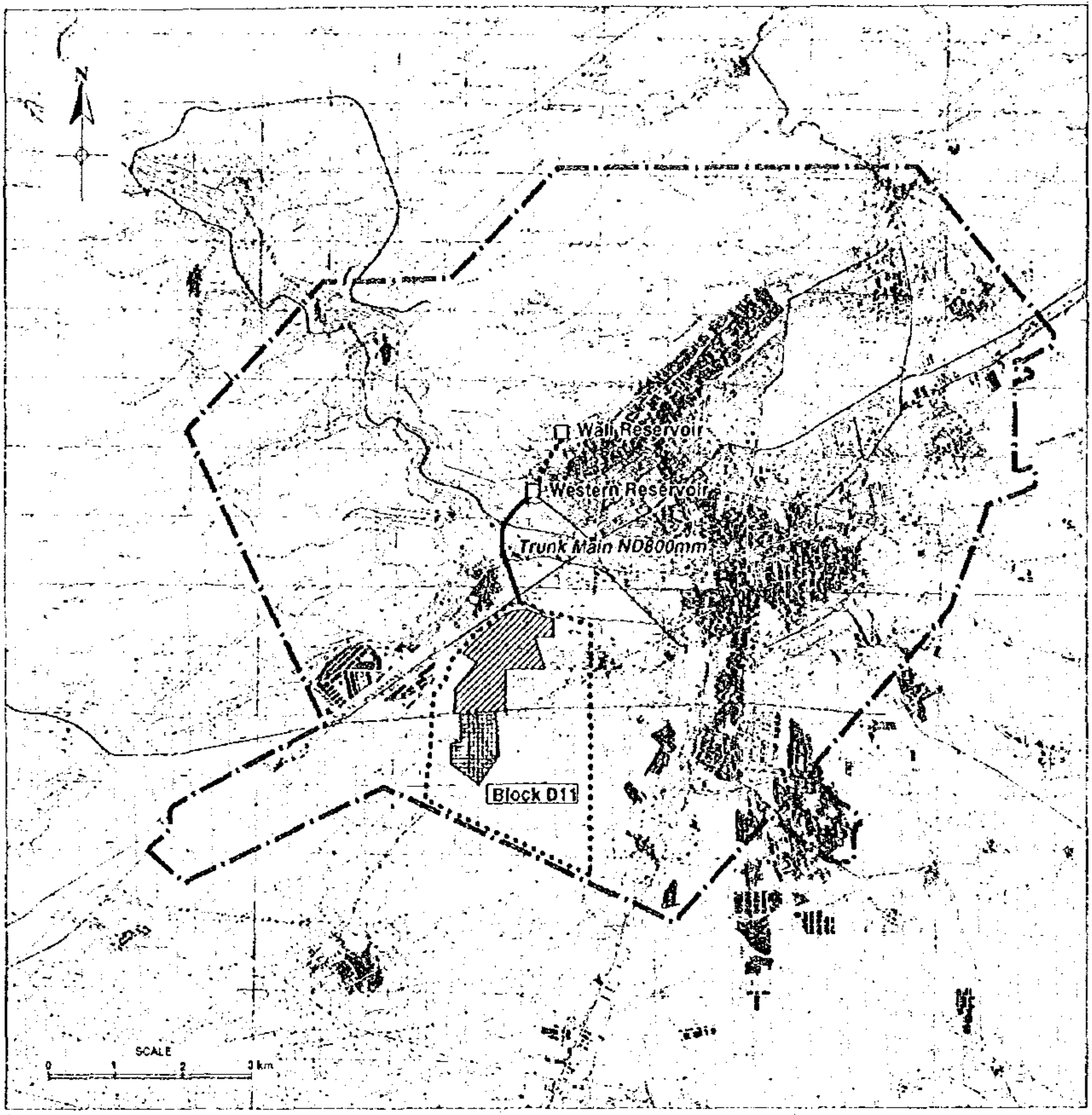
Scale : 1/6,000

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY

Figure B-3.4
Existing Water Supply (Kafar Souseh-Lawan)

NIPPON KOEI CO., LTD.



LEGEND

:Mezze-Razy Area

:Kafar Souseh-Lawan Area

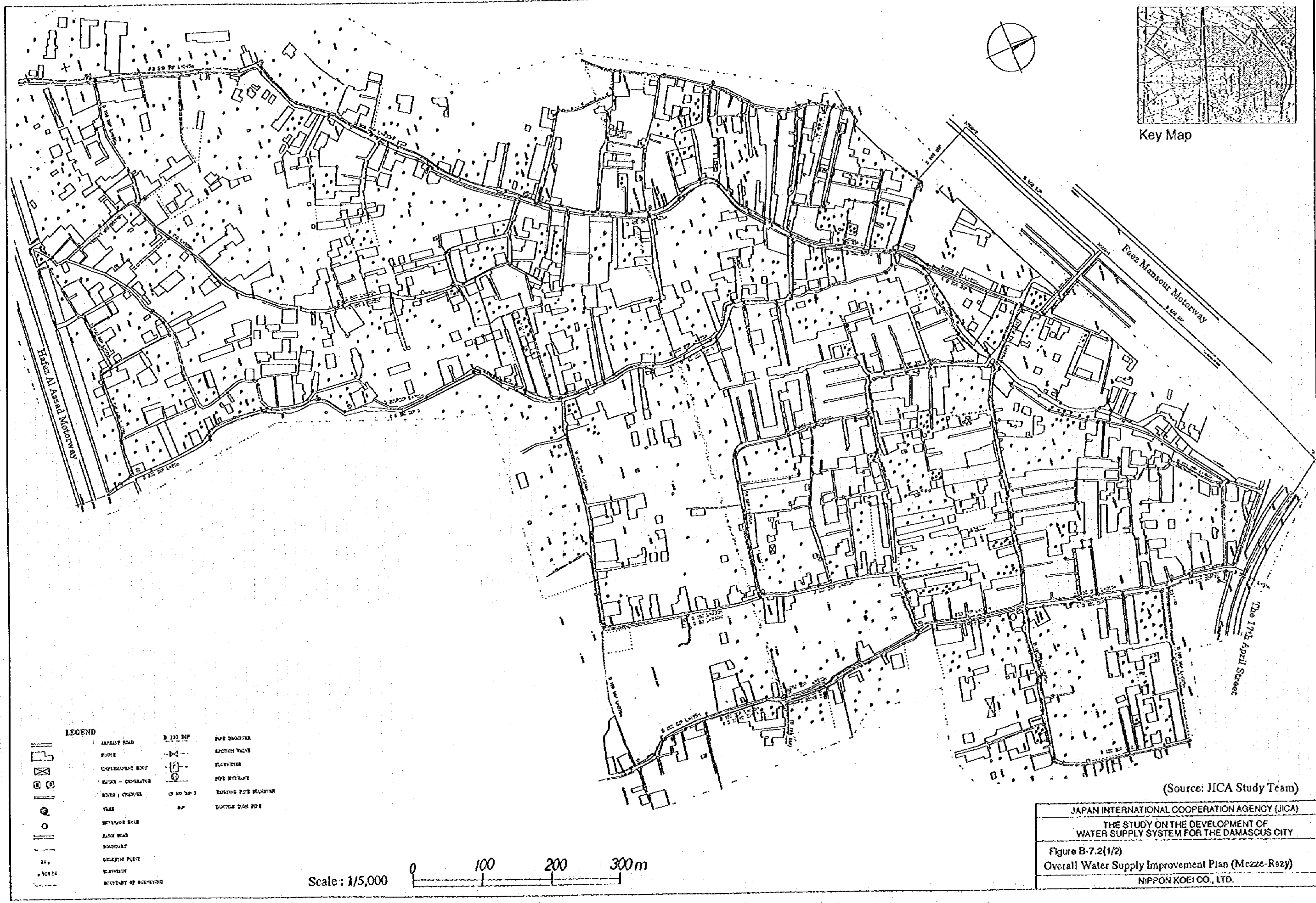
:Boundary of DMA Block D11

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY

Figure B-7.1 Trunk Main for Mezze-Razzy & Kafar Souseh-Lawan Area

NIPPON KOEI CO., LTD.



(Source: JICA Study Team)

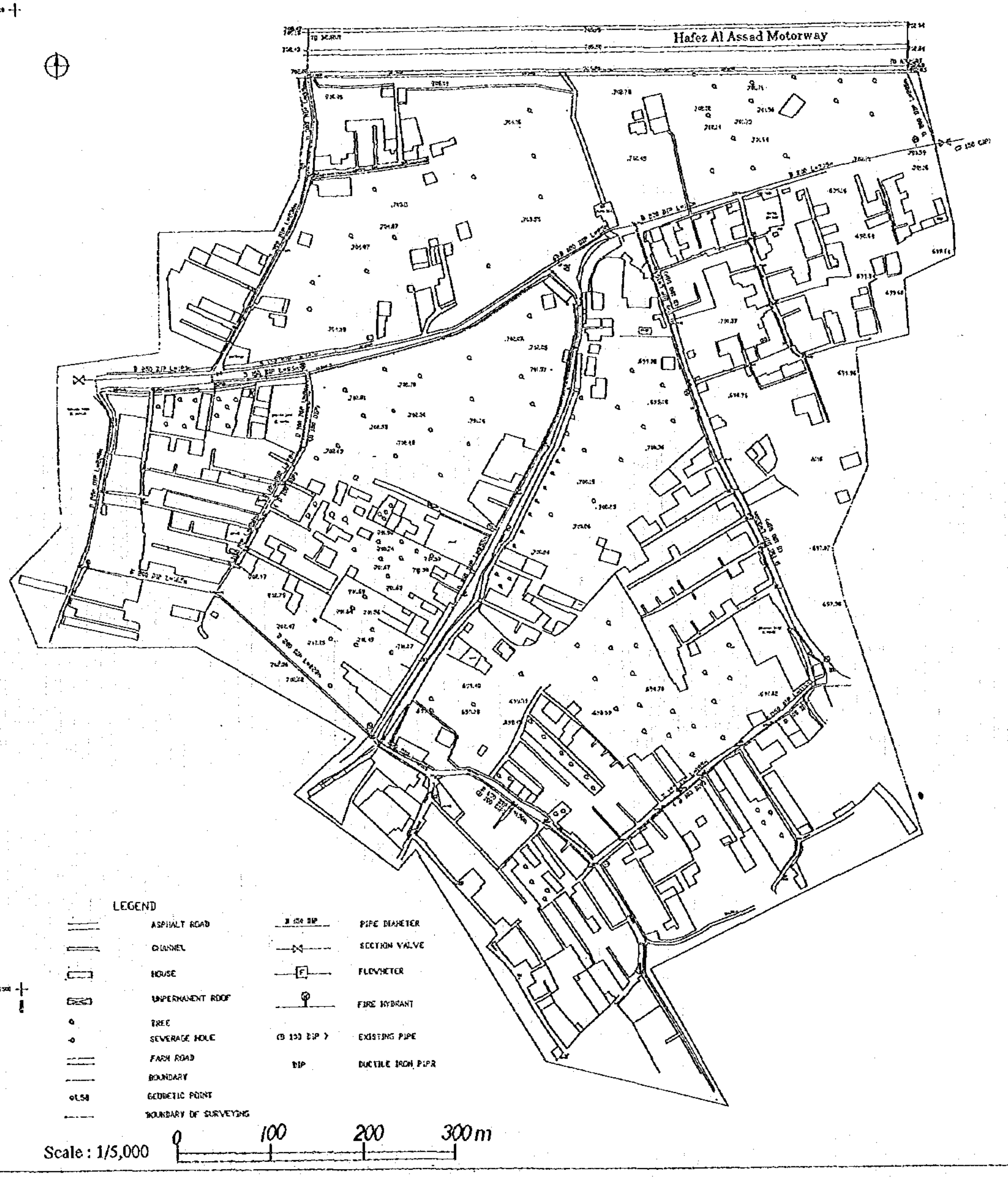
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

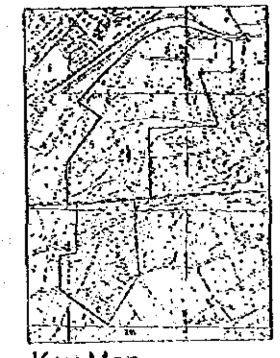
THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY

Figure B-7.2(1/2)

Overall Water Supply Improvement Plan (Mezze-Rezy)

NIPPON KOEI CO., LTD.





(Source: JICA Study Team)

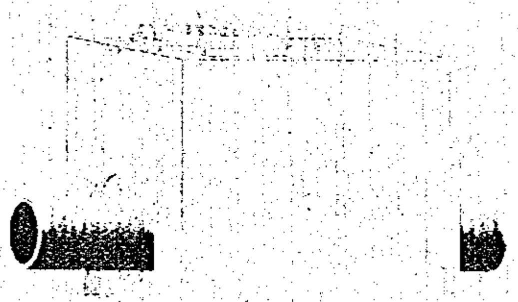
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY

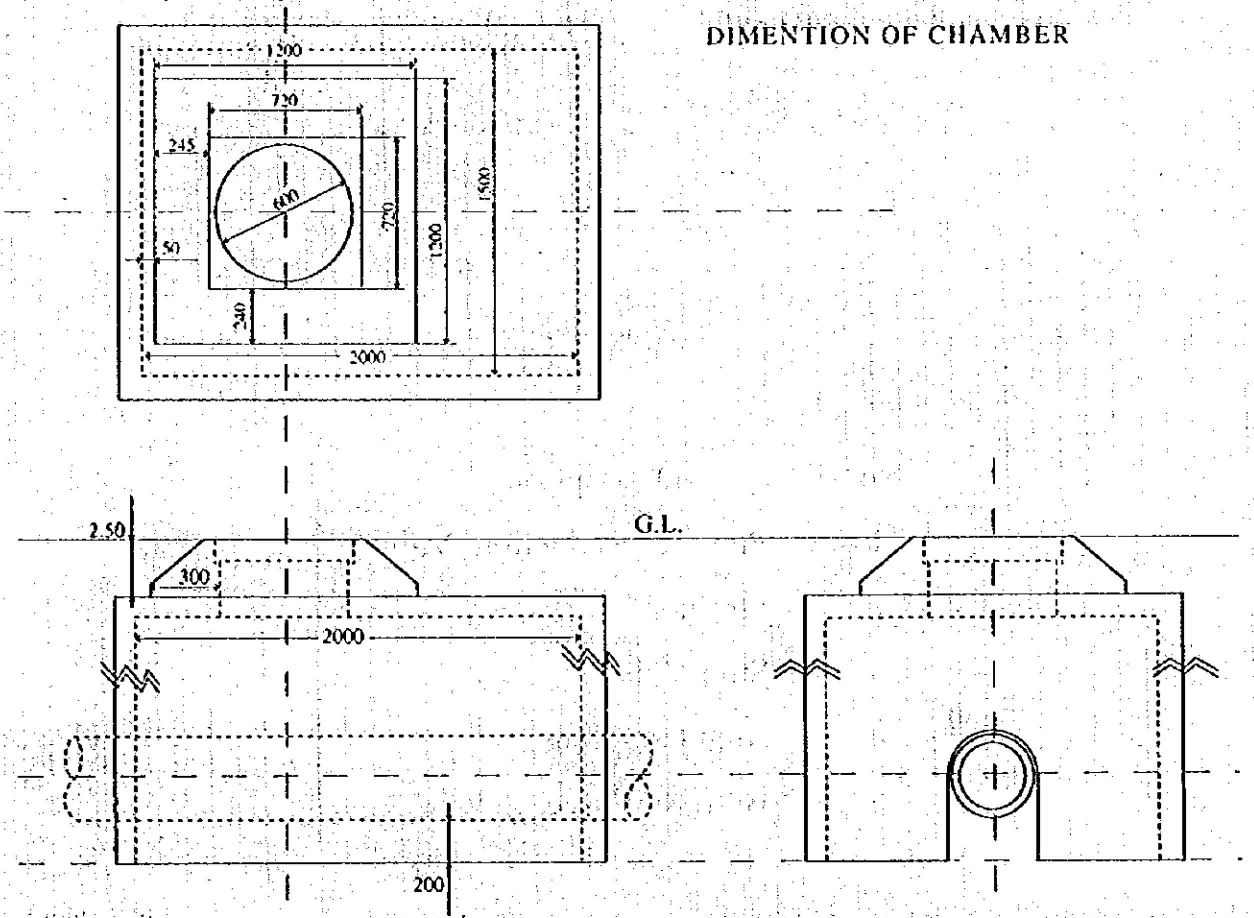
Figure B-7.2(2/2) Overall Water Supply Improvement Plan (Kafar Souseh-Lawan)

NIPPON KOEI CO., LTD.

Sketch of Chamber



DIMENTION OF CHAMBER



(Not in scale)

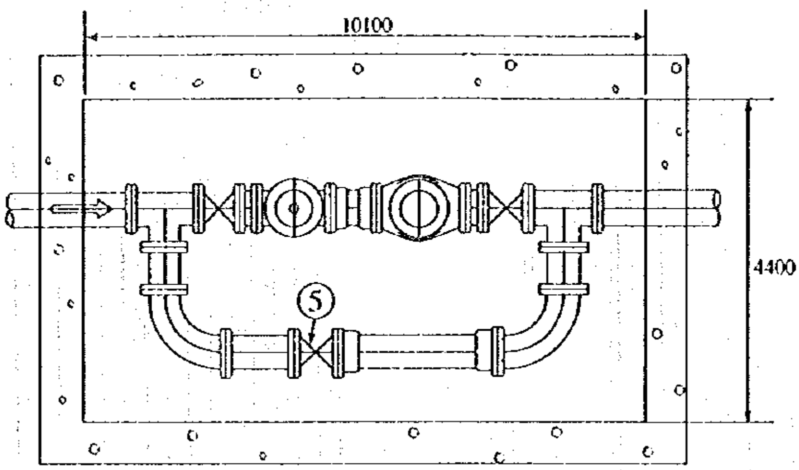
(unit : mm)

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

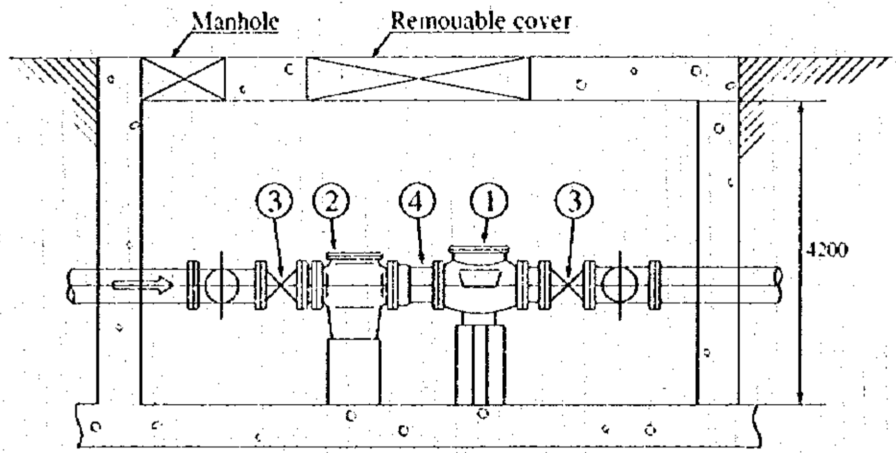
THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY

Figure B-8.1 Flow Meter Chamber

NIPPON KOEI CO., LTD.



Plane



Profile

No.	Description
1	Pressure Reduction Valve
2	Strainer
3	Stop Valve
4	Joint Coupling
5	By-pass Valve

(unit : mm)

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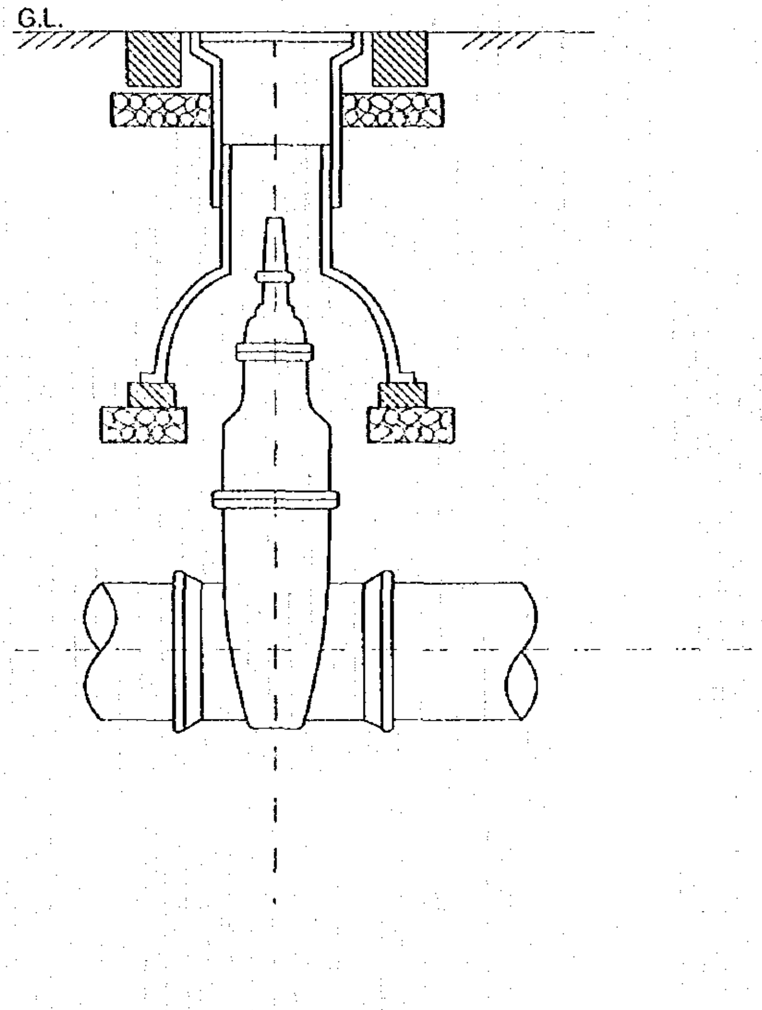
Figure B-8.2
Installation of Pressure Reduction Valve (ND800mm)

NIPPON KOEI CO., LTD

(Not in scale)



Note:Pipe diameter is below 350mm

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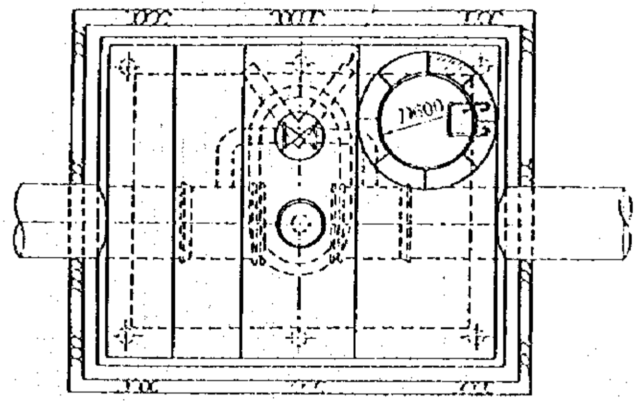
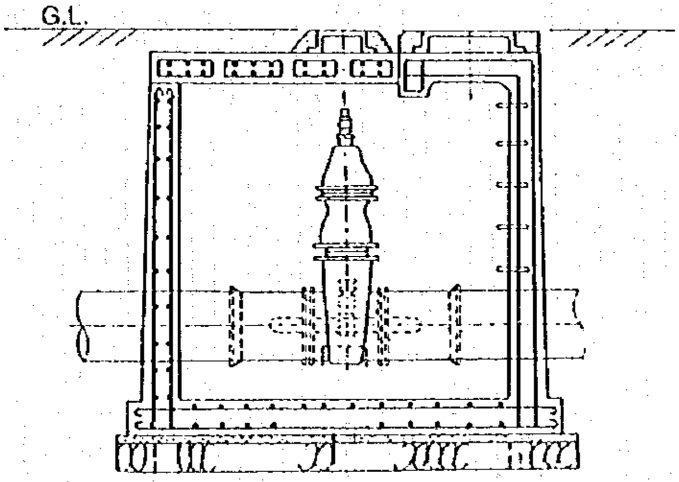
Figure B-8.3 Valve Installation(1)

NIPPON KOEI CO., LTD.

(Not in scale)





Note:Pipe diameter in below 350mm

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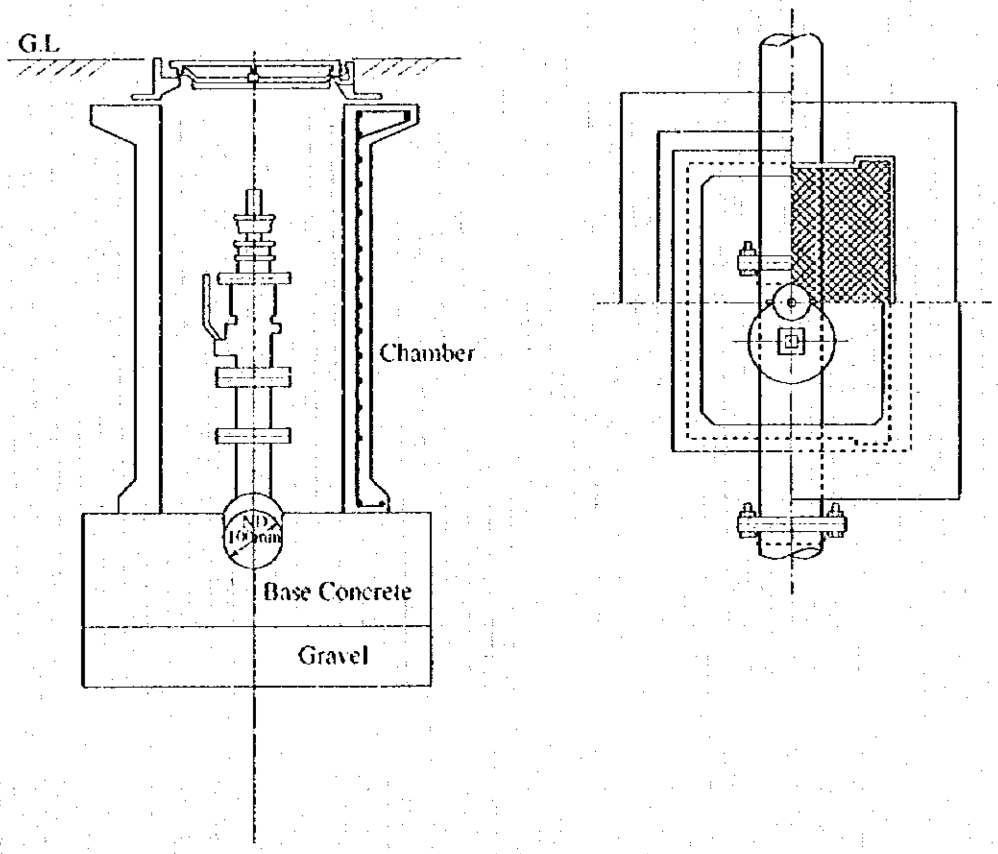
Figure B-8.4 Valve Installation(2)

(Not in scale)

NIPPON KOEI CO., LTD.



(Not in scale)

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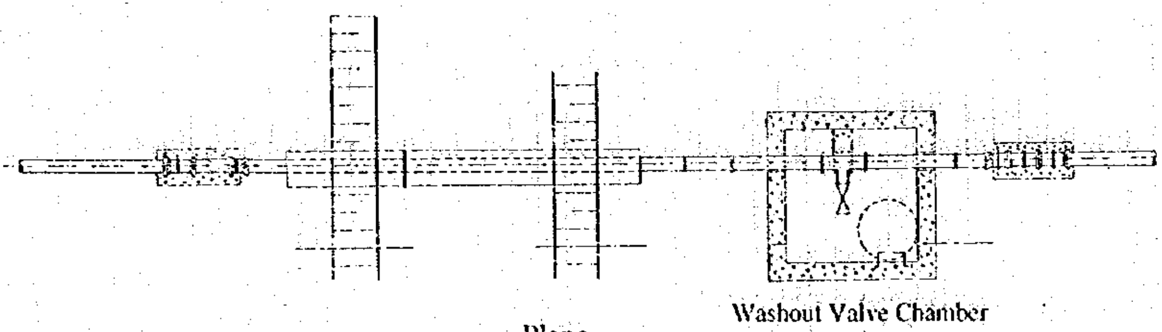
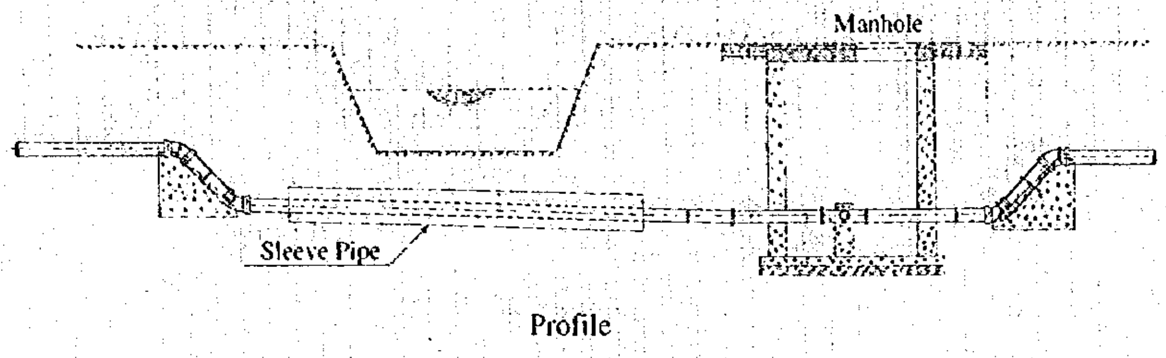
THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY

Figure B-8.5 Fire-hydrant Installation

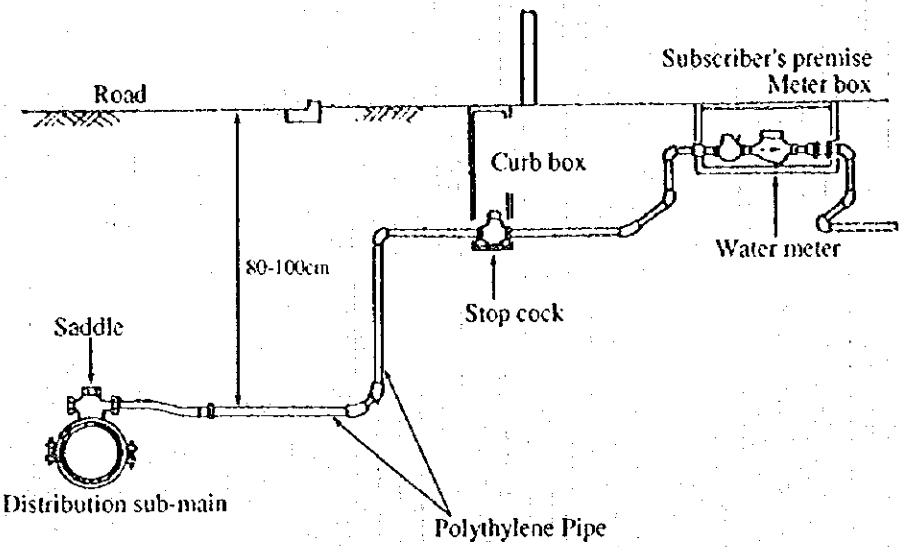
NIPPON KOEI CO., LTD.





(Not in scale)

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY
Figure B-8.6 Typical River Crossing
NIPPON KOEI CO., LTD.



DISTERIBUTION MAIN(Dia.mm)	SERVICE PIPE (Dia.inch)
250	2"
200	1 1/2"
150	1 1/4"
100	1" 3/4" 1/2"
80	1" 3/4" 1/2"
60	1" 3/4" 1/2"

(Not in scale)

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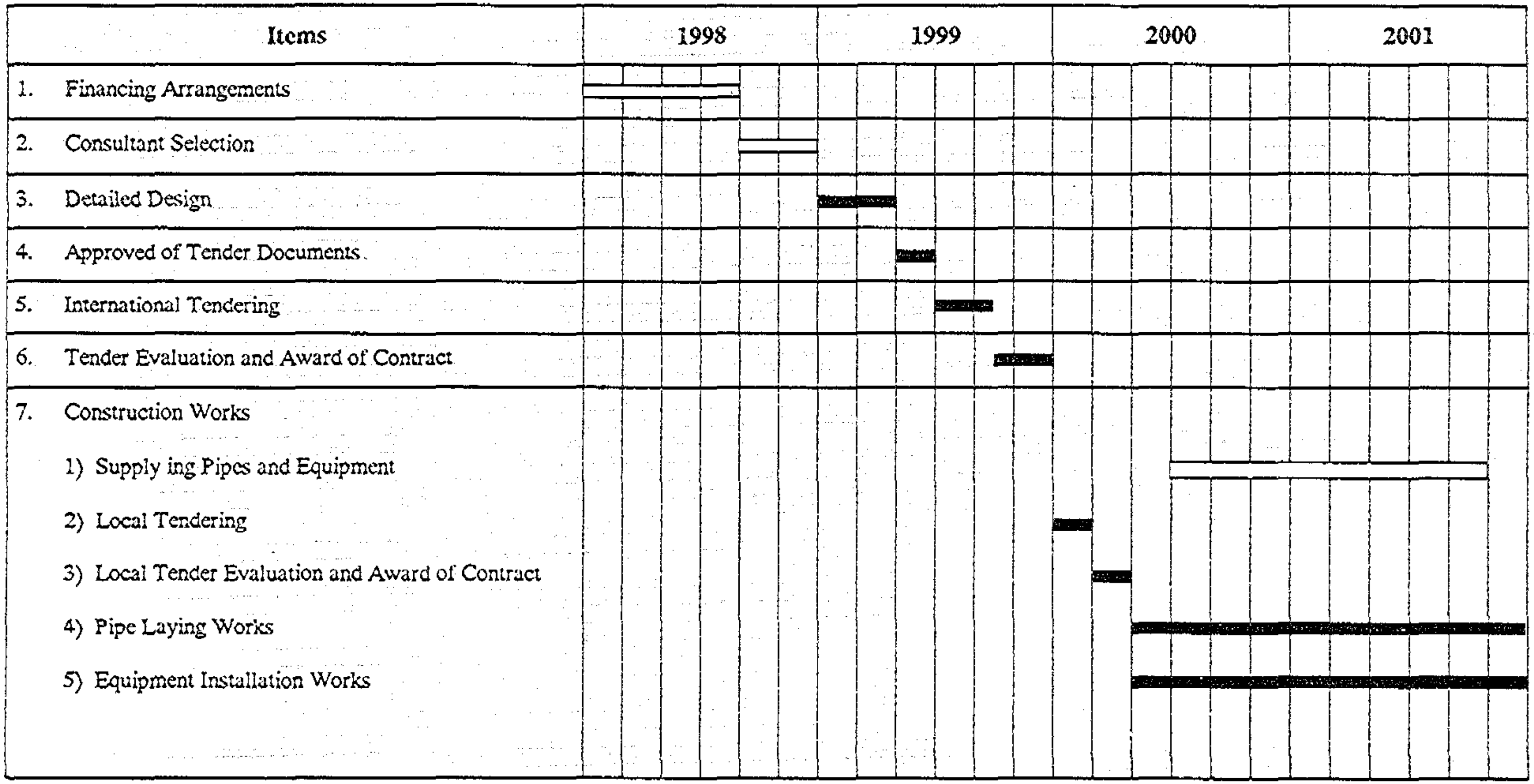
THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY

Figure B-8.7 Typical House Connection

NIPPON KOEI CO., LTD.

Fig.B-10.1 Implementation Schedule of Mezze Razy & Kafar Sousch - Lawan System



APPENDIX C

WATER QUALITY AND ENVIRONMENT

APPENDIX C
WATER QUALITY AND ENVIRONMENT

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1. INTRODUCTION

This Supporting Report (Appendix C) on water quality and environment makes a part of *The Study on the Development of Water Supply System for the Damascus City, Phase II (Feasibility Study)*. The objective of this report is to provide detailed description of the environmental studies conducted in Syria in May - August, 1997, which are summarized in the Main Report.

This report consists of the following 4 chapters:

Chapter 1 :	Introduction
Chapter 2 :	Water Quality Study
Chapter 3 :	Interview Survey in Mezze - Razy & Kafar Souseh - Lawan Area
Chapter 4 :	Environmental Impact Assessment

2. WATER QUALITY STUDY

2.1 Pesticide Analysis

In Phase-1, detailed water quality studies were carried out. The results showed that the overall quality of the water supplied by DAWSSA was good. However, the possibility of pesticide contamination (aldrin, dieldrin, heptachlor, and fenitrothion) at Oumawiyin wellfield could not be confirmed or rejected despite three sets of studies. The objective of this water quality study is thus to confirm this pesticide contamination problem at Oumawiyin well field.

2.1.1 Sampling

Three wells (#1, 4 and 13) in Oumawiyin wellfield were selected for investigation (Figure C-2.1) : these wells were selected because the contamination of these wells were suspected in the Phase-1 of the study (JICA/DAWSSA, 1997). In May, 1997 , wells in Oumawiyin wellfield were not being used because the water supply from Figeh spring in this time of the year was sufficient to meet the water demand, and thus there was no need to operate the city wells. To take representative water samples from the Oumawiyin aquifer, therefore, the pumps were operated for about 2 days prior to the sampling. The sampling was carried out on May 27, 1977 (Well #4 and 13), and on May 28, 1997 (Well #1). The samples were stored in amber glass-jars equipped with Teflon-lined caps to minimize sorption and degradation of pesticides.

2.1.2 Analysis

The analysis of pesticides (aldrin, dieldrin, heptachlor, fenitrothion, and carbofuran) was carried out at Institute of Environmental Toxicology (IET) in Japan (IET is the same institute as Residual Pesticide Research Institute, or RPRI). Pesticides in aqueous samples were extracted to dichloromethane phase. After a series of clean-up with florigil columns, the extractants were concentrated, dissolved in hexane, and analyzed with either GC equipped with ECD (electron-capture detector) or GC equipped with NPD (nitrogen/phosphorous specific detector). The detailed analytical method and the results are attached in the Databook. The detection limits and recoveries are as follows.

chemical	detection limit* (μg/L)	recovery (%)	method
aldrin	0.03	88	GC-ECD
dieldrin	0.03	94	GC-ECD
heptachlor	0.03	75	GC-ECD
fenitrothion	0.1	98	GC-NPD
carbofuran	0.1	92	GC-NPD

* : detection limits were set on the basis of Syrian / WHO drinking water standards.

An independent analysis of the same sample (cross-examination) was attempted at the Higher Institute of Applied Sciences and Technology (HIAST) in Damascus. The analytical methods are similar to the ones used at IET (see Databook). It was noted that an ECD, which is a selective detector for chlorinated compounds, was used at HIAST this time instead of less selective HPLC-UV method. The following pesticides were analyzed.

chemical	detection limit (μg/L)	recovery (%)	method
BHC	0.033	90	GC-ECD
lindane	0.008	-	GC-ECD
heptachlor	0.028	57	GC-ECD
aldrin	0.009	83	GC-ECD
endosulfan	0.014	96	GC-ECD
DDE	0.012	99	GC-ECD
dieldrin	0.010	98	GC-ECD
endrin	0.013	100	GC-ECD
TDE	0.023	100	GC-ECD
DDT	0.018	91	GC-ECD

2.1.3 Results

Tables below summarizes the results of pesticide analysis at IET and HIAST.

analysis at IET

pesticide	detection limit	Well #1	Well #4	Well #13
aldrin	0.03 ppb	N.D.	N.D.	N.D.
dieldrin	0.03 ppb	N.D.	N.D.	N.D.
heptachlor	0.03 ppb	N.D.	N.D.	N.D.
fenitrothion	0.1 ppb	N.D.	N.D.	N.D.
carbofuran	0.1 ppb	N.D.	N.D.	N.D.

N.D.: below detection limit

analysis at HIAST

chemical	detection limit	Well #1	Well #4	Well #13
BHC	0.033 ppb	N.D.	N.D.	N.D.
lindane	0.008 ppb	N.D.	N.D.	N.D.
heptachlor	0.028 ppb	N.D.	N.D.	N.D.
aldrin	0.009 ppb	N.D.	N.D.	N.D.
endosulfan	0.014 ppb	N.D.	N.D.	N.D.
DDE	0.012 ppb	N.D.	N.D.	N.D.
dieldrin	0.010 ppb	N.D.	N.D.	N.D.
endrin	0.013 ppb	N.D.	N.D.	N.D.
TDE	0.023 ppb	N.D.	N.D.	N.D.
DDT	0.018 ppb	N.D.	N.D.	N.D.

N.D.: below detection limit

No pesticide was found from any wells examined this time. Because two independent studies gave consistent results, the potential of pesticide pollution at Oumawiyin is low. Furthermore, as soon as the potential of pesticide pollution at Oumawiyin wellfield was discovered last year (1996), the administrator of Tishreen Park, where the Oumawiyin wellfield is located, was instructed not to use any pesticide. However, pesticides including illegal ones are widely used in Syria, and regular pesticide monitoring, which is not done at all due to the lack of local capacity to analyze pesticide, is urgently needed.

2.2 Suitability of Water Resources for Potable Water Supply

Based on the findings in the Mater Plan study (see Section 3.4 of the Main Report (Volume II) of Phase I) and the result of the water quality study conducted this time, the water qualities of existing and promising water resources are evaluated in the table below. The aspects of water quality that do not satisfy the Syrian or WHO drinking water standards are indicated by shaded area.

Groundwater

Area	Group	Aspect of Water Quality			
		Microbial Aspect[1]	Health Related Inorganics[2]	Health Related Organics[3]	Aesthetic Aspect[4]
Zabadani	Barada	good	good	good	excellent
	Zabadani	fair	fair - good	not known	fair - good
Figeh	Figeh Main	excellent	good - excellent	good - excellent	excellent
	Figeh Valley	fair	good	good	good
Hermon - Houran	Mountain	unknown	unknown	unknown	good - excellent
	Flat Land	unknown	unknown	unknown	good - excellent
Damascus	West High	good	good	unknown	not acceptable
	Oumawiyin	good	good	good[5]	good
Damascus	Kafar Sousch	good	good	unknown	good
	South	good - fair	fair - not acceptable	unknown	fair - not acceptable
	East	good	good	good	good

Surface Water

Area	Aspect of Water Quality			
	Microbial Aspect[1]	Health Related Inorganics[2]	Health Related Organics[3]	Aesthetic Aspect[4]
Barada Spring	good	good	good	excellent
Tekieh	fair	fair	not acceptable	good
Figeh	not acceptable	not known	not known	not acceptable
Damascus	not acceptable	not acceptable	not acceptable	not acceptable

Notes : 1) total bacteria/coliform counts.
2) heavy metals, nitrate/nitrite/ammonia.
3) pesticides.
4) temp., odor, color, pH, EC, hardness, major ions, turbidity.
5) based on the study conducted this time. not acceptable (shaded area): does not satisfy Syrian/WHO drinking water standard.

The overall quality of the water supplied by DAWSSA is high. This is mainly because nearly 80 % (1995) of the water supplied by DAWSSA is available from Figeh Main Spring; a major spring which has been recognized for its superb water quality and abundant yield for centuries. Indeed the water quality of Figeh Main Spring is one of the best in the area, and is characterized by low conductivity (around 300 μS/cm) and low hardness (around 150 mg as $CaCO_3$/L). The pH is around 7.7, and the total bacteria count is typically below 50 counts/100 mL.

With the recent increase in water demand, however, DAWSSA is being forced to use other water resources with less desirable water quality. There are numerous secondary water resources in the area. The water qualities of these water resources vary significantly from place to place. In general, the quality of water in the mountain areas (Zabadani, Figeh and Hermon areas) is satisfactory. For example, Barada well field, which provided approximately 7 % of the water used by DAWSSA last year, produces water with good quality. Other water resources in the mountain areas are smaller, but the water quality is comparable to Figeh Main Spring. The groundwater in Damascus is not as good as the water in the mountains, although the water from most city wells still meet the Syrian Drinking Water Standard. Typically the conductivity is around 700 - 1000 μS/cm, hardness is around 300 - 400 mg as $CaCO_3$/L, and the nitrate concentration is around 25 mg/L. The suspected pesticide problem at Oumawiyin wellfield (Master Plan Study) was rejected in this study.

Surface water in the study area is not a good resource for drinking water as it is heavily contaminated by sewage and industrial discharge. The lack of sewerage system seems to be the main reason for the surface water pollution. The construction of a sewage treatment plant is underway, and will be completed by 1997.

2.3 Water Quality in the Network

As it was discussed in the Master Plan, the quality of supplied water is not uniform in dry season when city wells are in operation to supplement the supply from the Figeh Spring. The distribution of water in the supply system has not been fully analyzed. In addition, with the proposed change in the system (e.g., proposed DMA project and Mezze-razy & Kafar Souseh-Lawan system), the distribution of water quality may change.

To evaluate the distribution of water quality for a given system configuration, therefore, it was desired to develop a water quality prediction model from mass balance consideration. Figure C-2.2 depicts a hypothetical water pipe network. Assuming that the polutant of interest (nitrate is considered here) is conservative (no chemical or biological degradation), and assuming complete mixing at a node, the mass balance of pollutant at a node (the mass coming into a node equals the mass going out form the node) can be expressed in the following expression.

$$\left(\sum_{Q_{ij}\geq 0} Q_{ij} + D_i\right)C_i + \sum_{Q_{ij}<0} Q_{ij}C_j = 0$$

where C_i : concentration of incoming pollutant from node "j" (mg/l/sec)

C_j : concentration of outgoing pollutant from node "i" (mg/l/sec)

Q_{ij}: flow rate from node "i" (l/sec)

($Q_{ij} < 0$ outgoing from node "i"; $Q_{ji} > 0$ incoming to node "i")

This expression holds for all nodes. In practice, a set of these linear equations was numerically solved to obtain solutions (concentration at each node). The flow rate, Q_{ij}, were obtained from the results of network analysis (APPENDIX A), and the water qualities at the sources were taken from the measured or estimated water qualities given in the Master Plan. All city wells were assumed to be in operation.

(1) Present condition

Figure C-2.3 shows the predicted water quality (nitrate) of the entire network in the present condition (dry season). It is clear that the water quality is worse in the south Damascus region (nitrate concentration is as high as 45 mg/l). Water quality in the lower Berze and Tabaleh areas are also somewhat low (nitrate concentration is in the order of 25 mg/l). These results are in good agreement with the results of the field water quality study in the Master Plan.

(2) After implementation of DMA

Figure C-2.4 shows the predicted water quality (nitrate) after the implementation of the DMA. Large change in water quality is not expected. However, there are minor improvements of water quality in the Kadam Store area and Kafar Souseh area.

3. INTERVIEW SURVEY IN MEZZE-RAZY & KAFAR SOUSEH-LAWAN AREA

3.1 Objectives

Mezze-Razy and Kafar Souseh-Lawan areas are known as informal areas because people in these areas have built houses informally without obtaining permits from the local government. It is generally known that the living standard of the informal residents is lower than the one of formal residents in Damascus. However, information regarding the social and natural environmental conditions of these areas is very limited. Therefore, an interview survey was conducted in May-June, 1997 to identify the followings.

- socio-economic conditions of the local residents
- status of water use in the study areas
- major environmental problems in the study areas
- environmental impact of the proposed project

3.2 Study Area

The study areas (Mezze-Razy & Kafar Souseh-Lawan informal area) are shown in Figure C-3.1. Mezze-Razy area is located off a main road in Mezze, and is characterized as a transitional area from the residential area of Mezze to agricultural area of Kafar Souseh. The setting of Kafar Souseh-Lawan area is similar to Mezze-Razy area, and is somewhat less urbanized than Mezze-Razy area.

name	population	area	population density
Mezze-Razy	32,786	100.5 ha	297 persons/ha
Kafar Souseh-Lawan	14,000	59.8 ha	234 persons/ha
Total	46,786	160.3 ha	292 persons/ha

Source : JICA/DAWSSA, 1997

3.3 Study Method

The interview survey was administered by local interviewers who orally asked questions in the questionnaires (see Databook) to the local residents. Table C-3.1 summarizes the type of questions asked in the survey. 100 respondents were selected randomly from Mezze- azy and Kafar Souseh-Lawan areas in proportion to the estimated population: 70 respondents from Mezze-Razy area, and 30 respondents from Kafar Souseh-Lawan area. Because the socio-economic status of the residents in these areas are quite uniform, no stratification in sampling design was considered. The respondents are heads of families or equivalent, and are familiar with the socio-economic and environmental conditions of their families.

3.4 Results

3.4.1 Local Socio-economy

Tables C-3.2 to C-3.5 summarizes the general socio-economic condition of the interviewers. The average family size was 8.40 in the Mezze-Razy area, and 7.43 in the Kafar Souseh-Lawan area. These numbers are higher than the average family size in Damascus, which is about 6.0 persons/family. The difference is in the number of children which are much higher in these areas, 4.28 children/family in Mezze-Razy and 4.26 children/family in Kafar Souseh-Lawan, in comparison with 2.15 for whole Damascus.

Figure C-3.2 shows the histogram of total household income. The average household income in these areas is SL 3,500 - 7,000/household/month (Table C-3.2), which is significantly smaller than the average family in Damascus (SL 16,254/household/month). Generally speaking, the living standard in Kafar Souseh - Lawan area is lower than the one in Mezze-Razy, and 15 % of the households in Kafar Souseh - Lawan earns less than SL 3,000/family/month. (It was noted that these numbers may somewhat underestimate their actual income level because 1) some of them grow food for their own consumption, and 2) some residents lie about their income to avoid taxation.)

87 % of the households did not claim the land ownership, which reflects the fact that these are informal areas. However, most families own laundry machine, refrigerator, TV, private bath and toilet (Table C-3.4).

3.4.2 Water Use

(1) Consumption

According to the survey (Table C-3.6), 85 % of the people feel that they use about the average (177 lpcd) or less amount of water. A rough estimate of average per capita daily consumption was attempted as follows:

$$160(lpcd)\times 0.48+170(lpcd)\times 0.04+180(lpcd)\times 0.33+190(lpcd)\times 0.08+200(lpcd)\times 0.07$$
$$=172(lpcd)$$

It should be noted, not many people know exactly how much water they use. Therefore, this number is only a crude estimate. Coincidentally, however, the result (172 lpcd) was exactly same as the estimated per capita daily consumption of informal residents in the Master Plan Study (see Section 4.4.4 of Main Report, Phase 1). Per capita consumption was higher in Mezze-Razy (Table C-3.6), which can be seen from the positive correlation (Table C-3.23) too.

(2) Source

According to the survey (Table C-3.7), 44 % of the residents have official individual connection to the DAWSSA system (formal user of the water). 52 % get water from DAWSSA system unofficially by sharing connections or stealing. 4 % of the residents, all in Kafar Souseh-Lawan area, are not connected to DAWSSA system. People in Mezze-Razy area have easier access to DAWSSA system, while in Kafar Souseh-Lawan area, people complained about the lack of water resources in the area. There are private wells in Kafar Souseh-Lawan, and as much as 30 % of the residents use such resource for laundering, bathing, toilet, and agriculture (Table C-3.8). However, none of them use this resource for drinking and cooking presumably due to poor water quality (Table C-3.8).

(3) Water storage device

97 % of the households have water storage devices (Table C-3.9). Most (95 %) of them are ≦ 1 m^3 in capacity. In Mezze-Razy area, the device was mainly controlled automatically, while in Kafar Souseh-Lawan, 66 % use hand-operated control. A water storage device is particularly important in summer when the supply is not reliable (Table C-3.10).

(4) Satisfaction

64 % of the residents in Mezze-Razy area are satisfied by the current water supply condition while only 30 % in Kafar Souseh-Lawan area are satisfied (Table C-3.11). On the average, 54 % are satisfied, which is considerably lower than the average for Damascus, 70 % (JICA/DAWSSA, 1997). The complaints are mainly on insufficient quantity (38 %) and low pressure (35 %) (also see Table C-3.23 for correlation structure). Water pressure is particularly low in summer, and some have water only late night to early morning. 4 % complained about poor water quality, and all of them are informal users. Merely 2 % of the formal users complained about the water price being too expensive. Nearly a half of the residents expressed the desire to use more water (Table C-3.12). The main reason why they do not use more water is the lack of water resource (44 %), and not for the economical reason (3 %).

(5) Water-borne disease

According to the survey, serious water-borne diseases (typhoid/typhus/paratyphoid, cholera, and dysentery) in these areas are rare, and only 2 cases of dysentery out of 100 respondents in the last 5 years were found (Table C-3.13). 12 % of the residents mentioned about kidney and thyroid gland problems, but their connection to water supply is unknown. 97 % of the residents are essentially (≦once/month) free from water-borne diarrhea (C-3.14).

(6) Tariffs and Willingness-to-pay

Table C-3.15 summarizes the tariffs water supply and electricity (there is no tariff for sewage, and tariff for garbage is fixed). The average monthly tariff for water (only formal users) is SL 114/family/month (SL 125/family/month in Mezze-Razy, and SL 85/family/month in Kafar Sousch-Lawan), which was somewhat lower than the average for Damascus (SL 147/family/month). If we assume the average income of SL 5,000/family/month, the water charge is about 2 % of the income. The average electricity charge was SL 358/family/month. Electricity charge is about 3 to 4 times higher than the water charge.

The residents were asked about the affordable water charge upon the completion of new water supply system (Table C-3.16). 37 % of the residents agreed to pay according to the actual spending (by meter), and 21 % would pay about the same rate. Interestingly 56 % of the informal users in Kafar Sousch-Lawan area, who probably have the least capacity to absorb increase in expenditure, said to pay according to the meter. These findings suggest that many residents are satisfied with the present tariff level. However, it was also noted that a significant number (28 %) of residents would pay the minimum amount required, and 4 % have not willingness-to-pay. Their willingness-to-pay for electricity showed similar trend (Table C-3.17).

3.4.3 Waste Control

In Mezze-Razy area, essentially all wastewater is discharged to ditches or the Dairani river without treatment, (Table C-3.18). On the other hand, 40 % of the residents in Kafar Sousch-Lawan area discharge the wastewater to public sewer system (Table C-3.18). However, there is no water treatment plant in the area, and the wastewater eventually end up in ditches and rivers. Human waste is mainly used as manure (Table C-3.19). 97 % of the residents said that garbage was regularly collected by the municipality (Table C-3.20).

3.4.4 Environmental Problems

(1) Major environmental problems

Nearly 70 % of the residents feel that the most serious environmental problem in the area is the surface water pollution (Table C-3.21). Related problems, such as odor (61 %) and lack of waste control (23 %), are also considered as serious problems. Among the informal users in Kafar Souseh, lack of clean, safe drinking water is as serious as the surface water pollution issue. Fewer people complained about air pollution (4 %) and noise (6 %). The study areas are less urbanized than the central Damascus, and sources of air pollution and noise are limited.

(2) Concerns about the impacts of proposed projects

In the interview survey, the nature of the proposed water supply project was briefly explained to the residents, and their environmental concerns about the project was asked. 80 % of the residents expressed no environmental concern about the proposed project (Table C-3.22). The local residents are aware of the direct benefit of the water supply project, and they are anticipating large long-term benefit of the project in comparison to the short-term adverse impact of the construction works. In addition, the municipality already did much digging in the area three years in row for sewerage projects, and the residents seem to be used to construction works in the area, although they want the works to be done as fast as possible. Among the concerns were children's safety during construction (about 7 %), dust problem (5 %), noise problem (4 %) and traffic problem (4 %).

3.5 Correlations between Parameters

Table C-3.23 shows the correlation matrix between selected parameters. The number of observations are generally 50 to 100. Among the pairs of parameters that showed high correlations were 1) family size and water charge, 2) dissatisfaction and pressure problem, 3) formality of water use and water charge. The correlation between household economy (e.g., household income) and water use was less obvious. Relatively uniform socio-economical structure in the study area seems to be the reason for this.

4. ENVIRONMENTAL IMPACT ASSESSMENT

4.1 Introduction

The major goal of the environmental impact assessments (EIAs) provided here is to evaluate the potential environmental impacts of the proposed projects, and to suggest alternative or mitigating actions to minimize environmental impacts.

This chapter consists of the following four parts.

1) Present Environmental Condition

The present environmental conditions of the study areas are briefly summarized.

2) Identification of Potential or Unknown Environmental Impact

The anticipated social, natural and pollution-related environmental impacts of the proposed projects are evaluated, and impacts that are considered significant or impacts whose magnitudes are potentially significant but unknown, are identified for further Environmental Impact Assessment studies.

3) Environmental Impact Assessment (EIA)

The environmental impacts of the potentially significant impacts are assessed.

4) Mitigating Plans and Environmental Monitoring

Alternative or mitigating plans are suggested to minimize the potential environmental impacts assessed in 3).

4.2 Present Environmental Conditions

4.2.1 Social Environment

(1) Local socio-economy

1) Population

< Damasucus > : Table C-4.1 shows the estimated population and population density of Damascus by district. According to the 1994 census statistics (Central Bureau of Statistics, CBS), the population of Damascus was 1.38 million in 1994 (Damascus Municipality, 1997). Based on 1994 census statistics there is an average of 6.0 persons per dwelling, and an average of 5.1 persons per family. The population growth rate in Damascus between 1981 and 1994 was 2.6 %, which was lower than the national average of 3.3 % (JICA, 1997). However, the population growth rate in great Damascus region was 4.8 %. This suggests that the city is expanding rapidly to the suburbs as the central part of the city is getting saturated. The estimated population of great-Damascus region is about 3 millions in 1994 (Damascus Municipality, 1997).

< Mezze-Razy & Kafar Souseh-Lawan > : Due to the lack of reliable statistics on informal residents, it is difficult to obtain precise estimate of population in informal areas. According to the interview survey conducted in June, 1997 (see Chapter 3 of this Appendix), the average family size is 8.1 persons/family, which is larger than the average family size in Damascus (6.0 persons/household). This difference was attributed to the difference in the number of children, which was higher in the informal areas (4.3 children/household) than the average (2.2 children/household).

2) Ethnicity / Religion

< Damascus > : Over 90 % of the population in Damascus is Arab. The rest consists of Palestinian, Armenian, Kurdish, and Jew. About 220,000 registered Palestinian refugee live in Damascus (Master Plan, Appendix A). Most of the Palestinian refugees live in the informal settlement areas of Yarmouk, and Kafar Souseh. Muslims accounts for about 85 %

of the population. The remaining 15 % are predominantly Christians, which live mostly in the Bab Sharqui and Bab Touma district of the old city. Despite the fact that mixed ethnic and religious groups are living in Damascus, there seems to be no major ethnic and religious conflict.

< Mezze-Razy & Kafar Souseh-Lawan > : Most of the residents in Mezze-Razy area are Syrian, while there are some Palestinians in the Kafar Souseh-Lawan area.

3) Household income

< Damascus > : The household survey of 600 families conducted in 1996 indicated that the average monthly household income was SL 16,254 per month (Figure C-4.1). About 30 % of the population receives less than SL 5,000 month, which is considered to be below the poverty level. About 60 % of the families receive less than SL 10,000 per month, and 80 % receive less than SL 25,000 per month. This distribution indicates that relatively small proportion of the population earns a disproportionate amount of the total income; approximately 20 % of the population earn 50 % of the total income (Master Plan, Main Report, Section 3.1.6).

< Mezze-Razy & Kafar Sousch-Lawan > : According to the interview survey, the average household income is around SL 3,000 - 6,500/month (Table C-3.2, Figure C-4.1). 51 % of residents in Mezze-Razy area, and 83 % of the residents in Kafar Souseh-Lawan area earn less than SL 5,000 / month. It was evident that the people in these areas are much poorer than the average people in Damascus (Figure C-4.1). Essentially all households have electric laundry machines, refrigerator, TV, bath and toilet (Table C-3.4).

(2) Land use

<Damascus > : Table C-4.2 summarizes the land use in Damascus (also see Master Plan, Main Report, Figure 3.2.2). About 60 % of the city area is residential and commercial area.

< Mezze-Razy & Kafar Souseh-Lawan > : These areas are classified as mixed regions of agriculture and residential areas, i.e., transitional areas from residential or commercial areas of more urbanized Damascus to agricultural areas of Ghouta.

(3) Transportation

< Damascus > : It is estimated that 33 % of the registered automobiles in Syria are in Damascus area (JICA, 1996). Microbus services are the main mean of public transportation, which account for over 65 % of passenger transportation in 1994, followed by private cars and rented cars (17 %), buses (8 %) and taxies (8 %) (Damascus Municipality, 1997). The number of automobile per capita is 0.05 vehicle/person in Damascus (cf. 0.36 vehicle/person in Tokyo) (JICA, 1997). The transportation system is chaotic reflecting the uncontrolled increase in the number of automobiles in Damascus recent years. Traffic jams are serious in commercial districts. In the old city and informal areas, most roads are narrow, and are not designed for automobiles. Many major environmental problems in Damascus, such as poor air quality, noise and vibration problems, are caused by automobiles.

< Mezze-Razy & Kafar Souseh-Lawan > : The streets in informal areas are generally narrower than 8 m (Table C-4.3), winding. The overall automobile traffic is lighter than the commercial districts of the city. According to the interview survey (Table C-3.4), 12 % of the households own automobiles (0.015 vehicle/person).

(4) Public health

1) Water supply

< Damascus > : Most of the population (approximately 95 %) in Damascus are serviced with potable water supply. The average per capita water consumption is 177 lpcd (litter/person/day) (Master Plan, Main Report, Section 4.4.4). Although the demand is not always met, 95 % of the formal users are satisfied with the present quantity of water available for consumption. Table C-4.4 shows the volume-averaged water quality of water supplied by DAWSSA. The quality of water supplied by DAWSSA is generally high, especially in spring when plenty of water is available from Figeh spring. However, in dry season, the

quality of supplied water is not uniform throughout the city, because waters pumped at city wells are locally used to supplement the shortage of water from the Figeh spring. The worst condition occurs in south Damascus where the local wells are contaminated by nitrate and hardness almost to the point of Syrian Drinking Water Standards. Sanitary condition of the supplied water is generally good: more than 97 % of 433 samples examined in June, 1996 contained > 0.1 mg/l of residual chlorine (Master Plan, Main Report, Section 3.4.2). However, due to leakage and illegal connection, the water supply system is prone to secondary contamination.

< Mezze-Razy & Kafar Souseh-Lawan > : Although these areas have been poorly serviced by DAWSSA, essentially all people (96 %) get water from DAWSSA's water supply system (Table C-3.7). This is a reflection of lack of other water resources, and it does not mean that they have a reliable water supply system. In fact, merely 44 % of the households in the areas get water officially from DAWSSA (Table C-3.7). Others share connections, or steal water somehow. The situation is worse in Kafar Souseh-Lawan area, where 60 % of the households do not have official connections (Table C-3.7). Nearly 70 % of the residents complained about insufficient quantity and/or low pressure of water, as opposed to less than 30 % in Mezze-Razy area (Table C-3.11). Essentially all households in Mezze-Razy and Kafar Souseh-Lawan areas use private water storage devices. The estimated average per capita water consumption is 172 lpcd, 3 % less than the average, although this estimate is somewhat crude (Chapter 3). Judging from the quality of supplied water in the mains (mainly from Figeh Spring), and from the occurrence of water-borne diseases, the water quality of tap water is expected to be quite good. Nevertheless, secondary contamination at illegally and poorly connected joint etc., seems to occur frequently. Improperly installed water storage device is another important source of contamination. Contaminations of supplied water with sand have been reported.

2) Sewerage

< Damascus > : It has to be said that the wastewater control in Damascus lags far behind the water supply. There are networks of combined sewer system in Damascus, which cover a large part of Damascus including some informal areas. However, there is no sewage treatment plant, and raw sewage is being dumped to ditches and rivers without any treatment.

Consequently a large part of the renewable water resources in the area is polluted to the level unsuitable for agricultural use, which is a major economic and environmental loss of precious water resources. The city is developing a central water treatment plant (capacity 500,000 m^3/day) in Adrer (about 25 km north east of Damascus), and the construction will be completed by the end of 1997. According to the plan, the majority of the municipal wastewaters are collected by the three major trunk sewers to a collection tank in Zabalatani, and then transported to the treatment plant in Adrer (about 25 km north east of Damascus). The treated effluents are to be pumped back to the irrigation systems around Damascus. The first year trial operation is scheduled for 1997/98. A number of technical and operational issues has to be resolved before the sewerage system becomes operational. Some of such issues include :

- control of toxic substances in sewage released from industries
- replacement of old sewer pipes
- operation and maintenance of rather advanced water treatment facility
- environmentally and economically-sound allocation (reuse) of treated water and sludge

In the past, similar sophisticated treatment plants have failed in other countries (e.g., Algeria and Egypt) due to inadequate institutional, operational and maintenance infrastructure (UNEP, 1996). The success of this program is yet to see in the several years to come.

< Mezze-Razy & Kafar Souseh-Lawan > : Limited sewers do exist in the informal areas, although there is no treatment plant. Consequently, the wastewater is discharged to nearby ditches, sewers, and the Dairani river (Table C-3.18). The Dairani river water is also used for irrigation. With the completion of the water treatment plant in Adrer, the wastewater in the area may be collected by the Mezze/Medan sewer main, and transported out of the area to the treatment plant.

3) Solid waste

< Damascus > : Garbage is dumped to metal containers installed throughout cities, and is collected by the municipality. Nearly 100 % of the garbage is collected in Damascus (JICA,

1996). It is estimated that the amount of solid waste produced in Damascus is about 1,000 tons/day in 1994 (JICA, 1997). After the collection, the solid waste is brought to Deir Al Hajar composting plant / landfill (JICA, 1996).

< Mezze-Razy & Kafar Souseh-Lawan > : According to the interview survey, essentially 100 % of the garbage is collected in these areas (Table C-3.20).

4) Water-borne diseases

< Damascus > : According to the interview survey conducted by JICA/DAWSSA team in 1996, 2.5 % of the 600 respondents in Damascus suffered from Typhoid/Typhus/Paratyphoid in the last 5 years, which were mainly concentrated in Kadam, Rukn Aldyn, and Midan areas (Master Plan, Main Report, Section 4.4.6). One case of cholera infection in the last 5 years was also reported. 15.5 % of the respondents reported getting other water-borne diseases, mainly diarrhea, in the last 5 years. However, diarrhea has many routes of transmission, such as food, and it was difficult to conclude that drinking water was the sole cause of such diseases.

< Mezze - Razy & Kafar Souseh - Lawan > : The interview survey conducted in the areas showed that 2 % of the residents got dysentery over the last 5 years (Table C-3.13). According to the study, there was no case of typhoid, typhus, paratyphoid or cholera. 86 % of the residents say they do not get water-related diarrhea. The rest of 14 % occasionally get diarrhea, although the frequency is generally once in a month or less.

(5) Cultural Assets

< Damascus > : Damascus is one of the oldest cities in the world, and there are a number of important cultural assets in the area. Figure C-4.2 shows the locations of important cultural assets. Being listed in the world heritage list (inscribed in 1979, UNESCO, 1986, 1996) along with Palmyra and Bosra, the Old City of Damascus is one of the most important cultural assets in Syria. However the cultural importance of the Old City is somewhat different from the historical importance of ruins such as Palmyra and Bosra. The Old City is the living center of Damascus, and in addition to its historic and touristic

importance, it is also important commercially and religiously. There are a number of significantly important historic and religious buildings in the Old City including Omayyad Mosque, Citadel (fortress), Azem Palace, Chapel of St. Paul, and so forth. Numerous buildings and stone-paved roads are at least a century old. Beside the Old Town, some cultural assets are found in Midan Akrad areas.

< Mezze-Razy & Kafar Souseh-Lawan > : There is no known cultural assets of importance in these areas.

4.2.2 Natural Environment

(1) Topography

< Damascus > : The city of Damascus has grown up at the point where the Barada River leaves the boundary mountain belt of the Anti-Lebanon and flows east onto the plain of the El Arab Trough. The urban area, at 650 to 750 m above sea level, has covered the alluvial fan created by the Barada River, and now has spread up the valley of the Barada River, and also to the plain in the east and south. The slopes of Kassion mountain and other hills to the north-west of the city, on the other hand, are very steep (more than 30 degree in many areas). Providing natural boundaries of the urban areas (see Master Plan, Appendix C for details).

< Mezze-Razy & Kafar Souseh-Lawan > : Mezze-Razy area is located on the western slope of the Damascus alluvial fan. Kafar Souseh is located on the Damascus alluvial fan further downstream from Mezze-Razy area.

(2) Geology

< Damascus > : The regional structure is made up of two domains, the Anti-Lebanon folds mountains and the El Arab Trough. The Damascus Fault marks the boundary between these two areas. The geological map of the area is given in Figure 3.2.2 of Main Report of the Master Plan. Within the Anti-Lebanon mountains the Jurassic to Paleocene strata have been folded and faulted by the northward movement of the Arabic plate. At the edge of the

Anti-Lebanon mountains, the Paleocene strata has been downthrown in a complex synsedimentary garben structure (Damascus Depression), and has been infilled with Neogene and Quaternary terrestrial sediments and numerous Miocene to Quaternary lava flows (Master Plan, Main Report, Section 3.3).

< Mezze-Razy & Kafar Sousch-Lawan > : The surface geology of these areas is upper. Quaternary to recent deposits of sands, pebbles, and clays.

(3) Climate

< Damascus > : The climate of the Damascus Plains is Mediterranean, characterized by hot dry summers from April to October and a humid cold winter from November to March. The main features of the climate in Damascus are given in Table C-4.5. On the basis of the meteorological data collected over 38-year-period (1947 - 1984), the highest average monthly air temperature is around 27°C in July, and the lowest average air temperature is around 7°C in January. Temperature in the day-time is considerably higher than the temperature in the night-time, especially in summer. The precipitation in the region is not uniform: the precipitation in the mountain belt of the Anti-Lebanon exceed 1,200 mm/year while the precipitation on the plain of the El Arab Trough is less than 100 mm/year. Located between the Anti-Lebanon mountains and the El Arab Trough, the average annual precipitation is 223 mm/year in Damascus (Mezze), and the precipitation is concentrated in winter (November – March). Evapotranspiration in Damascus roughly equals the precipitation. The most frequent wind direction in Damascus is west to east direction, i.e., along the fault. The next frequent direction is southwest to northeast, i.e., from the plane to the mountains. Detailed descriptions of climate in Damascus area is given in Appendix C of the Master Plan.

< Mezze-Razy & Kafar Sousch-Lawan > : The climate is essentially same as Mezze.

(4) Hydrology

< Damascus > : Figure C-4.4 shows the major hydrological Network in Damascus area. The single, most important river system in the Damascus Basin is the Barada River. The

Barada is a relatively short river, its full length being no more than 80 km. It rises in the mountain northwest of Damascus fed by major springs, then it cuts through the mountains to emerge onto the Damascus alluvial fan. Before the intensive use of river water for irrigation, flow extended to Lake Ateibeh. Presently, however, the water is extensively used by irrigation and groundwater abstraction along the river, and the river disappears before reaching the bed of the lake. The overall water balance for the Damascus basin is difficult to estimate accurately. Nevertheless a first cut estimation was attempted for the alluvial and proluvial aquifer of Damascus, which covers the alluvial fan of Damascus to the surrounding agricultural area of Ghouta. The water resources in this region are estimated to be 365 MCM/year (see Appendix C of the Master Plan Report). Essentially all of the renewable water resources are already utilized in the area.

< Mezze-Razy & Kafar Souseh-Lawan > :The Dairani river, which is a branch of the Barada river, runs through the areas. According to Ministry of Irrigation, the discharge is zero to $0.26m^3/sec$ depending on the season. The surface water is extensively used by irrigation in past time, however, the balance of water usage may have tended to switch from surface water to groundwater as the streams have become less reliable in both quality and quantity.

(5) Fauna and Flora

< Damascus > : Table C-4.6 shows the list of fauna (mammals and birds) and flora found in the study area. In this region, water is the limiting factor of vegetation growth. On the alluvial fan of Damascus, vegetation is mainly found in the discharge zone of alluvial cone, i.e., east-south outskirts of the city which is known as Ghouta. In the urbanized area, the ground surface is predominantly paved, and vegetation is limited. Biodiversity in Syria is currently under study by the Ministry of State for the Environment Affairs.

< Mezze-Razy & Kafar Souseh-Lawan > : Although these areas are less urbanized than the central Damascus, the natural environment has been strongly impacted by continuous agricultural activities in the area.

4.2.3 Pollution

(1) Air pollution

< Damascus > : Air pollution is a very serious environmental problems in Damascus. The major source of air pollution in Damascus is automobiles, which is believed to account for as much as 70 % of the emission. The Ministry of State for the Environment Affairs conducted a monitoring program in Damascus, in which ambient air qualities (3 - 5 m above ground) at 6 major squares (roundabouts) in the city were studied (Ministry of State for Environment Affairs, 1990). The results (Table C-4.6) showed that the levels of NO_x and SO_x often exceeds the WHO standards. The level of TSP (total suspended particulate) was as high as 650 $\mu g/m^3$ (24 hours), which is about 5 times higher than the WHO standard (120 $\mu g/m^3$). Although levels of TSP in aridic region is usually high due to naturally-borne dust, the elevated level of PM_{10}, which was in the range of 300 to 500 $\mu g/m^3$ in Damascus, suggested that the level of particulate originated from human activities is also high. Lead pollution is also strongly suspected because much of the fuel sold in Damascus is leaded. In the beginning of 1997, a high-level committee was formed to give incentives to control automobile exhaust. Among the recommendations by this committee were 1) the use of unleaded gasoline, which is now available in many gas stations in Damascus, 2) import of newer and environmentally friendly automobiles to replace less-environmentally friend old ones, and 3) improvement of road systems.

< Mezze- azy & Kafar Souseh-Lawan > : There is no data of air pollution in these areas. However, these areas are less urbanized than the downtown Damascus, and there is no major source of air pollution in these areas. Roads are narrow, and automobile traffic is generally light. There is no major polluting factory in the areas. Therefore, the air quality in these areas appears to be better than more urbanized areas of Damascus.

(2) Water pollution

< Damascus > : Surface water in Damascus is heavily contaminated by sewage and industrial wastewater. The water quality deteriorates as the Barada River flows down the

city; in the downstream of urbanized area, the BOD is as high as 100 mg/l, and the level of NH_4 in some areas exceeds 30 mg/l (Ministry of Irrigation, 1994). The conditions of smaller rivers and ditches, which are used to discharge raw sewage, are as bad as, or even worse than the Barada River. In general, the water quality is worse in summer, when the natural flux is low. The surface waters in the industrial zones of Damascus are seriously contaminated by toxic substances, such as heavy metals. An alarmingly high concentration of chromium (approx. 40 mg/L) was found in Dabaghat, which is a tannery area. Also illegal pesticides were found from surface water, which suggests excessive use of illegal pesticides in agriculture (see Appendix D of the Master Plan). Consequently surface water in downstream of Damascus is not suitable, or may be even unsafe, to use for irrigation, although it is used heavily in agriculture as it is the most easily accessible water. There is a plan to relocate polluting industries to an industrial park in Saramier or Hoshbras.

Due to the pollution of surface water, the quality of shallow groundwater has also deteriorated significantly. In general, water from shallow aquifer is not suitable for domestic use. The levels of heavy metals and other toxic organic chemicals need to be monitored very closely as the pollution by these substances is believed to be spreading.

The qualities of most groundwaters from deep wells (> 50 m) are still acceptable for domestic use. However, the groundwater quality is not uniform, and there are two regions where the groundwater qualities are as low as, or even worse than, the Syrian Drinking Water Standard (Table C-4.8). Groundwater in the western part of the city is usually characterized by elevated levels of hardness, salt and/or sulfur. These are considered to be of geological origin. Groundwater in south Damascus (Kadam area) is high in nitrate and hardness. In this region, the level of nitrate is as high as the drinking water standards (50 mg-NO_3/l). Seepage of sewage seems to be the main reasons for this. Another potential source of nitrogen in groundwater is fertilizers. Detailed discussions on water quality can be found in Appendix D of the Master Plan Report.

< Mezze-Razy & Kafar Souseh-Lawan > : The Dairani river, which is a branch of the Barada river, is as polluted as other branches of the Barada river. According to a study by the Ministry of Irrigation (1994), in which the water quality of Dairani river was monitored in Kafar Souseh, the DO was around 40 to 75 % of saturation, BOD was as high as 110 mg/L,

and NH_3 was as high as 50 mg/L in summer (Table C-4.9). The inflow of untreated sewage is the main reason of the pollution. The interview survey conducted in June, 1997 revealed that essentially all wastewater from the houses in the areas ends up in the river (Chapter 3). The local residents admitted that the most serious environmental problems in these areas is the pollution of surface water, and related odor problem (Table C-3.21). Although the surface water is heavily contaminated.

(3) Noise and Vibration

< Damascus > : There is little information regarding noise and vibration problems in Damascus. The Ministry of State for the Environmental Affairs is developing environmental standards of noise for roadside and factories. Generally speaking, the noise level in commercial districts of Damascus is high due to the heavy traffic condition. Vibration in the historic part of the city is said to be causing damages to the historical buildings (JICA, 1996).

< Mezze-Razy & Kafar Souseh-Lawan > : These areas are less urbanized than the downtown Damascus, and there is no major source of noise and vibration problems, such as major roads. Therefore, the noise and vibration levels appear to be somewhat better than more urbanized areas of Damascus. The present noise levels in these areas are probably about 60 dB(A) along the local streets in day time, and are about 40 dB(A) at night.

(4) Subsidence

< Damascus > : Subsidence problems are found in Dummar, Kassion Mountain, and the area around the Main Post Office near the Railway Station. The subsidences in Dummar and the Kassion Mountain are believed to be caused by silicate sand mining, and are not due to excessive groundwater withdrawal. The subsidence around the Main Post Office is said to be related to groundwater pumping at a construction site across the Barada River, although the connection is not clear.

< Mezze-Razy & Kafar Souseh-Lawan > : There is no known major subsidence problem in these areas.

4.2.4 Environmental Laws and Regulations

Environmental laws in Syria is in the developing stage. Although many laws and regulations have been formulated, most of them, including the Environmental Protection Act, have not been ratified yet. This section reviews briefly the nature and status of these laws and regulations that are pertinent to the proposed project.

(1) Environmental Protection Act (draft)

The fundamental environmental law in Syria, "Environmental Protection Act", is has been formulated, and is in the process of ratification. The following articles (draft) are particularly pertinent to the environmental aspects of water resources.

- Chapter II, Article 2-a: need for water quality standards
- Chapter II, Article 3: prohibition of pollution of surface water and aquifers
- Chapter III: Environmental Impact Assessment

(2) Drinking Water Standard (Law 45, 1994)

The Syrian drinking water standard (Table C-4.) is the oldest environmental standard in Syria. It was enacted in 1973, and has been amended most recently in 1994. It generally follows the WHO drinking water standard guideline (1994).

(3) Ambient Air Quality / Noise Standard (draft)

The ministry of the states for environment affairs is developing ambient air quality standards, that also include noise standard. Table C-4. summarizes the proposed standards which generally follows the WHO standards.

(4) Industrial Discharge Standard (draft)

Table C-4. summarizes the proposed industrial discharge standards applicable to industry that releases wastewater to public sewerage system. This law was designed to protect water treatment plant from getting contaminated by toxic chemicals discharged by industries.

(5) EIA (draft)

Uncontrolled development often leads to environmental disaster. To realize environmentally sound development, those who issue the permit or authorization to a development activity have to be informed about the potential environmental impact of the proposed activity. This assessment of potential environmental impact by the proposed activity is the aim of EIA. Another important objective of EIA is to suggest any alternative plans or mitigating measures to the decision makers so that the proponent of the project can make the project as environmentally sound as possible. Under the Environmental Protection Act, Chapter III, EIA is now mandatory for projects with potentially large environmental impact.

Protection of water resources is one of the most important goals of EIA in Syria. The following special considerations are incorporated in the EIA Decree.

- According to EIA Decree (Draft), Annex 2, water basins which have a hydraulic connection with permanent or semi-permanent usable surface water or usable aquifers are designated as sensitive areas. For any major project in such area, EIA is likely to be obligatory.

- EIA is compulsory for all major water polluting activities or activities that use significant amount of water. They are listed in EIA Decree (Draft), Annex I.

- EIA is compulsory for the following water supply activities.

Activity	Criterion for EIA requirement
groundwater wells	yield ≧ 10 MCM/year
artificial or controlled infiltration of water	capacity ≧ 10 MCM/year
reservoirs	reservoirs with capacity ≧ 10 MCM water pipelines with a diameter of more than 1 m and length of more than 10 km

(6) Prohibition for Import and Use of Chemical Pesticides (Decision 10, 1980)

This decision prohibits the import and use of the following 33 agrochemicals.

- aldicarb	- H.H.D.N.	- arsenic compounds	- BHC
- cadmium compounds	- cyanide compounds	- carbofuran	- chlordane
- cyanofenphos	- cyhexatin	- DDTs	- diazinon
- dibromochloro	- dinoseb	- endosulfan	- endrin
- EPN	- heptachlor	- leptophos	- dicofol
- dieldrin	- oxyamyl	- paraquat	- fenamiphos
- fonofos	- prothoate	- 2,4,5-T	- bromoxynil compounds
- daminozide	- ethyl parathion	- mieretic compounds	- flurine compounds
- dioxine compounds			

(7) UNESCO 1972 Convention concerning the protection of the world cultural and natural heritage (1972)

Syria's membership was ratified on August 13, 1975. The Old City of Damascus, Palmyra, and Bosra are listed in the world heritage list of UNESCO.

(8) Cultural Assets Law (Law 222, 1963)

This is the fundamental law to protect cultural assets in Syria. According to this law, any human-made object that is 200 years-old or older is considered as a cultural asset. All cultural asset issues are handled by the Committee for Cultural Assets and

(9) Protection of the Old City (Resolution No. 192/A, 1976)

This resolution was issued by the Ministry of Culture to designate the Old City as cultural assets. A special committee (Committee of the Old City of Damascus) was formed to protect the Old City.

4.3 Identification of Potentially Significant or Unknown Impacts

4.3.1 Synopsis of the Proposed Projects

(1) DMA project

As it was discussed in the Master Plan, as much as 35% of the water supplied by DAWSSA is lost to leakage. This is a large loss of precious water resources. DMA is a unified approach to control leakage and water distribution by dividing the service area into a number of mutually isolated blocks, and regulating the water distribution within or between the blocks by using a series of valves and pressure/flow rate monitors.

Construction Stage : According to the proposed project, the service area will be divided into 50 blocks, and 165 chambers (1.5 m×2.0 m×depth to the network) will be installed throughout the city to house monitors. In addition, 2 km of D200-600 mm pipe will be installed, and 5 sluice valves and 3 reduciton valves will be installed.

Operation Stage : The operation of DMA involves regular monitoring of pressure and flow conditions in each DMA blocks. The obtained data are used to further optimize the operation of water distribution system.

The details of the DMA project are explained in Chapter 5.2 of the Main Report.

(2) Water supply in Mezze-Razy and Kafar Souseh-Lawan

The areas of Mezze-Razy and Kafar Souseh-Lawan are known as informal areas because people have built houses in these areas without obtaining permits from the municipal government. These areas are least developed areas in Damascus, and water supply system is only partially installed. There is no major water resources in the area, and many residents are either sharing connections that are not mean to serve so many people, or illegally stealing water.

Construction Stage : The proposed project will install 15.5 km of distribution main and submain under existing roads. The construction work involves removal of pavement, excavation, installment of pipes, backfill, restoration of pavement.

Operation Stage : Water will be supplied from Wali service reservoir to Mezze-Razy and Kafar Souseh-Lawan areas through the network.

The details of Mezze-Razy & Kafar Souseh-Lawan project is given in Appendix B.

(3) Construction activities in the Old City

The Old City of Damascus is one of the most important cultural assets in Syria, and it is listed in the World Heritage List of UNESCO (1996) along with other important cultural assets in Syria, namely Palmyra and Bosra. Unlike historical ruins of Palmyra and Bosra, however, the Old City of Damascus is the living center of Damascus, and about 20,000 people live in the Old City. Many distribution pipes in the Old City are in good condition. However, there are a number of old cast iron pipes in the Old City, and they have to be replaced soon to control massive leakage. Detailed Environmental Impact Assessment (EIA) on construction activity in the Old City is beyond the scope of this feasibility study. However, considering the importance of the Old City, and anticipated need to replace old distribution mains, a general, and preliminary EIA of construction activities in the Old City is provided.

Construction Stage : Replacement or new installation of pipes in the Old City.

4.3.2 Identification of Potentially Significant or Unknown Impacts

To identify potentially significant environmental impacts, the actions associated with the construction stage and operation stage of the proposed projects were analyzed with respect to social environmental impact, natural environmental impact, and pollution-related environmental impact. From this analysis, potentially significant environmental impacts, or environmental impacts with unknown significance, were identified as follows.

		Social Environment							Natural Environment					Pollution					
		Resettlement	Local Socio-Economy	Transportation	Social Isolation	Cultural Assets	Public Health	Waste	Geology, Topology	Climate	Hydrology	Flora and Fauna	Landscape	Air Pollution	Water Pollution	Soil Pollution	Noise and Vibration	Subsidence	Odor
DMA Project	Construction	×	×	×	×	○	×	×	×	×	×	×	×	×	×	×	×	×	×
	Operation	×	×	×	×	×	○	×	×	×	×	×	×	×	○	×	×	×	×
Informal Area	Construction	×	○	○	×	×	×	×	×	×	×	×	×	×	×	×	○	×	×
	Operation	×	○	×	×	×	○	×	×	×	×	×	×	×	○	×	×	×	×
Old City	Construction	×	○	○	×	○	×	×	×	×	×	×	×	○	×	×	○	×	×

○ : potentially significant environmental impact, or impact unknown

× : no significant environmental impact anticipated, and no further assessment is necessary

The reasons of selection are explained in Table C-4.12. The environmental impacts of the items selected here were analyzed further in Environmental Impact Assessment (Section C-4.4).

4.3.3 Conformity with EIA Regulation in Syria

The EIA law in Syria has not been ratified, and at the time that this document was prepared, there was no regulatory requirement to perform EIA on the proposed project. Therefore, the environmental impact assessment was conducted based on the guidelines of JICA (JICA, 1994) and World Bank (World Bank, 1991).

4.4 Environmental Impact Assessment (EIA)

4.4.1 DMA Project

(1) Cultural assets (construction stage)

As a part of the DMA project, 165 underground chambers (size 1.5 m×2.0 m×depth of the network) will be constructed throughout the city to house flow/pressure monitors. These chambers are constructed under the existing roads where the water mains are already laid. Therefore the chambers will not be built in the immediate proximity to important cultural assets. Furthermore, in designing the locations of chambers, locations very close to important cultural assets were avoided (7 chambers will be installed in the perimeter but not inside of the Old City. The general impacts of construction activities in the Old City were assessed in Section 4.4.3). Other construction activities associated with the DMA project. Consequently, the impacts of the DMA project to cultural assets will be small. In any case, there is a chance that a new cultural asset is discovered during construction. Therefore, a set of guidelines to protect cultural assets is given in Chapter 5.

(2) Public Health (operation stage)

1) Availability of Water (operation stage)

It is difficult to estimate the amount of water saved by DMA project alone as water conservation will be achieved by a number of leakage reduction programs including DMA and replacement of leaky water mains. The total amount of water saved by these programs will be 18.5 MCM/year, which is equivalent to the water consumption of 253,000 capita/year (assuming 200 lpcd).

2) Quality of supplied water (operation stage)

Table C-4.4 shows the expected volume-averaged quality of water supplied by the project. The concentrations, C_{ave}, were estimated as follows

$$C_{ave} = \frac{\sum_i C_i Y_i}{\sum_i Y_i}$$

where C_i : concentration of the substance at well/spring "i"
Y_i : annual yield (MCM/year) of the well/spring "i"

Because as much as 80 % of the supplied water comes from Figeh/Barada sources, which are known for good water qualities, the yearly water quality easily satisfies the Syrian Drinking Water Standards. However, the water quality is expected to deteriorate in dry season when the yield from Figeh Main Spring decreases (also see APPENDIX D of Master

Plan Report). The DMA project will improve the quality of supplied water in the following ways.

1) Saving of High Quality Water : The DMA project will help reduce leakage of high quality water from the Figeh Spring.

2) Reduction of Secondary Contamination : Leakage is a important source of secondary contamination. The DMA will detect any abnormally low pressure in the system, and help reduce the secondary contamination.

3) Strategic Allocation of High Quality Water : As it was discussed in the Master Plan, water quality in Damascus is not uniform in dry season (nitrate and hardness problems) because low quality water from local wells (e.g., Kadam Railway Wellfield) is used to supplement the high quality water from Figeh. The proposed DMA project will alter the water allocation scheme, which will also alter the distribution of water quality in the system. Figure C-2.3 shows the predicted water quality (nitrate) in before (present conditon) and after the implementation of DMA project. Although overall water quality will not change, some improvement of water quality around the Kadam Store area and Kafar Souseh area is expected (see Section C-2.3). These changes are due to the allocation of high quality water to the area of low water quality.

These positive impacts of the DMA project can only be realized by constructing the DMA system properly. Guidelines to reduce secondary contamination in the construction stage are given in Section 4.5. Another important practices required to ensure safety of supplied water are water quality monitoring and maintenance of the system. These are also discussed in Section 4.5.

(3) Wastewater (operation stage)

As it was discussed in Section 4.2.3, surface water pollution by wastewater is one of serious environmental problems in Damascus. Wastewater problems are pertinent to water supply projects at least for the following reasons.

1) Generation of wastewater is an inevitable environmental consequence of a water supply project. By implementing the DMA project along with other leakage control programs, a large amount of supplied water (up to 18.5 MCM/year) will be saved, which will, in turn, result in the net increase in wastewater.

2) Wastewater can pollute important water resources of water supply.

3) Both leakage and wastewater are significant sources of renewable water resources in Damascus. Consequently the leakage control programs and wastewater control programs can have profound impacts on the regional environment and economy.

For these reasons, a water supply program should be accompanied by appropriate wastewater control program(s), and these two should be implemented as a set. To deal with the wastewater problem, Damascus Municipality is currently developing a central water treatment facility in Damascus suburb (Section 4.2.1), which is expected to become operational by the end of 1997 before the implementation of the proposed water supply project. This sewerage program will be used to treat wastewater associated with the water supply project.

This report is concerned with the environmental impact assessment of the proposed water supply projects, and the environmental impact assessment of the sewerage program is beyond the scope of this work. However, there are a number of environmental concerns associated with the current sewerage program. If the sewerage program fails, the generated wastewater will continue to be discharged to the environment without treatment, and the water pollution problem in Damascus will be worsen. Therefore, important environmental issues associated with the water supply and sewerage programs are reviewed here. DAWSSA is urged to discuss these issues with the Damascus Municipality and the newly established sewerage authority so that failure of the sewerage program can be prevented.

1) Operation of treatment facility : The planned facility will adopt activated sludge technology to treat wastewater. Activated sludge is a very popular method, although it is rather sophisticated, and requires highly trained technicians to operate.

2) Toxic substances in sewage : Toxic substances such as heavy metals in sewer can kill microorganisms in the activated sludge system. In addition, contaminated treated water and compost cannot be used for agriculture. Therefore, it is very important to regulate the amount of toxic substances discharged to sewer especially from industries. Enforcement of the industrial effluent discharge standard to sewer (Section 4.2.4) will be essential to operate the treatment facility properly.

3) Recharge in the upper Damascus basin : The amount of groundwater recharge in the upper Damscus basin will be reduced due to the reduction of water leakage achieved by proposed DMA system. On the other hand, groundwater abstraction amounts from DAWSSA's wellfields in the upper Damascus basin are expected to be greatly decreased because of the water saving effects of the proposed DMA system. In addition to the above conditions, the current sewerage program aims at the maximum re-use of treated wastewater for agricultural use in the Ghouta area, east of Damascus. This will further reduce the need to groundwater instead of abstraction of groundwater for irrigation use. The project will not, therefore, have a significant impact on the water balance of the upper Damascus basin.

4.4.2 Mezze-Razy & Kafar Souseh-Lawan Project

(1) Local socio-economy (construction stage and operation stage)

1) Local socio-economic impact of construction activities (construction stage)

Because the water supply systems are installed under roads, no relocation or resettlement of local residents is anticipated. According to the result of the interview survey, 80 % of the residents expressed no concern about the proposed project (Table C-3.22). The local residents are aware of the direct benefit of the water supply project, and they are anticipating large long-term benefit of the project in comparison to the short-term adverse impact of the construction works. However, the local residents are hoping that this construction activities are done as fast as possible to minimize inconvenience. Some of the important issues for the local residents are children's safety during construction (about 7 %), dust problem (5 %), noise problem (4 %) and traffic-related problem such as commuting, customers' access to the area, and traffic jam (4 %) (Table C-3.22). Negative socio-economic impacts of the construction works to the local residents can be greatly minimized by informing the residents about the project prior to the construction works. Section 4.5 provides a set of guidelines to minimize general negative impacts of the construction activities to the local residents.

2) Affordability (operation stage)

The interview survey showed that the current informal users pay minimal amount for water use. With the completion of the project, these informal users become formal users, and they will have to pay the official water charge for the service. The impact of this increase in expenditure to the local residents depends highly on the financial capacity of the customers, which is analyzed in detail in Appendix D. Although the local residents in the informal areas have limited income (average houshold income SL 3,000 - 6,500/household/month), the local residents will have sufficient capacity to absorb increase in expenditure. The interview survey showed that 4 % of the informal residents refused to pay at all (Table C-3.16). 46 % of the informal residents agreed to pay as long as the tariff is based on the actual spending (Table C-3.16). These results indicate that the local residents feel that the water charge is reasonable. Incidentally, the average electricity tariff, which essentially all residents pay, is SL 358/household/month, and is much higher than the water tariff (Table C-3.15).

3) Equity (operation stage)

The people who are benefited by the proposed project will be limited to the residents in Mezze-Razy and Kafar Souseh-Lawan areas. Nevertheless, the project will contribute to the equity among the people in Damascus for the following reasons.

- Currently public water supply in these areas is limited, while most other areas in Damascus are serviced by DAWSSA.
- The living standard of the beneficiaries (people in these areas) is lower than the average of Damascus.

- Many people living in these areas are informal use, while others are paying for the water. The project will stop the informal use, and charge the water users according to their consumption.

The project, however, will not benefit the people outside of Damascus.

(2) Public Health (operation stage)

1) Availability of water (operation stage)

According to the interview survey, 27 % (Mezze - Razy) and 37 % (Kafar Souseh - Lawan) of the residents claimed that the lack of clean and safe drinking water is the most serious environmental problem in the area (Table C-3.21). This condition will be improved significantly with the installation of proposed water supply system.

2) Quality of supplied water (operation stage)

Table C-4.4 shows the expected quality of water supplied by the project. According to the proposed DMA project, waters supplied to Mezze-Razy & Kafar Souseh Lawan areas are fed from Wali Reservoir. The 100 % of the supplied water comes from Figeh/Barada sources, which are known for good water qualities (also see Figure C-2.4). Consequently water quality will be superb throughout year, and will easily satisfy the Syrian Drinking Water Standards.

Another very important issue in water quality is the prevention of secondary pollution from poorly connected joint, illegal connection, corroded pipe, dead-end pipe in which the water is stagnant, cross-connected circuit, and improperly installed water storage devices. The proposed project is expected to reduce secondary contamination by ensuring the followings :

- proper installation of system
- elimination of illegal connection
- proper pressure regulation through DMA program

- regular maintenance of the system
- water quality monitoring program

3) Water-borne diseases and overall public health condition (operation stage)

Public health condition is determined by many factors, and it is difficult to qualitatively estimate the improvement of general public health conditions brought by the proposed project. Nevertheless, there is no doubt that the project will greatly enhance the overall public health condition of the area by providing the local residents with sufficient quantity of safe water to drink, wash hands, bath, and wash vegetables and fruits. Further improvement of public health condition requires effective wastewater management.

(3) Transportation (construction stage)

According to the results of interview survey, merely 4 % of the residents expressed concerns about the traffic related socio-economic impacts, such as commuting and customers' access to the area (Table C-3.22). However, these roads are generally narrow (e.g., 60 % of the roads in Mezze-Razy area are 4 - 6 m wide, Table C-4.3) and construction activities will inevitably affect the traffic condition. Although it is difficult to avoid traffic problems during construction, they can be minimize by enforcing a set of mitigating practices as suggested in Section 4.5.

(4) Construction related noise and vibration (construction stage)

Table below gives the estimated noise and vibration power levels near the major noise and vibration sources to be used in the construction.

source	noise, dB(A)	vibration, dB
distance from source	7 m	5 m
loader	75	60
excavator	85	65
asphalt cutter	85	55
concrete breaker	100	60
dump track	85	60
generator	85	60

Source: MITI, 1985; AJMC, 1985

Noise and vibration levels are determined by the specification and the working condition of the construction machinery, and these estimates are given only to provide general idea of noise and vibration levels near the construction machineries. When more than one source (power level L_i) exist simultaneously, the overall noise (L_{Total}) and vibration levels can be estimated as follows.

$$L_{Total} = 10\log\sum_i 10^{L_i/10}$$

If we assume that all these machineries are in operation simultaneously in proximity, the overall noise and vibration level may be as high as 100 dB(A) and 65 dB respectively. In reality, however, not all machineries are used simultaneously in proximity. Therefore, the typical overall noise level near the source is estimated to be around 85 dB(A), and the vibration level would be around 60 dB.

The noise and vibration levels die out rapidly as the distance from the source increases, which may be roughly estimated as follows.

Noise

$$L_N(r) = L_N(r_0) - 20\log\left(\frac{r}{r_0}\right) - 8 \qquad \text{(assuming point source)}$$

where $L_N(r)$: noise power level at distance "r" from the source

$L_N(r_0)$: noise power level at distance "r_0" from the source

Vibration

$$L_V(r) = L_V(r_0) - 10\log\left(\frac{r}{r_0}\right) - \alpha \qquad \text{(assuming point source)}$$

where $L_V(r)$: vibration level at distance "r" from the source (dB)

$L_V(r_0)$: vibration level at distance "r_0" from the source (dB)

α : coefficient related to the dissipation of vibration in ground

Based on these prediction method, the noise and vibration levels at 20 m from the source were estimated as 68 dB(A) for noise and 50 dB for vibration. When a hand breaker is used, the noise level at 20 m from the source would be as high as 82 dB(A). It should be noted that transmissions of noise (through air) and vibration (through ground) are also affected by reflection, diffraction, and absorption, and these estimates are only first-order approximation.

The predicted level of vibration (50 dB) is lower than the admissible vibration standard for similar construciton activity in Japan (70 dB) (there is no environmental standard for noise and vibration in Syria). The noise level is also lower than the admissible noise standard for similar construction activitiy in Japan (80 to 85 dB(A)). In addition, the area where noise and vibration levels are high will be contained within immediate vicinity of construction sites. Therefore the impacts of noise and vibration during the construcition activities will not be significant. Nevertheless, the desirable noise for residential areas is about 55 dB(A) (based on the Japanese environmental standards for noise and vibration in residential area in daytime). Therefore, it is essential to reduce noise and vibration levels during consutruction activities. A set of guidlines to reduce noise and vibration during construction are given in Section 5.1. Good public relation with the local residents will be the key to minimize environmental impact.

(5) Wastewater (operation stage)

The pollution of surface water by wastewater is already the most serious environmental problems in the areas, and an active control of wastewater is essential to solve this problem. Assuming the average water consumption of 200 lpcd, the increase in wastewater will be 2.3 MCM/year. As it was discussed in Sections 4.2.1, the local government has a plan to solve this problem with combined sewer systems and a central water treatment plant in Adrer. Important environmental issues related to this plan were also mentioned in Section 4.2.1 already. An issue particularly important to the informal areas of Mezze-Razy and Kafar Souseh-Lawan is the development of sewer system, which lags behind the other part of Damascus. As the surface water quality of Dairani river suggests, a large part of surface water is contaminated by wastewater. This is a serious environmental damage to the local farmers who depend on the surface water.

4.4.3 Construction Works in the Old City

According to the World Bank (1991), "any project which involves excavation, leveling or filling of earth as part of construction operational practices, is a potential threat to archaeological and historical remains."

(1) Cultural assets (construction stage)

There are numerous cultural assets with different levels of importance in the Old City. Figure C-4.4 shows the location of important cultural assets in the Old City. Based on the World Bank's classification scheme (Goodland and Webb, 1989), most of these assets may be classified as tangible and immovable (classification 1), and historic and/or religious (classification 2). In addition to these important cultural assets, there are numerous less important cultural assets. Most of the old water supply mains are buried under existing roads, and direct impact of the construction activities related to water supply project will be limited to the old roads (some of the stone-paved roads are over 100 years old). Judging from other utility-related construction activities (sewerage, electricity, and telephone) in the Old City, replacement of old water supply mains in the Old City can be achieved with minimal impact to cultural assets, as long as the permit is obtained from the relevant authority, and a set of guidelines to protect cultural assets are followed.

(2) Traffic (construction stage)

A labyrinth of narrow, twisting alleyways in the Old City was designed hundreds of years ago, and is not suitable for automobile traffic. However, many automobiles make their ways into the Old City, and the traffic condition in the Old City, especially in the commercial districts, is distressing. Construction works in the Old City will make the situation worse, and will create sizable social impact to the area. This has to be minimized by practicing a series of mitigating activities recommended in Section 5.1.

(3) Vibration (construction stage)

The damage of building caused by vibration depends on the integrity of the building, ground condition, type and duration of impact, etc., and it is not possible to draw general conclusion about at what point vibration will cause damage to a building. But many buildings get minor structural damage if the vibration exceeds 70 dB (MITI, 1985). The buildings in the Old City are very old (many of them are at least 100 years old), and are expected to be even more vulnerable to vibration. The estimated vibration levels near construction machineries (7 m) are about 60 dB (see Table in Section 4.4.2 (4)). The roads in the old city are generally narrow (many roads are about 3 m wide, and winding), and the building walls are built right next to the roads. Therefore, it will be difficult to expect much distance for damping of vibration. Judging from these conditions, it is possible that structural damage is inflicted on a builindg if the construction work is not designed and carried out properly (in the past, a few incidents of structural damage (cracks) to houses have occured during public utility related construction activities). In Section 5.1, a set of guidelines for construction activities in the Old City is provided.

(4) Air pollution and noise

Although air pollution associated with the construction activity will be rather small, air pollution in the Old City requires a special attention because ventilation in the Old City is poor (especially in the Souks), and dispersion of pollutant will be limited. Noise also requires special attention because the area is densely populated, especially daytime. Again, a series of mitigating practices is strongly recommended.