understanding is the fundamental requirement of any organized management of network operation and maintenance. For example, how can one decide whether an important water main or item of equipment should be kept in place or replaced if its real usefulness in overall network operation or even its exact characteristics are not accurately known?

The mathematical model, by being continually updated and improved, will thus provide easily accessible and often irreplaceable files concerning the exact state of the in-sites networks.

- The model provides a rapid and strict mean of calculating the consequences of a given choice concerning the basic assumptions. It is without doubt in this field that electronic computers and associated software give the greatest impact.

To achieve these results, a mathematical model must be:
- of easy access,
- capable of strict and reliable calculations.
- able to carry out such calculations quickly and to present the clearest possible manner.
- easy to perfect.

It was on the basis of these principles that the model of water supply networks of the Zarqa District was drawn up.

3.2 Facilities Used

3.2.1 The Software (WATNET)

Since the detailed manual of the software will be supplied within the context of the study this report will simply give a brief summary of the main features and describe its various possibilities.

a. <u>The Calculation Method</u>

As indicated in Section 3.1, the calculation is based on the algorithm of the Hardy Cross process, also known as the node method, which involves satisfying the flow continuity equation at each of the nodes in the model by adjusting the hydraulic heads.

Take for example any node where it is possible to determine the algebraic sum of the flow rates originating either from pipes leading to this node, or from external flow exchanges. This sum will have a non-zero value until the hydraulic heads and flow rates in the network

have been balanced. The head is then modified in this node in order to satisfy the continuity equation. All the other nodes in the network are then reviewed in the same manner, except of course for reservoirs where the head is usually fixed.

These operations are repeated for a sufficient number of times so that the flow continuity at each node remains practically unaltered by the calculation of a neighboring node. Calculation conveyance is accelerated between the conventional series of iterations by an overall resolution of the complete system of previously line arised continuity equations (resolution by matrix inversion). The accuracy has no limit and can easily reach 0.01 l/s on flow rate continuity of the most unbalanced node.

- It is not defaulted by the possible presence of check valves which are capable of randomly prohibiting flow inversion in certain pipes during iteration process (the conventional loop - balancing method becomes in operative in such cases).

- It is capable of associating without difficulty the consumption abstracted of each of the nodes with the pressure prevailing of this node, a feature which is much more representative of reality; here again the conventional loop method cannot provide this refinement.

b. Program Organization

Figure 3.1 illustrates the basic scheme for a network simulation. Essentially the simulation consists of a series of steady state network analyses throughout the simulated time period. Additionally the simulation models the variation in the reservoir level. The results of a simulation can therefore give a snapshot view of hydraulic variables (e.g. pressure and flows) for the network of any required time during the simulated period. The simulation can also provide a profile of the performance of an individual network feature (e.g. reservoir level, or nodal pressure) during the whole, on part, of the simulation period.

It should be appreciated that traditional steady state network analysis is simply a special case of network simulation where the simulation period is a single time point. WATNET is capable of performing both analysis and simulation.

4. Model Construction

This section describes the construction of two network models covering the existing Zarqa, Rusaifa, Hasmeyer and Sukhna distribution areas. It then presents an outline network design for 2015 together with details of new plant needed. The recommended works have been broken down into four categories of urgency.

The 1995 network models were developed between December 1994 and July 1995 using WRc's WATNET v5.35 simulation program.

4.1 Model statistics

The Zarqa district model is represented graphically in the calibrated network plots ZARQA DISTRICT NORTH - 1995 MODEL and ZARQA DISTRICT SOUTH - 1995 MODEL contained in Data book. The total model statistics are:-

TABLE MODEL STATISTICS FOR YEAR 1995

Description	ZARQA and RUSEIFA	Hashemiyah and SUKHNA
Estimated Population (person)	511,872	22,802
Nodes	1,502	234
Pipes	1,863	259
Variable head reservoirs	4	3
Pump sets	12	0

4.2 Pipe data

Pipework selection within the zone was based on the 1:10000 system layout drawings prepared for this study. All pipes of 3 inches (80 mm) or greater in diameter have been included. Some information on pipe ages and materials is given on the system layout drawings. Nominal internal diameters of mains have been used. The lengths of mains were scaled from the system layout drawings to the nearest 5 metres. An initial Colebrooke-White roughness value of 1mm was used for all pipes.

4.3 Node data

Ground levels of nodes were derived from the information given on the system layout drawings. The value represents the elevation of the node centroid, not the elevation of the highest customers supplied from the node.

Nodes in the Zarqa and Ruseifa area model have been numbered according to their census area. Numbers increase from west to east within each census area. Nodes in the Hashemiyah and Sukhna area model have been numbered as 2*** and 3***, respectively.

4.4 Reservoirs

The reservoirs at Hararieh, Sukhna, Zarqa pumping station, Batrawi, Awajan and Rusaifa site 18 have all been modelled as variable head reservoirs. The Zarqa, Al Bassateen, Rusaifa 4 and Rusaifa 18 booster pumpsets have been modelled as time switched pumps. The Awajan, Rusaifa, Al Bassateen and Hutteen wells have been modelled as negative exceptional demands.

Reservoir statistics used in the models are:

Reservoir	Volume (Ml)	BWL (m AND)	TWL (m AND)
Hararieh	0.750	578	581
Sukhna	0.250	548	551
Zarqa PS	4.000	574	579
Batrawi	4.500	647	652
Awajan	4.500	695	700
Rusaifa site 18	0.050	626	629

4.5 Base demands

Demands have been estimated using census population figures detailed in Data book. The population per node within a census area has been calculated by dividing the population in that area by the number of nodes. The Type 1 base demand figures therefore represent population.

Part of the area around the Hutteen wells in Ruseifa appears not have been included in the population census. Therefore, nodes in this area have been given an area number of 70 and have the same base demand as nodes in the adjoining area 66.

Part of the area between Hashemiyah and Sukhna appears not have been included in the population census. Nodes in this area are numbered according to the distribution system and have been given the same base demand as other Hashemiyah or Sukhna nodes.

5. FIELD WORK AND CALIBRATION

The preliminary fieldwork consisted of the following:

- identifying suitable pressure and flow measuring sites,
- having sites excavated and pressure tappings and ultrasonic flowmeters fitted,
- surveying pressure sites using a barometer,
- arranging with WAJ (Water Authority of Jordan) to have water supplied to the agreed area and to have the necessary valves closed,

5.1 Calibration field tests

The calibration field tests involved the simultaneous measurement of flows, pressures and other relevant data over a 24 hour period.

For the Zarqa test commencing on the 19th July 1995, flows and pressures were monitored as follows:

- recorded pressures at 4 sites,
- recorded flows at 3 sites,

Domestic water tanks at high points in Zarqa were checked around midday on the 19th and were found to be full. Guards were present at each location for the 24 hours of the test to safeguard the equipment. The equipment was retrieved on the 20th July.

Field test records were inspected. Flows and pressures showed very little variation over the 24 hour period, in marked contrast to those recorded during the Rusaifa pilot area test in March 1995. Given that house tanks were found to be full at the start of the test, this suggests that the field test area had not been fully isolated. Therefore, it was not possible to use the field test data for model calibration. An earlier field test also showed that the area under test had not been isolated and that results could not therefore be used for model calibration.

The above tests highlighted the difficulties involved in isolating areas for field testing. Valve testing is only possible at times of supply which are restricted by the rationing program. It was therefore decided that an uncalibrated network model would be used.

5.2 The Zarqa District 1995 models

All pipes were given a Colebrooke-White roughness values of 1mm. A demand of 113 lcpd (litres per capita per day) was assigned to the network by applying a type 1 demand weighting of 0.0013 (=113/24/60/60).

Reservoirs were set to 2m above bottom water level. Pump curves were not available for the booster pump sets and so were assumed, using the duty point as a guide. Pipes with valves marked NC (normally closed) on the system layout drawings were made unavailable.

Negative exceptional demands at wells were set to the average 1994 figure with the exception of Murhib which has been ignored. It is thought that this well will not remain in service for much longer because of declining water quality standards.

The results showed negative pressures in some areas, especially the highest parts of Rusaifa. This is what would be expected if no rationing were undertaken. Pressures in the lower Rusaifa pilot area were consistent with those measured during the pilot study. Flows through the pumpsets at Zarqa pumping station agreed with those recorded. It was felt that the model formed a useful tool with which to design the future network.

6. Network Performance And Recommended Improvements

6.1 Design criteria

The 2015 network has been designed to deliver continuous supply to customers at peak day, average hour conditions, taking account of the forecast increases in population and per capita consumption. The network has not been designed for peak day peak hour conditions. Since all properties have storage tanks, this is not seen as a priority.

The new network employs a gravity feed system. It is envisaged that the extra initial capital cost of the scheme will be offset by lower pumping costs and lower rates of leakage and pipe bursts. Gauge heads have been kept between 10m and 100m wherever practicable.

It has been assumed that all additional water needed will come from the Khaw pumping station and the existing Khaw - Amman line will exclusively be for Zarqa. Supplies at wells have been left at their 1994 average.

6.2 Demand estimates

Nodal demands are presented in Databook. The 2015 network assumes a peak day per capita consumption of 155 litres. The forecast population for the Zarqa district for 2015 is 950,784, compared with 534,674 in 1995. Therefore, demand in 2015 is 147,400 m^3/day.

The increased demand is distributed as per the 1995 model. Therefore areas of new housing not served by the 1995 model are not shown on the 2015 model.

6.3 Present Network Performance

The ZAR1995 network model indicates that the present network cannot function without rationing. The present configuration of pipes, pumps and reservoirs is not able to provide a continuous supply of water to customers. The topography of the district together with the present network configuration require that excessively high pressures are generated in order to supply customers.

The 1995 model is shown on A0 sized plot ZAR1995 and A3 sized plots Z95BOTLE and Z95LOWHI. ZAR1995 shows node names and pipe diameters. Z95BOTLE highlights bottlenecks by showing all pipes losing more than 50m head per Km. Z95LOWHI shows areas with excessively high or low pressures.

The Z95IMP model is the 1995 network with improvements but with no additional supply from the Khaw to Amman line. New pipes added to Z95IMP are:

From Node	To Node	Diameter (mm)	Length (m)
66203	66205	400	30
6684	N9001	400	30
66179	N6607	300	40
66205	N6602	600	930
N6601	N6602	600	250
6696	N6601	200	10
6633	N6601	600	600
N6602	N6607	300	470
4112	4128	200	1420
5338	6102	300	30

All pipework listed above is also required for the 2005 and 2015 networks. New pumpsets added to Z95IMP are:

From Node	To Node	Duty Head (m)	Duty Flow (l/s)
AWAJAN	4129	44	25
B18IN	66205	182	94

Both pumpsets are replacements to existing pumpsets. Those at Awajan will not be required after 2005 once other recommended major works have been completed.

Whilst the Z95IMP model reduces the number of customers receiving inadequate pressure, it increases the number of customers experiencing excessively high pressure. It is at best a temporary solution, although almost all the extra plant needed can then form part of a more permanent solution.

6.4 2015 network design

The estimated 2015 demands were allocated to the 1995 model. Pipes and reservoirs were then added to the model until the design criteria were satisfied.

Extensive use was made of contour maps to establish the proposed reservoir zones and pipeline routes. Pipes have been run along existing road routes wherever practicable. Where new pipes cross the Zarqa river they do so at existing crossing sites.

New nodes are prefixed by the letter N and have no demand attributed to them. New reservoir node names are of the form RES*** with *** being the ground level at the proposed site.

Field visits were made to most of the proposed reservoir sites. This area is already built up and buildings would need to be demolished before a reservoir could be built.

The proposed design is shown on plot ZARQA and ZARQA AREA in Data book. Plot ZARQA highlights the new pipework required and Node Numbers. The diameter and length of the proposed new pipework is sumarized in section 2.4.3 (F/S Main Report).

The procedure used for reservoir sizing was as follows: A diurnal pattern for the area served is assumed. This has been taken from flow records for the Rusaifa pilot area tested in March 1995. The average hour peak day demand for the area served is taken from the Z2015ZAR model. Generally, the proposed reservoir capacity is equivalent to the peak 6 hours demand of the area directly served by the reservoir plus half a metre water depth. It is estimated that 6 hours will be sufficient time for water authority staff to deal with most supply problems that arise. Where reservoirs also supply other reservoirs, an additional 2 hours reservoir supply has been added to the capacity. This gives water authority staff two hours in which to close valves to stop water emptying or being pumped from one reservoir into another.

It is assumed that all reservoirs will comprise two sections seperated by an internal dividing wall. This allows one section to be taken out of service for maintenance whilst the other section remains operational. The reservoir costs included in this chapter assume this design.

The design involves seven new reservoirs in addition to those existing at Awajan and Batrawi. Operational flexibility is improved with a reinforced trunk main system. Lower level reservoir zones have the ability to take water from higher ones in emergencies or during maintenance operations.

A new 600mm diameter pipeline from Khaw to the Awajan wells is also proposed.

District metering is seen as a key tool in reducing unaccounted for water and the new network has been designed with this in mind.

The booster pumps at Al Basatin and Rusaifa site 4 are no longer required. Pumps at Rusaifa site 18 remain, boosting to RES750. New pumps at RES750 and BATRAWI boost water directly to new higher reservoirs.

It is proposed that boosters at Zarqa pumping station pump direct to Batrawi reservoir along a new pipeline. Alternatively, thought can be given to bypassing Zarqa pumping station and boosting directly from Khaw to Batrawi.

A surge analysis should be considered for all dedicated pumping mains.

The only new pipework added to the Hashmeyer and Sukhna distribution systems was shown in Chapter 2 (F/S main report). The diameter ranges from 100mm to 300mm. These are included in the cost estimates and shown on the network plot HS2015. However, the Hararieh tanks would seem to be in poor repair and can be considered for replacement. There are also properties higher than the existing reservoirs and pipework and so one may also wish to allow for two new 0.5Ml reservoirs and sufficient pipework to serve areas not presently served. These have not been modelled.

Areas have been numbered for ease of reference only.

Controlling Reservoir	Area	Supply Node	Area Demand (l/s)	Min. Av. Head at Avg flow (m)	Min. Node
AWAJAN	8	5916	33.8	15.8	5845
AWAJAN	9	N5802	46.39	10.7	5621
AWAJAN	10	N6001	27.37	15.6	6010
AWAJAN	11	N6101	20.14	14.2	6024
AWAJAN	12	4136	20.52	12.7	N4103
AWAJAN	13	4130	31.45	18.8	4137
RES750	14	RES750	50.89	12.5	5314
RES815	15	RES815	8.63	37.0	6604
RES650	16	N3903	18.7	14.2	6042
RES640	17	RES625	74.35	13.4	4305
RESBATR	18	0412	48.16	13.9	0505
RESBATR	19	0412	43.96	18.5	0201
RESBATR	20	N0901	27.14	16.4	1306
RESBATR	21	0902	58.03	10.3	N1401
RESBATR	22	2007	169.06	12.6	2908

Details of the new pipework included in the ZAR2015 are shown in Chapter 2 in F/S main report.

Proposed Distribution Pipeline

Pipe Diameter (mm)	Total Length Required (m)
600	9300
500	600
400	9300
300	6900
200	6600
150	13400
100	9100

Attachment shows which pipework is not needed until after 2005. However, all the proposed reservoirs and the majority of the proposed pipework is needed as soon as possible.

Data Book shows Node data and Residual head of each model Area, vrz, Zarqa, Rusaifa & Awajan, and Hasymey & Sukna Areas.

L. ORGANIZATION AND OPERATION & MAINTENANCE

Appendix L
- ORGANIZATION AND OPERATION & MAINTENANCE -

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I. REGISTRATION

Water Authority of Jordan (WAJ) was established in December 1983 and became operational in January 1984, integrating the function of the following four entities:

(1) Amman Water and Sewerage Authority.

(2) Water Supply Corporation.

(3) Natural Resources Authority: Water Study and Irrigation Department.

(4) Jordan Valley Authority: Domestic Water Supply Section

In 1988, the ministry of Water and Irrigation (MWI) was established, and WAJ was put under the Minister of MWI.

Legally, "Water Authority Law" came into effect in March 1988, which authorized to establish the Water Authority as an autonomous corporate body with financial and administrative independence. According to the law, WAJ shall exercise the following responsibilities and tasks to achieve all the objectives intended by the law:

(1) Survey the different resources, conserve them and determine ways, means and priorities for their implementation and use.

(2) Develop the potential water resources, increase and improve their quality.

(3) Regulate the construction of public and private wells.

(4) Study, design, construct, operate, maintain and administer water and public sewerage projects.

(5) Draw terms, specifications and special requirements in relation to the preservation of water and water basins and protect them from pollution.

(6) Carry out theoretical and applied research and studies regarding water and public sewerage.

(7) Issue permits to perform public water and sewerage works.

(8) Regulate the uses of water, prevent its waste and conserve its consumption.

A Board of Directors was organized for determining the basic policy and strategy including the budget of WAJ, which consists of 12 representative of the related ministries and government organizations including the Minister of MWI, Secretary General of Jordan Valley Authority and Secretary General of WAJ. The chairman of the Board is the Minister of MWI.

2. ORGANIZATION OF WAJ

2.1 WAJ Headquarters

WAJ Headquarters consists of five administrative departments at the headquarters and eight governorate offices. Included in the administrative department are Administration and Finance, Operation and Maintenance, Projects, Water Resources, and Stores and Tender. Total number of employee of WAJ are 6,745 (in 1993) comprising of 1,701 staff at the headquarters and 5,044 staff in the governorate offices. Present organization of the WAJ headquarters including the governorate offices is presented in Fig 2.1

2.2 WAJ Zarqa

WAJ Zarqa governorate was established in 1985 as one of the governorate offices of WAJ and all the water administration was transferred from the Zarqa municipality. Total number of employee, WAJ Zarqa is about 607 or about 9 % of WAJ total. There are five departments under WAJ Zarqa governorate, namely, planning, studies and information department, operation and maintenance department, subscribers department, administrative and finance department, and Ruseifa water department. Present organization of the WAJ Zarqa is presented in **Fig. 2.2.** Allocated number of staff to each department are as follows:

• Planning, studies & information department	: 10
• Operation & maintenance department	: 347
• Subscribers department	: 87
• Administrative & finance department	: 41
• Rusaifa water department	: 122
• Total	: 607

Job description of the above organization is not available in WAJ. Through a series of interviews with the respective departments and sections, major jobs currently undertaken are clarified and briefed hereunder.

Under Planning, Studies and Information Department, there are three sections; 1) Planning and Development Section. 2) Supervising & Design Section and 3) Water Resources & Labs Section. Major jobs are to collect and analyze various kinds of technical data and information relevant to water sources, water supply and sewerage services, to design pipe networks, to conduct laboratory testing, and to keep data and records.

Operation & Maintenance Department has its main office in the premises of Zarqa Pumping Station. There are three sections under the department : 1) Drinking Water Section, 2) Sewage Section and 3) Maintenance Section, which are responsible for operation and maintenance of water and sewerage systems in Zarqa District except Rusaifa and Shennuller.

Subscribers Department has three sections; 1) Supervising Section, 2) Subscribing Requests Section and 3) Billing Section. Their jobs cover issues related to subscribers and house meters, including inspection at the site for registration of new customers, preparation of design drawing of house connections, supervisory works of their installation, customer meter calibration and maintenance, meter reading and bill collection, and receipt and response to customers' complaints.

Under Administration & Finance Department, there are three sections; 1) Administration Section, 2) Accounting Section, and 3) Supply & Storage Section. They are responsible for general and administrative matters which extend to control of incoming and outgoing letters, employees leaves, maintaining WAJ buildings, preparing payroll for salary, determining installation fee for house connections, book keeping, supply and delivery of stored materials including chemicals, office equipment, pipes and fittings, spare parts of vehicles, etc.

Rusaifa Water Department, although organized under WAJ Zarqa, has a different feature from the above. The department carries out operation, management and administration of the entire Rusaifa water supply system. From its responsibility vested on, it can be characterized as semi-governorate water authority.

Number of the customers for WAJ Zarqa are 73,830 households, which is equivalent to 14% of the total WAJ customers. Number of staff per 1,000 customers are 8.4 in WAJ Zarqa, while those are 12.7 in WAJ total. It can be concluded that staff customers ratio is relatively efficient in WAJ Zarqa.

3. OPERATION AND MAINTENANCE

Operation and maintenance of the water supply system, in general, aims to supply water to the whole service area in sufficient quality and quantity and to maintain the facilities under normal working conditions. WAJ's current practices for this area are briefly explained focusing on 1) organization and staffing, 2) system operation, 3) procurement and storage and 4) workshop and laboratory.

3.1 Operational Organization and Staffing

In WAJ Zarqa, two departments, i.e., "Operation and Maintenance Department, Zarqa" and "Operation and Maintenance Section of Rusaifa Water Department", are in charge of operation and maintenance of the water supply system including wellfields, pumping stations, transmission and distribution pipe network. To assist them in acihieving optimal and effective operation, "Planning, Studies & Information Department" conducts laboratory and field testing for quality control and water resource monitoring.

(1) Operation & Maintenance Department, Zarqa

"Operation & Maintenance Department" has its main office (Zarqa Water Office) on the premises of the Zarqa pumping station.

To manage and give direction, one management chief and 6 engineers are assigned to the department. Under them, there are 117 staff and technicians for operation and maintenance, including 44 persons of superintendents, plumbers, welders, workers and clerks at Zarqa Water Office and 73 operational staff at the pumping stations and wellfields.

Major jobs of the department are:

1) to maintain and operate pipe network including trunk, secondary and service mains, while house connections and meters are monitored and maintained under responsibility of Customer Department;

2) to maintain and operate mechanical and electrical instruments in pumping stations;

3) to operate valves and pumps based on the water rationing program;

4) to maintain vehicles on a routine basis, while a full scale repair is carried out under responsibility of WAJ Headquarter;

5) to convey water to the people resided in high and remote area of the governorate by water tankers (2 tankers as of June 1995) including its maintenance;

6) to supply water to the governmental institutions;

7) to record all relevant data in a standardized format including flow rate, pressure, water level, pump working hour, etc.

8) to prepare proposal for installation of pipe network in a new built-up area.

(2) Rusaifa Water Department

There are 55 staff and workers assigned under "Operation and Maintenance Section". It consists of 21 workers, 14 plumbers, 12 operators, 2 engineers, 2 electric and 1 mechanical staff, 2 welders, and 1 clerk.

Duties assigned are similar to Zarqa Water Office except the following tasks.

1) to control and monitor large consumer meters;

2) not to execute the work items 8) above, which is under responsibility of the other section.

3.2 System Operation and Maintenance

(1) *Wellfields and Pumping Stations*

As for maintenance of wellfields scattered in Zarqa Governorate, "Planning, Studies & Information Department" carries out the field test for monitoring monthly fluctuation of static and dynamic water level of each well.

Pumping stations are operated by "Operation and Maintenance Department Zarqa" and "Rusaifa Water Department". The former operates 6 pumping stations in Azraq, Hallabat, Khaw, Zarqa, Hashemeyeh and Murhib and the latter operates 4 pumping stations located in Rusaifa municipality.

Khaw pumping station which collects groundwater from Azraq, Hallabat, Za'atari and Khaldieh wellfields are operated in accordance with the agreement between WAJ Amman and Zarqa. This agreement which defines water allocation to each service area is usually updated yearly. According to the 1994 Agreement, maximum 1,700 m3/h of water can be delivered to Zarqa District (Zarqa and Rusaifa municipalities), while Amman municipality and Army camp in Zarqa receive maximum 2,200 m3/h and 100 m3/h, respectively.

Further, there is an agreement between Zarqa and Rusaifa In summer seasons when consumers' water demand increases under limited yields of the groundwater, water are allocated as follows. During almost five days in a week strating from 4:00 am Wednesday up to 21:00 pm Sunday, around 400 to 500 m3/h of water are delivered to Rusaifa. In the remaining two days of the week, water from Zarqa is boosted to 1,000 m3/h to supply northern hilly areas in Rusaifa.

In compliance with the agreements stated above, pumps and valves are carefully operated by WAJ staff of Zarqa pumping station. However, residents in most Rusaifa and north-west of Zarqa areas suffer from the chronic water shortage caused from the water rationing.

(2) Reservoir/Tank

Periodical maintenance for cleaning, leak detection and repair is not routined by WAJ. But operational staff and/or watchmen keep records on hourly fluctuation of water level at most of reservoirs/tanks except the balancing tanks that float on the pipe network.

The existing water supply system does not apply any treatement processes except chlorination. Chlorine dosage is usually carried out at the reservoirs and tanks of major pumping stations. Two types of chlorinators, pressure dosing type of stand and wall hanging and advanced type are equipped. The dosing rate is determined to ensure safety of the supplied water under direction of the qualified engineer. Typical chlorine containers used are of 1,000 kg and 50 kg capacity.

(3) Transmission and Distribution Mains

Repair crews organized under the departments carry out passive leak repair. Active leak detection and control has not been practiced yet. WAJ engineer explained any pipe bursts and leaks are usually repaired on the same day when it is found, although they depend on the site condition and leak causes.

(4) Other Facilities

(Customer Meters)
In WAJ Zarqa office, one set of meter calibrator is owned by Customer Department. On an average, 500 house meters are repaired yearly. Rusaifa Water Department also has one set of meter calibrator. Borken house meters are reparied there. They calibrated 500 and 1,000 meters in 1994, respectively.

(Water Tankers)
Two water tankers are operated each under Zarqa and Rusaifa offices. Since large scale repair of mechanical equipment such as pumps and vehicles are being made under responsibility of WAJ Headquarters, the Rusaifa and Zarqa offices retain only small tools and devices for leak repair and pipe installation. As to transportation, each office operates a sufficient number of pick-ups and trucks for system operation and maintenance.

3.3 Procurement and Storage

Procurement is usually made by WAJ Headquarters upon request by WAJ Zarqa. WAJ Headquarters has standard specifications for all equipment and materials. Hence, their quality and quantity are kept at a certain level satisfactory to WAJ.

Small length of steel pipes, ductile iron pipes, polyethylene pipes are stored in the yard near Zarqa Pumping Station. These stored materials are under control of Supply & Storage Section, Administration & Finance Department, Zarqa. Stored materials are not

necessarily kept in suitable conditions. Pipes exposed for a longer period under the sun sometimes degrade its quality of lining and pipe wall itself.

Bulk of chemicals (chlorine tanks) are stored at storage houses in As-Samura and Amman. They are periodically delivered to the site when required. In average, chemicals at site are for two weeks - one month usage. They are sufficient in quantity for normal operation.

As regards house meters (B-class, ISO standard), Subscribers Department of WAJ Zarqa and Rusaifa Water Department usually keeps 2,000 and 500 meters respectively. The house meters are delivered from Amman Storehouse after sample calibration to the respective department. These meters are considered sufficient in number and performance.

3.4 Workshop and Laboratory

There are two minor workshops, each in Zarqa and Rusaifa. They are merely for meter calibration and repair. Full scale repair of pumps, flow meters and vehicles is being done at Amman Workshop.

Laboratory testing is carried out under Water Resources & Laboratory Section, Planning, Studies & Information Department of WAJ Zarqa. The engineers and inhouse staff take samples at major water supply facilities in Zarqa governorate on a routine basis. The sampled water are brougt into the Microbiological Laboratory in Amman. WAJ Zarqa engineers carry out all testing and analyses. These activities aim to 1) monitor trends and quality of the groundwater acquifer in the governorate, and 2) to ensure safety of the water quality based on the drinking water standard. Biological and physical parameters such as bacteria, faecal coliform, total coliform, pH, turbidity, residual chlorine are tested on a daily basis. Due to the slightly limited capacity of the Laboratory, average 20 samples in a week are brought in for testing. Chemical parameters such as fluoride, calcium, magnesium, TDS, nitrate, saudium, potasium, chloride, sulphate, carbonate, bicarbonate are examined once or twice a month according to the neccessity. As to heavy metals and trichlroethylene, WAJ carries out once a year. Parameters and frequency of the routine water testing are considered sound and favorable.

In addition, this section carries out water sampling at all private wells for laboratory testing. Waste water from the major factories are also tested. This is to monitor and control groundwater contamination in Zarqa governorate.

4. Meter Reading, Billing and Bill Collection

4.1 Meter Reading

Meter reading is being carried out by WAJ collectors (collectors conduct both meter reading and bill collection) every three months. There are 74,000 water subscribers in WAJ Zarqa governorate, about 70% of which are in Zarqa and the remaining 30% in Rusaifa. Total number of collectors working in WAJ governorate is 50 (35 in Zarqa and 15 in Rusaifa). Number of subscribers to be covered by one collector are 500 to 2,000, in principle, depending on the densities of the house connection.

Most of the meters installed are relatively small in diameter, 1/2" (99%) and 3/4" (1%). As WAJ frequently conducts meter calibration at their meter shop, unfunctioning meters seem negligible in number. But, meters are inadequately installed above the ground and/or in their kitchen, and some subscribers tend to tamper (remove or reversely reinstalled) illegally.

Meter reading is usually conducted within 3 weeks (sometimes 4 weeks or more). A meter reading card is prepared at the site, based on which water consumption for each subscriber is computed and recorded in the WAJ Zarqa.

4.2 Billing and Bill Collection

All the data are processed by computer in WAJ Zarqa for preparation of bills. Water bills thus prepared are distributed to subscribers every three months by collectors. In general, 2-3 weeks are required for preparation and distribution of bills. As meter readers are familiar with local conditions, they are also engaged in bill collection. Periodical shifting of bill collectors to other area has not been conducted.

According to the regulation, subscribers should pay the bill within 7 days after receiving the bill, and if failed, water supply is to be cut off. However, this regulation is not applied strictly in due consideration of the physical situation and its practical effect. Actually it takes about two weeks to collect the bill after distributing the bill.

There are three payment methods, namely pay to collectors, bring cash to WAJ and pay through banks. Most of the subscribers (60-70%) are paying to collectors in WAJ Zarqa, and the remaining bring cash to WAJ Zarqa. Payment through banks is quite limited.

Whole the process of the bill collection is summarized in **Fig. 4.1.**

According to the statistics in WAJ Zarqa, billing amount and the actual collection in 1994 are as presented below :

Bills and Collection

QUARTER	BILLING	COLLECTED	COLLECTED/ BILLING
1st	515,156	391,878	0.76
2nd	510,281	482,540	0.94
3rd	714,159	618,185	0.86
4th	749,314	713,005	0.95
Total	2,488,912	2,205,608	0.89

Source : Subscribers Dept., WAJ Zarqa

Ratio of collected/ billing in 1994 is 0.89, which indicates high recovery of the bill compared to that of other developing countries.

According to the information collected through UFW survey and in WAJ Zarqa, the following problems need to be solved or improved:

1. many subscribers tend to maltreat water meters.
2. it takes 2 months or more for collecting bills including meter reading.
3. quarterly billing instead of monthly billing is being practiced.
4. bill collectors work as meter reader as well as bill collector, and periodical shifting of them is not being practiced.

5. Financial Management

5.1 General

As mentioned in the earlier section, management of WAJ, is still being centralized. All the budgets of the local governorates are planned and controlled by WA Headquarters. Water bills are collected by local governnorates which are remitted to and managed by the central office.

Major expenses such as payroll of the employees and electricity are being paid through the central office. The budget for additional investment and repair is also being controlled by the central office.

5.2 Tariff Structure

Present water related charges in Jordan are presented in Table 5.1. Applied tariff rates in Zarqa District both for water and sewerage are summarized below.

Water and Sewerage Tariff

Block (3 months consumption)	Water Tariff	Sewerage Tariff
0 - 20 M^3	0.065	0.030
21 - 40 M^3	0.090	0.040
41 - 70 M^3	0.300	0.100
71 - 100 M^3	0.500	0.200
101 M^3 more	0.600	0.250

Source: Information Dept., WAJ

In January 1994, water tariff for specific consumers was abolished and there is no different tariffs between domestic consumption and such bulk consumer as commercial and industry.

Beside the above two tariffs other fees and charges are to be imposed in the following manner :

For water supply:

Meter charge	:	JD 0.300 per quarter
Connection fees (for house connection)	:	JD 88 per connection for 3/4 inch pipe

JD 103 per connection for 1 inch pipe

JD 209 per connection for 2 inch pipe

For sewerage:

Connection fees (for house connection)	:	25% of the rental value of property (house)
Sewerage Tax	:	3% of the rental value of property (house)

5.3 Financial Statement

5.3.1 Financial Statements of WAJ Headquarters

Income statements of WAJ during the past 5 years are presented in Table 5.2. Figures in 1994 indicate that the total revenue almost covers salaries and wages and O&M cost. However, depreciation cost and interest on loans could not be covered by the revenue. Deficit for the year reached to J.D 49.3 million in 1994, which is larger than the annual income.

Total expenses are almost two times of annual income, which results in producing considerable deficit yearly.

Based on the actual water consumption in 1994, the revenue and the cost are analyzed as presented below:

Revenue and Cost Analysis, WAJ in 1994 (JD)

Revenue / cost			Revenue / cost per m^3 *
1.	WAJ Revenue		
	1)	Water Revenue	24,269,095	0.25
	2)	Water revenue plus sewerage revenue and sewerage tax	34,195,141	0.35
2.	WAJ OM. Cost		
	1)	O&M Cost excluding depreciation	41,919,786	0.43
	2)	OM. Cost plus depreciation	69,505,770	0.71
	3)	OM. Cost plus depreciation and interest	85,288,268	0.87

* Above figures are calculated on the basis of the water consumption (billing amount) of 97,888,825 m^3 in all WAJ.

As indicated above revenue from the sale of water is JD 0.25 /m3. Even if sewerage revenue and sewerage tax are added, the revenue increases by 4% to the level of JD 0.35/m3. However, the revenue could not cover OM cost of JD 0.43/m3, which accounted for 49% of the OM cost plus depreciation, and 40% of the OM cost plus depreciation and interest respectively.

Operational and Maintenance costs of WAJ during the past 3 years are summarized as presented below:

	1992		1993		1994	
Salary and Wages	13,316,713	(19.9)	15,218,277	(21.4)	16,099,444	(18.9)
Electricity	8,318,353	(12.4)	14,996,061	(21.1)	16,966,535	(19.9)
Repair and Others	11,192,675	(16.7)	4,518,724	(6.3)	8,853,807	(10.4)
Depreciation	22,332,096	(33.4)	24,388,270	(34.3)	27,585,984	(32.3)
Interests	11,838,784	(17.6)	12,043,867	(16.9)	15,782,498	(18.5)
Total	66,998,621	(100%)	71,165,199	(100%)	85,288,268	(100%)

As indicated above, about one fifth of the total OM costs are for salary and wages, while about 20% for electricity. High rate of electricity cost is attributed to the type of water resources (mainly wells) and required long transmission in Jordan.

Depreciation shares about 30% showing relatively high ratio, while 17-18% of the total cost was allocated to interest.

Balance sheets of WAJ during the past 5 years are presented in Table 5.3. Source and application of fund of WAJ during the period of 1989-1993 is also prepared as presented in Table 5.4. As indicated, investment in fixed assets is being financed by government contribution and long term loan. Annual income could not cover the depreciation cost and the annual deficit was finally offset by reducing WAJ capital. Net capital of WAJ has been decreasing since 1988 which reached JD 34 million in 1994, despite of considerable contribution from the government.

5.3.2 Financial Situation of WAJ Zarqa

Independent accounting system has not been introduced in each WAJ governorate and the system is still centralized. Therefore the governorate balance sheet has not been prepared and even detailed information on income statements for WAJ Zarqa is not available. On the basis of the governorate information, annual budget for WAJ Zarqa is prepared by WAJ Headquarters, which is presented in Table 5.5.

Expected total revenue of WAJ Zarqa in 1995 is about JD 4.0 million which consists of revenue from water (JD 3.1 million) and revenue from sewerage (JD 0.9 million). Total

expenses are projected at JD 5.0 million excluding depreciation and interest costs. The resulting net revenue is estimated at minus JD 1.0 million.

On the bases of the assumed water consumption in 1995 (14,358,000 m^3), unit revenue and cost for WAJ Zarqa are calculated.

For the calculation, depreciation cost for capital expenses and interest cost to be shouldered by WAJ Zarqa are tentatively estimated by applying the customers' share of WAJ Zarqa in WAJ total.

Depreciation cost :

27,600,000 X 0.14 = 3,864,000

Interest cost :

17,509,000 X 0.14 = 2,451,000

The estimated figures for WAJ Zarqa are as follows :

1)	Water Revenue	JD 0,210 / M^3
2)	Sewerage Revenue	JD 0,064 / M^3
3)	Total Revenue	JD 0,280 / M^3
4)	Total Expenses	JD 0,352 / M^3
5)	Total Expenses plus Depreciation	JD 0,621 / M^3
6)	Total Expenses plus Depreciation and Interest	JD 0,791 / M^3

From these figures, the following conclusive remarks can be made on the financial situation of WAJ Zarqa :

1. Total revenue covers about 80% of the total expenses excluding depreciation.

2. Since the total revenue is only 45% of the total expenses plus depreciation, substantial increase in revenue or cost reduction is pre-requisite for the cost recovery.

3. If interest is included, present total revenue covers only 35% of the cost.

Historical revenue of WAJ Zarqa during the period of 1990-1994 are presented in Table 5.6.

5.4. Overall Comments

Among various difficulties and problems facing WAJ, the most serious one is the fact that the expenses exceed income from water revenues and contributions from the GOJ. On the basis of financial data of 1994, average cost of water per cubic meter is calculated at JD 0.87 including depreciation and interest on loans. However, average revenue from water is estimated at JD 0.35 per cubic meter including sewerage fee and sewerage tax, which is equivalent to 40% of the production cost. The shortage is being partly covered by the government contribution, but the accumulated deficit has increased and net capital of WAJ decreased.

According to the recent study, this can be explained by relatively high operation and maintenance costs of WAJ and low efficiency in income.

High operation and maintenance costs are related to the following matters:

1. high percentage of unaccounted-for water;
2. high pumping cost (due to its topographic conditions);
3. high pressure and inefficient pipe alignment applied in the pipe networks; and
4. lack of appropriate maintenance and repair works.

Low efficiency in income side is related to :

1) weakness in the collection of revenues due to
   - inadequate meter installation and maintenance.
   - inefficient meter reading and bill collection procedure.
   - weak control and inspection systems.
   - inadequate accounting and cash receipt handling procedures.

2) centralized and inefficient budget process of WAJ; and

3) absence of separate product oriented budget system for the government.

In order to overcome the above problems, particularly the financial issues of WAJ, it is suggested that the following improvement are to be introduced.

1) Income increase from sale of water and waste water (increase tariff, tariff structure improvement).

2) Improvement of financial arrangement with GOJ (increase of government contribution, special arrangement for the existing loans).

3) Increase productivity and cost reduction (renovation of management and organization including privatization scheme).

6. ORGANIZATION RESTRUCTURING

In order to solve the structural problems of WAJ and the related water organizations, two studies are being conducted by Canadian International Development Agency (CIDA) and German Technical Cooperation (GTZ).
CIDA plans to rationalize and strengthen the institutional responsibilities through restructuring water related organizations including Ministry of Water and Irrigation, WAJ and JVA. GTZ is now conducting a study of operations and management support for WAJ, Amman. In the GTZ study, organization of WAJ, Amman is proposed to be decentralized and transformed to a commercially oriented autonomous water and sewerage company.

An action plan proposed for the decentralization is:

1) Decision of GOJ to grant relative autonomy to Water And Sewerage Company Amman (WSCA), and to exempt the WSCA from some of the most rigid civil service rules and regulations.

2) Provision of a budget to the WSCA, starting with a fixed subsidy and gradually decreasing year by year, thus forcing WSCA to operate efficiently and cost conscious.

3) Delegation of all necessary administrative and financial power to WSCA.

4) Intensive training and preparation of existing staff on skills and management techniques, required for the establishment of WSCA.

5) Implementation of organizational changes.

For materializing the structural change conceived above, further studies and discussions among the parties concerned would be necessary.

Tables

Table 5.1. WATER & SEWERAGE TARIFF

1. Amman Governorate Tariff

Tariff Block (Cubic meter for 3 months consumption)		Price (Fils /cubic meter)
From	0 - 20	100
	21 - 40	190
	41 - 70	400
	71 - 100	500
	101 +	600

2. Remaining Ghour (Jordan Valley) Area Tariff

Tariff Block (Cubic meter for 3 months consumption)		Price (Fils /cubic meter)
From	0 - 20	65
	21 - 40	115
	41 - 70	250
	71 - 100	400
	101 +	600

3. Remaining Kingdom's Governorate Tariff

Tariff Block (Cubic meter for 3 months consumption)		Price (Fils /cubic meter)
From	0 - 20	65
	21 - 40	90
	41 - 70	300
	71 - 100	500
	101 +	600

4. Sewage Tariff

Tariff Block (Cubic meter for 3 months consumption)		Price (Fils /cubic meter)
From	0 - 20	30
	21 - 40	40
	41 - 70	100
	71 - 100	200
	101 +	250

Source : Information Dept., WAJ 1994

Table 5. 2 WAJ INCOME STATEMENTS, 1990-1994

Revenue	1990	1991	1992	1993	1994
Revenue					
Water Revenue	15,419,933	16,096,536	18,464,468	21,805,262	24,269,095
Revenue of Water by Tanks	190,731	241,227	185,323	243,581	332,752
Sewerage & Drainage Revenue	982,410	1,581,221	3,380,938	4,324,811	4,516,323
Sewerage Tax	2,500,003	3,717,430	4,056,347	4,170,716	5,409,723
Subscribtion,Maintenance & Connection	2,245,538	1,647,984	1,607,992	3,754,851	4,239,095
Bank Interest	384,788	530,618	128,218	132,554	48,431
Other Revenue	198,694	538,671	16,299	392,533	1,274,909
Total Revenue	21,922,097	24,353,687	27,839,585	34,824,308	40,090,328
Expenses					
Salaries & Wages	11,086,670	13,509,452	13,316,713	15,218,277	16,099,444
Operation & Maintenance Exepen	13,166,111	16,605,450	19,057,232	19,017,254	25,187,607
General & Administrative Expen	971,872	572,821	453,796	497,531	632,735
Depreciation	15,379,082	21,679,601	22,332,096	24,388,270	27,585,984
Interest on Loans	8,868,825	7,490,219	11,838,784	12,043,867	15,782,498
Total Expenses	49,172,560	59,857,498	66,998,621	71,165,199	85,288,268
Excess of Expenses over Revenue	27,250,463	35,503,811	39,159,036	36,340,891	45,197,940
Differances in Rate of Exchange	8,693,389	4,319,173	3,213,966	2,26,909	4,129,084
Previous Years Adjustments	0	763,432	0	0	0
Deficit for the Year	35,943,852	39,059,552	42,373,002	38,567,800	49,327,024
Prior years Defict	74,754,262	110,698,114	149,757,666	192,130,668	230,698,468
Accumulated Deficit	110,698,114	149,757,666	192,130,668	230,698,468	280,025,492

Source: WAJ, Finance Directorate

Table 5.3 WAJ BALANCE SHEET AT DEC.31, 1990-1994 (1)

Assets	1990	1991	1992	1993	1994
Fixed Assets					
Cost	344,803,604	449,334,,987	477,354,772	526,154,425	569,291,298
Accumulated deprciation	55,371,496	84,489,149	106,821,244	131,209,514	158,020,858
Net Book Vlue	289,432,108	364,845,838	370,533,528	394,944,911	411,270,440
Work In Progress of Projects	21,694,439	33,045,725	42,503,756	49,737,975	54,205,459
Current Assets					
Inventories	7,583,379	9,265,893	11,658,097	11,816,219	11,459,419
Prepayments On Letters of Credit	0	0	0	0	0
Debtors Net of Provision	14,103,368	11,798,444	16,535,459	14,962,137	16,757,582
Misellaneous Debtors	876,932	975,974	2,486,375	2,733,185	2,157,188
Cash	4,424,065	4,081,580	4,099,596	1,628,895	798,357
Total Current Assets	26,987,744	26,121,891	34,779,527	31,140,436	31,172,546
Deferred Currencies Differences					
Differences of International					
Loans Reevaluation	91,394,298	0	0	0	0
Minus the Amount on this Year					
Note - B	8,693,389	0	0	0	0
Net Differences	82,700,909	0	0	0	0
Total Assets	420,815,200	424,013,454	447,816,811	475,823,322	496,648,445

Source: WAJ, Finance Directorate

Table 5. 3 WAJ BALANCE SHEET AT DEC.31, 1990-1994 (2)

Equity & Liabilities	1990	1991	1992	1993	1994
Equity					
Capital	233,541,681	249,534,385	271,022,280	296,414,377	314,444,110
Accumulated Deficit	110,698,114	149,757,666	192,130,668	230,698,468	280,025,492
Net Capital	122,843,567	99,776,719	78,891,612	65,715,909	34,418,618
Prvision for Contingencies	1,472,820	1,462,746	1,462,686	1,462,686	1,462,548
Long Term Loans					
International Loans	147,049,326	141,044,580	134,233,955	127,344,781	127,342,326
Local Lonas	17,796,621	216,82,972	39,531,742	56,598,001	76,879,347
Bonds & Debntures	15,325,000	21,325,000	21,325,000	21,325,000	21,325,000
Total Long Term Loans	180,170,947	184,052,552	195,090,697	205,267,782	225,546,673
Current Liabilities					
Creditors	5,385,313	257,369	6,367,048	9,065,294	13,887,823
Retention of Contractors	900,444	861,380	1,612,364	2,789,951	2,488,070
Deposits	17,899,892	21,599,711	24,068,073	26,047,917	26,742,896
Overdue Installements & Accrued intrest on Loans	84,427,830	109,170,233	133,533,105	158,113,581	182,168,335
Pension Fund	89,721	89,721	89,029	89,029	88,576
Banks	7,624,666	6,743,023	6,702,197	7,271,173	9,844,906
Total Current Liabbiliities	116,327,866	138,721,437	172,371,816	203,376,945	235,220,606
Total Equity & Liabillities	420,815,200	424,013,454	447,816,811	475,823,322	496,648,445

Source: WAJ, Finance Directorate

Table 5. 4 WAJ, SOURCE AND APPLICATION OF FUND, 1989-1993

Source of Funds	1989	1990	1991	1992	1993
Net deficit for the year	(26,787,389)	(35,943,852)	(39,059,552)	(42,373,002)	(38,567,800)
Depreciation	11,153,228	15,379,082	29,117,653	22,332,095	24,388,270
Contributions	10,506,738	11,595,486	15,992,704	21,487,895	25,392,097
Long Term Loans	85,566,177	16,237,517	24,088,153	29,816,111	21,035,532
Projects In progress	61,122,897	20,583,557	0	0	0
Diferd Currency Diferencies		334,507	0	0	0
Total Source of Fund	141,561,651	28,186,297	30,138,958	31,263,099	32,248,099
Application of Funds					
Settlment of International Loans	6,610,000	12,680,646	14,482,890	4,407,529	6,889,174
Settlment of Local Loans	3,660,666	4,108,195	5,723,659	14,370,437	3,969,273
Settlment of Bonds & Debentures	4,000,000	2,150,000	0	0	0
Fixed Assets	75,800,684	39,732,952	21,830,473	28,019,785	48,799,653
Work in Progress	0	0	11,351,286	9,458,031	7,234,219
Provision for Contingencies	27,000	180	10,074	60	0
Reevaluation L. Deffirences	83,035,416	0	0		
Total Application Funds	173,133,766	58,671,973	53,398,382	58,255,842	66,892,319
Decrease in Working Capital	31,572,115	30,485,676	23,259,424	24,992,743	34,644,220

Source: WAJ, Finance Directorate

Table 5.5 BUDGET FOR WAJ ZARQA, 1995

Item	JD
I. Revenue	
1. Water Revenue	
Water Charge	2,702,035
Connection Fee	250,286
Meter Charge	96,139
Repairing Fee & Others	62,295
(Sub - total)	(3,110,755)
2. Sewerage Revenue *	
Sewerage Charge	435,677
Connection Fee	416,000
Others	64,260
(Sub-total)	(914,937)
Total Revenue	4,025,692
II. Expenses **	
1. Salary and Wage	1,422,666
2. Electricity	3,007,107
3. Repair Cost and Fuel	457,053
4. Others	162,069
Total Expenses	5,048,895
III. Revenue minus Expenses	- 1,023,203

Source : WAJ Finance Directorate
* : Excludes sewerage tax to be collected by MOF
** : Excludes depreciation cost

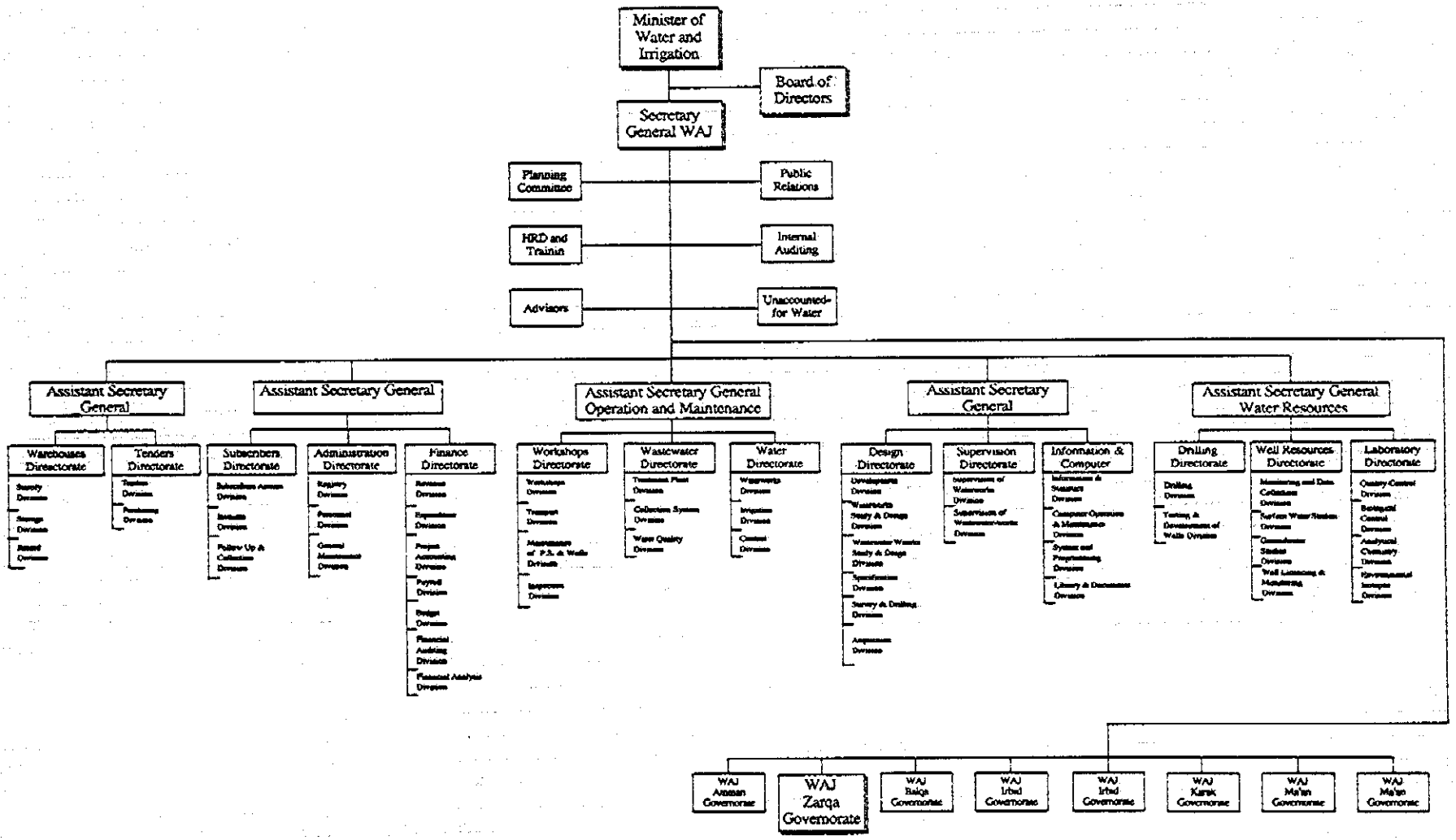
Table 5.6 REVENUE OF WAJ ZARQA, 1990-1995

	Water Revenue	Sewerage Revenue	Metere Charge	Total Revenue	Water Consumption (m^3)	Revenue per m^3	
						Water JD	Total JD
1990	1,543,107	92,950	55,893	1,691,950	9,833,122	0,16 m^3	0,17 m^3
1991	2,009,143	149,556	82,320	2,241,019	10,630,832	0,19 m^3	0,21 m^3
1992	1,862,256	280,511	78,702	2,221,469	16,195,058	0,18 m^3	0,22 m^3
1993	2,290,052	379,294	84,825	2,754,171	11,873,092	0,19 m^3	0,23 m^3
1994	2,648,543	385,737	88,917	3,123,197	13,306,818	0,20 m^3	0,23 m^3
1995 <1	3,014,616	914,937	96,139	4,025,692	14,358,000	0,22 m^3	0,28 m^3

Source : WAJ, Finance Directorate

<1 : WAJ, Zarqa Budget

Figures



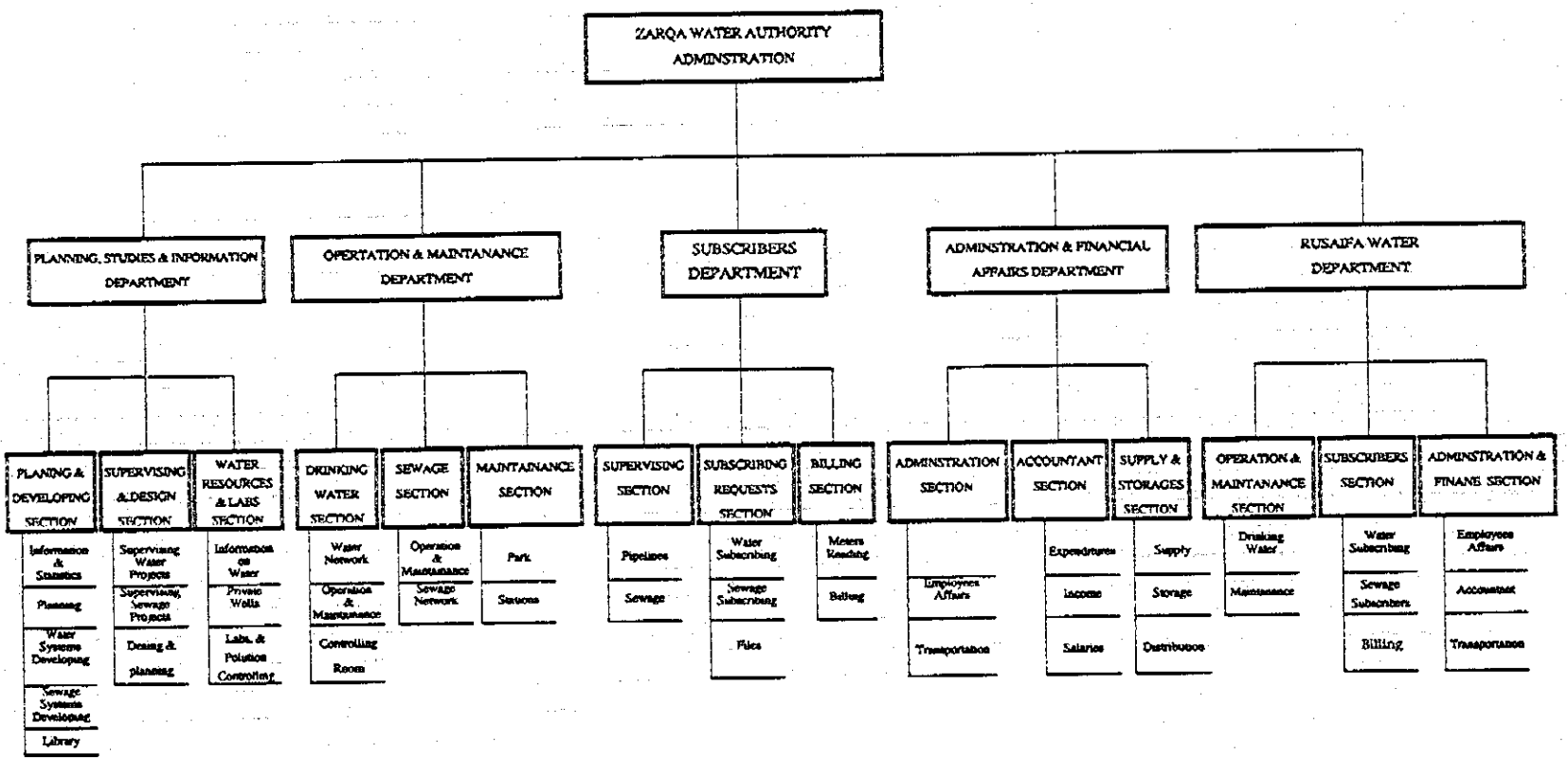
Source: WAJ

THE STUDY ON
THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM
FOR THE ZARQA DISTRICT

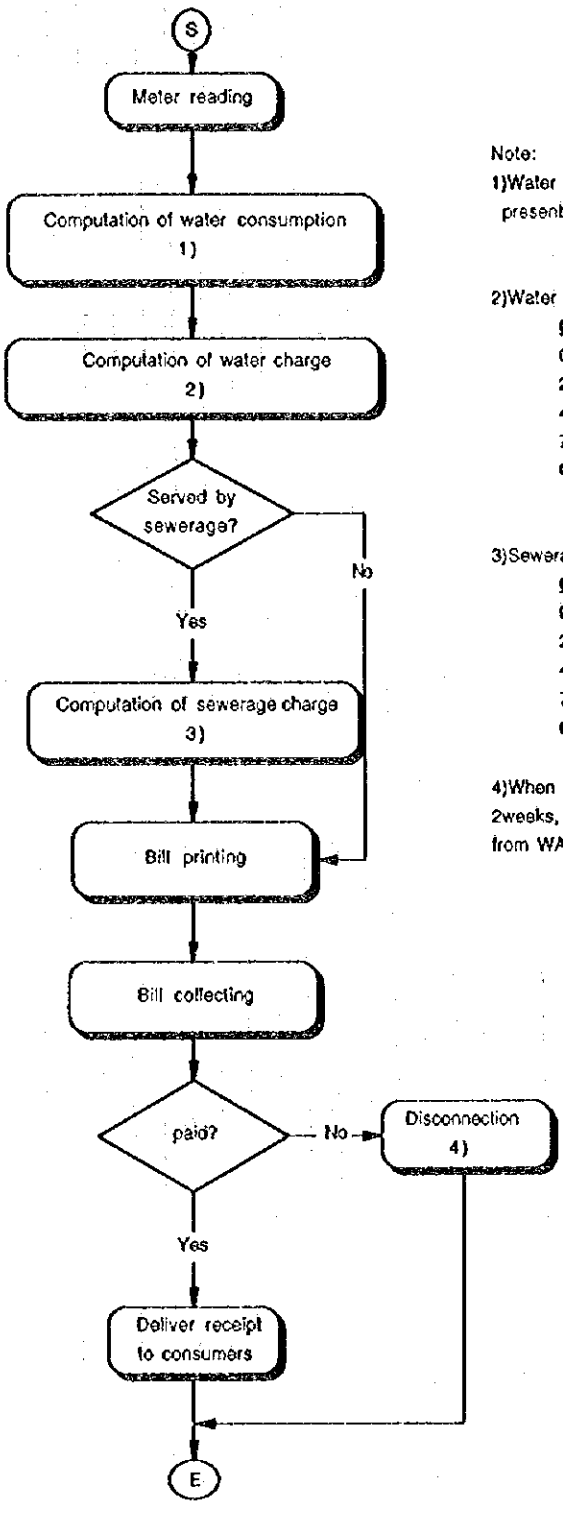
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.1
ORGANIZATION CHART OF
WAJ HEADQUATERS

Organization chart of Zarqa Water Adminstration



THESTUDYON THEIMPROVEMENTOFTHE WATER SUPPLY SYSTEM FOR THEZARQADISTRICT	Fig. 2.2 ORGANIZATION CHART OF WAJ ZARQA
JAPANINTERNATIONALCOOPERATIONAGENCY	



Note:

1)Water consumption =
present reading - last reading

2)Water charge as follows:

Class m3	Tariff fils
01 - 20	65
21 - 40	90
41 - 70	500
71 - 100	600
Over 100	600

3)Sewerage charge as follwes:

Class m3	Tariff fils
01 - 20	30
21 - 40	40
41 - 70	100
71 - 100	200
Over 100	250

4)When the payment delays for more than 2weeks, customers are disconnected from WAJ pipes.

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. 4.1 PROCESS OF BILL COLLECTION
JAPAN INTERNATIONAL COOPERATION AGENCY	

M. TRANSMISSION LINE AND RELATED PUMPING FACILITIES

Appendix M
- Transmission Line and Related Pumping Facilities -

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Appendix M Transmission Line and Related Pumping Facilities

Water supply system in the Study Area is designed with the following significant characteristics,

1. Zoning System (8 zones)
2. Separation of transmission and distribution pipes
3. Zarqa & Hashmeyeh Wells' water is transmitted to Khaw PS for blending
4. Awajan & Rusaifa Wells' water is transmitted to Awajan 21 PS (new) for blending
5. The existing wells' production rate will be half by the year of 2015 (it is reported that the existing abstraction exceeds the safe yields.)
   Thus, the water shortage(Demand-Supply) in future will be balanced by the water from Amman.

The considerations of each transmission line are explained mainly in this section, showing some alternatives and the derived results.

Hazen & Williams' formula is used for the hydraulic calculation.

$$I = 10.666 * C^{-1.85} * D^{-4.87} * Q^{1.85}$$

where, I: hydraulic gradient

Q: flow-rate, in m^3/s

C: velocity coefficient, 120

D: diameter of pipeline, in m

1. Supply to Hashemeyeh and Sukhna Zones (From Khaw to Hararieh (Hashemeyeh) and Sukhna Reservoirs)

The following four alternatives are considered:

A. Pump Flow from Khaw PS to Batrawi Res 650 and Gravity Flow from Batrawi to both zones
B. Pump Flow from Khaw PS
C. Pump Flow from Khaw PS to Hararieh (Hashemeyeh) Reservoir and gravity flow from Hashemeyeh to Sukhna reservoir
D. Gravity Flow from Khaw PS to Hashemeyeh PS and Pump Flow to Hararieh and Sukhna reservoirs

The four alternatives are shown in Fig. M.1. and summarized in the following Table. The other alternatives, for example, gravity flow from Batrawi reservoir to Sukhna zone is not considered because the pipe length is too long.

Table M.1 Main Features of the Alternatives (Supply to Hashemeyeh and Sukna Zones)

	Alternative A	Alternative B	Alternative C	Alternative D
Supply to Hashemeyeh	Pump from Khaw PS to Batrawi, then Gravity Flow	Pump from Khaw PS	Pump from Khaw PS	Gravity Flow from Khaw PS to Hashemeyeh wells, then pump
Supply to Sukhna	Same as above	Same as above	Gravity Flow from Harareih	Same as above
Pipes (New)	400 mm L=0.1 km 300 mm L=2.3 km 250 mm L=1.9 km 200 mm L=1.0 km 150 mm L=6.8 km Total L=12.1 km	300 mm L=2.4 km 200 mm L=5.7 km 150 mm L=7.8 km Total L=15.2 km	300 mm L=6.1 km 250 mm L=4.6 km Total L=10.7 km	300 mm L=2.4 km 150 mm L=7.8 km Total L=10.2 km
Pipes (Existing)	400 mm L= 4.7 km 150 mm L= 7.8 km Total L= 12.5 km	300 mm L= 5.7 km 150 mm L= 7.8 km Total L= 13.5 km	300 mm L= 5.7 km 150 mm L= 7.8 km Total L= 13.5 km	300 mm L= 5.7 km 150 mm L= 7.8 km Total L= 13.5 km
Required Pumping System	One (1) Khaw to Batrawi (share)	Two (2) Khaw to Harareih Khaw to Sukhna	One(1) Khaw to Harareih	Two(2) Hashmeyeh to Harareih Hashmeyeh to Sukhna
Pumps	Sharing the pumps for Zarqa zone	22 kW 4 units 18.5 kW 3 units	45 kW 4 units	30 kW 4 units 18.5 kW 3 units

Basically, the existing pipelines are carefully considered to choose the new transmission routes for each zone.

Alternative A is expected to have less energy cost. Water for Hashmeyeh and Sukhna zones is first transmitted to Batrawi Reservoir (GL=650 m) from Khaw PS (GL=595) together with the water for Zarqa zone. From Batrawi, water is transmitted to both zones by gravity. The transmission and pumping equipment from Khaw to Batrawi are common for Zarqa high and low zones and Hashmeyeh and Sukhna zones. Therefore, for the cost comparison, pump equipment and annual power cost for this Alternative are estimated by a proportion of the flow rates.

Water demand (daily maximum demand) in the year of 2015 for each zone is estimated at 72 l/s in Hashmeyeh zone and 27 l/s in Sukhna zone

Existing pipe (400 mm) between Zarqa and Hashmeyeh, which is currently used for transporting Hashemeyeh wells water to the Zarqa PS for blending, is converted to transmission line. The length of the section is 4.6 km. Also, in addition to the existing 150 mm pipe between Hashemeyeh and Sukhna, another 150 mm pipe is added.

Alternative B has two separate transmission lines to Hashemeyeh and Sukhna from Khaw PS. So, it is required to provide two pumping systems at Khaw PS, one for Hashmeyeh and the

other for Sukhna. The existing 300 mm pipe (5.7 km) from Khaw to Hashmeyeh is used for the supply to exclusively to Hashemeyeh. Additional pipeline of 200 mm is used for the supply to Sukhna up to Hashemeyeh point. From Hashemeyeh, the transmission line to Sukhna is also duplicated same as the case in Alternative A.

Alternative C is the series line from Khaw through Hararieh Reservoir (GL=600 m) to Sukhna Reservoir (GL=580 m). Water for both zones is once pumped up to the Hararieh Reservoir and from where water for the Sukhna zone is diverted by gravity flow. The transmission line between Hararieh reservoir to Sukhna Reservoir is also duplicated, but the diameter of the new line is 250 mm different from the 150 mm in Alternatives A and B. Same as Alternative B, the existing 300 mm pipe is used from Khaw PS to Hashmeyeh.

Alternative D follows the current supply system, enlarging the facility size according to the demand increase. Water from Khaw is gravitated to the existing Hashmeyeh PS (GL=532 m), then transmitted to each zone by pumps. Two pumping systems are planned for each zone.

Estimated Costs and Net Present Value

For each alternative, capital and annual operation costs are estimated as shown below.

(unit: US$ 1,000)

	Pipe-Laying Cost	Pump Equipment Cost	Capital Total	Annual Operation Cost
Alternative A	1,451	113	1,564	64
Alternative B	1,794	174	1,968	62
Alternative C	1,783	130	1,913	75
Alternative D	1,139	185	1,324	72

The net present value (NPV) is applied for the cost comparison of capital and annual operation costs giving 20 years calculation period and 10 % of discount-rate. The results are shown as follows:

Alternative A:	US$ 1,791,000
Alternative B:	US$ 2,128,000
Alternative C:	US$ 2,148,000
Alternative D:	US$ 1,657,000

Comparison

Alternative C is the second highest cost (and almost equal to the highest cost) and the highest NPV. This is caused by the small difference in elevations between Hashemeyeh and Sukhna, resulting in larger 250 mm pipe. Hence, this alternative C is excluded from the selection.

Alternatives B is the highest cost and the second highest NPV owing to the independent pipes to the both zones. As a result, this alternative B is excluded from the selection.

Out of the remaining alternatives A and D, despite the lowest NPV in Alternative D, considering non-economic aspects such as O&M, land acquisition for pumping station, and technical aspects, we recommend Alternative A with the following specific reasons:

① In alternative A, further land acquisition is not required for pumping station, because pumps are common for Zarqa zone. In addition, flow rate for Hashmeyeh and Sukhna zones is relatively small, about one seventh (1/7) of that of Zarqa zone.

② Power cost is proportional to flow rate, but in the case of Alternative A, the power of large capacity pumps (310 kW) for the Zarqa zone will not increase even the flow rate increased by few percentages (the demand of Hashmeyeh and Sukhna zones).

③ Alternative A has less operation cost than Alternative B.

④ In terms of flow control to Hashmeyeh and Sukhna zones, Alternative D needs telemetry system to control each pump according to the reservoir water level. However, in the case of Alternative A, flow control will be done only with float valves at each reservoir.

2. Khaw to Zarqa Zones

No gravity flow from Khaw PS to Zarqa PS is expected due to topographical condition. Accordingly, it is clear that the direct pumping up system from Khaw PS to Batrawi Reservoir is the more advantageous than the existing two staged pumping up system at Khaw and Zarqa PS.

Hydraulic Calculation

1) Planned flow rate (in 2015):

Zarqa Low zone:	572.3 l/s
Zarqa High zone:	134.3 l/s
sub-total:	706.6 l/s
Hashemeyeh and Sukhna zones:	99.0 l/s
Total	805.6 l/s

2) Diameter and Length:

800 mm x L= 7,900 m (I=0.003)	From Khaw to Batrawi
400 mm x L= 2,200 m (I=0.032)	From Batrawi to Res 715 (Zarqa High reservoir)

3) Pumping Facilities

- Khaw to Batrawi:

Number:	5 units in duty
Total head:	77 m
Pump specification:	310 kW x 6 units (one standby)

- Batrawi to High zone (Res 716)

Number:	3 units in duty
Total head:	87 m
Pump specification:	75 kW x 4 units (one standby)

3. Khaw to AWAJAN 21 PS

The planned pipeline is to pass a hill of GL=662 m. Therefore, the pump head is decided to pass the hill. To save the energy cost, a junction tank is designed at the hill to make free water level. Then ,water is conveyed by gravity from the tank to Awajan 21. Thus, the transmission line has two parts,

Part one : Khaw to the junction tank (L=8,100 m) by pump up flow

Part two: The junction tank to Awajan 21 PS (L=4,100 m) by gravity flow

Alternatives

Two alternatives are considered here for the section of pressured part, viz., from Khaw to the Junction Tank to decide the pipe diameter. On the other hand, the gravity flow line from the Tank to Awajan 21 PS is decided as 400 mm in diameter with hydraulic aspects.

Two alternatives of smaller pipe diameter with higher pump head and larger diameter with smaller head are planned. The following table summarizes the Alternatives.

Alternatives

	Alternative A	Alternative B
Pipes	400 mm, L=8.1km, Q= 271 l/s	500 mm, L=8.1 km, Q= 271 l/s
Pumps	Total Head=161 m, 200 kW, 5 units (one standby)	Total Head=97 m, 132 kW, 5 units (one standby)

Cost Comparison

Pump equipment and pipe-laying costs and pump power costs are estimated as follows:

Estimated Cost (U$ 1,000)

	Pipe-Laying Cost	Pump Equipment Cost	Capital Total	Power Cost *1)	Total Cost
Alternative A	2,063	370	2,433	1,469	3,902
Alternative B	2,502	244	2,764	9,71	3,717

*1) Power cost is estimated for 6 years from 2005 to 2010 according to the expected flow rates in each year.

As the result of the above, since the total cost of Alternative B is less than that of Alternative A, Alternative B, 500 mm in diameter of pipeline is employed from Khaw to the Tank.

4. Awajan 21 to Rusaifa Zones (Res 750 and Res 810)

Water is transmitted to Rusaifa reservoir 750 by pumping up from Awajan 21 PS in the 1st Stage (target year =2005). Res 750 covers the Rusaifa low zone of which the altitude varies from 650 m to 710 m. Water is further pumped up from Res 750 to Res 810 which covers Rusaifa high zone.

Rusaifa Low Zone Reservoir (Res 750)

Up to the year of 2005 (1st stage), Res 750 gets the water from Awajan 21 PS by pump up system. In the stage 2 (target year=2015), the water from Amman is received at the point of Res 750. Then, the required amount of water is transmitted to Awajan 695 and Khaw PS by gravity flow from Res 750. Thus, the facilities are planned with the water demand in 2005 and the pipeline is checked with the 2015 year demand later.

1) Pipeline

New pipeline is installed from Awajan 21 PS to Res 750. There would be a alternative thinking to plan the pipe diameter in terms of pumping capacity. However, in the year 2015, the flow form Res 750 to Awajan 21 PS by gravity flow is expected as 289 l/s, which is smaller than the flow in 2005 (362 l/s). Taking into consideration the future reduction of transmission flow rate, 500 mm diameter pipe is recommended.

Flow rate: Q = 362 l/s (in 2005)

Diameter and length: D = 500 mm L=6.6 km I=0.0068

2) Pump

Number: 5 units duty and 1 unit standby

Discharge:	362 l/s x 1/5 = 4.4 m^3/min.
Total head:	225 m
Specification of pump:	290 kW x 6 units

Rusaifa High Zone Reservoir (Res 810)

The water is pumped up from Res 750 to Res 810.

1) Pipeline

Flow rate:	Q = 160 l/s (in 2015)
Diameter and length:	D = 400 mm (v = 1.27 m/s) L = 1.8 km I = 0.00444

2) Pumps

Number:	3 units duty and 1 standby
Discharge:	160 l/s x 1/3 = 3.2 m^3/min.
Total head:	71 m
Pump specification:	75 kW 4 units

Examination of Pipeline after receiving the water from Amman at Res 750

After receiving water at the point of Res 750, the water is able to be transmitted to Awajan 695 and Khaw PS by gravity flow. The pipelines planned for Stage-1 (from Awajan 21 PS to Res 750) are to be utilized for the transmission in Stage-2 (in 2015). The loss of head and the dynamic water level at Awajan 21 PS are computed as follows:

Flow rate:	Q = 289 l/s (in 2015)
Diameter and length:	D = 500 mm L = 6.6 km I = 0.0045
Dynamic water level at Awajan 21 PS:	715 meter

The transmission line to Awajan 695 is branched from the above 500 mm line between Res 750 and Awajan 21 PS, at about 5.7 km from Res 750. The diameter of this line (from the branch to Awajan 695) is 400 mm (L=1.4 km). The dynamic water level at the branch is expected as 730 m.

5. Awajan 21 PS to Awajan High and Low Zones

Two transmission systems are to be established from Awajan 21 PS to Awajan high zone (Res 695), and Awajan low zone (Res 640). Water demand allocated for Res 640 is small flow rate, about 10 % of total demand in Awajan zone so that whole water is to be pumped up to Awajan 695, then water for the low zone is transmitted to Res 640 by gravity flow.

Facilities are usually planned for the water flow in the target year. Nevertheless, the facilities in this section are planned for the water flow in the year 2010. The reason is as follows;

Future water shortage is to be balanced with the water from Amman. The supplied water from Amman will come to the point of Res 750 (Ruseifa low zone reservoir). So, the demand increase in Awajan zone is covered by the flow from Res 750 in Ruseifa after 2010. The water demand in 2010 will reach at 366 l/s , which is supplied by the water from Khaw PS, Awajan Wells, Rusaifa Wells, and Rusaifa Res 750. The flow pumped up from Awajan 21 PS to Awajan 695 will be gradually decreased after 2010. Thus, pumps are planned with the flow in 2010. After 2010, the water supplied from Rusaifa Res 750 is to be conveyed by gravity flow to Awajan Res 695.

1) Pipeline from Awajan 21 to Awajan 695
   The existing pipeline of 600 mm in diameter branched off from Khaw-Amman line which has not been used for long period, is to be used as a transmission line from Awajan 21 to Awajan 695 Reservoir.
   - Flow Rate: 366 l/s
   - Diameter and Length: 600 mm L=2.0 km I=0.0029
2) Pumps
   4 units of pumps (5.5 m^3/min. each) in duty and 1 unit standby are planned.
   - Total head: 122 m
   - Pump specification: 220 kW 5 units (one standby)
3) Transmission line to Res 640
   - Flow rate: Q = 63 l/s (in 2015)
   - Diameter and length: D = 200 mm L = 0.8 km I= 0.023
   - Loss of Head: 19 m (residual head at Res 640 is expected to be 34 m, which will be regulated by control valve)

Examination of pipeline in the year of 2015

Water supplied from Amman is conveyed to Awajan and Zarqa zones by gravity flow through the above-mentioned transmission lines installed by 2005. As described in the previous section, part of water from Amman is to be conveyed from Res 750 to Awajan 695 in 2015. 400 mm pipe is to be installed, branched from the transmission line between Res 750 and Awajan 21 PS in future.

Hydraulic Analysis

1) Pipe
   - Flow rate: Q = 398 - (215 + 10 Murhib) = 183 l/s
   - Diameter and length: D = 400 mm L = 1.4 km I = 0.005

2) Pump to be used at Awajan 21 PS

Total flow rate:	215 - 10 = 205 l/s
Installed pumps:	5.5 m^3/min. (92 l/s) x 5 units
Operation of pumps:	5.5 m^3/min. x 3 units

6. Hashemeyeh and Zarqa Wells Water to Khaw PS

Hashemeyeh and Zarqa wells' water with high contents of TDS is transmitted to Khaw reservoir for mixing with lower TDS contents water to dilute high TDS concentration. In this section, the results of the hydraulic analysis for pipelines and pumps from the wells to Khaw PS is described briefly.

Hashemeyeh Well to Khaw PS

1) Pipeline

The new pipeline of 250 mm in diameter is installed.

Flow-rate:	Q = 150 l/s	
Pipe length:	(existing)	D = 300 mm L = 5.7 km
	(new)	D = 250 mm L = 5.7 km
		equivalent D = 360 mm
	I = 0.0066	

2) Pumps

Total head required: 150 m

It is assumed that present pumping water level is 55 m to 58 m down from the ground level according to the observation well records. Total head of existing pumps are 110 m to 150 m. The existing intake pumps (submersible motor type) is almost usable to transmit the well water to Khaw PS directly, except one pump with head 110 m which is to be replaced with new one. Thus, in this system, new one pump and the new 250 mm pipe is required to convey the well water to Khaw PS.

Zarqa Well to Khaw PS

1) Pipeline

The existing pipeline of 400 mm in diameter will be used as the transmission.

Flow rate:	Q = 140 l/s
Diameter and length:	D = 400 mm L=8,000 m , I=0.0035

2)Pumps

Since the water to Batrawi Reservoir is transmitted from Khaw PS, Zarqa PS will be abandoned in future. Accordingly, the pumps in Zarqa PS will be used as transmission pumps for well water to Khaw PS. Three pumps are utilized as 2 duty and 1 standby. The

pump discharge is larger than it of well pumps so that the flow control is required so as to meet the well yield. The existing pump specification is as follows:

Discharge: $Q = 300\ m^3/h = 5\ m^3/min.$

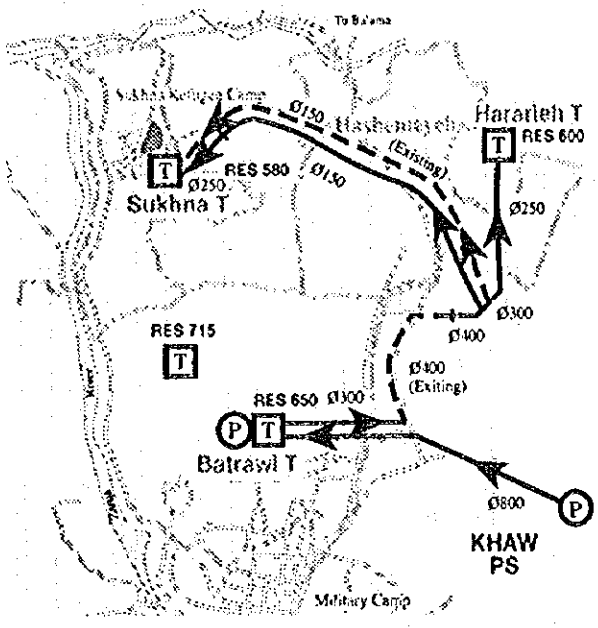
Total head: $H = 100\ m$

Pump specification: 220 kW x 3 units (existing pump)

Thus, there is no extra new investment needed for sending Zarqa Well water to Khaw PS.

Figures

ALTERNATIVE A



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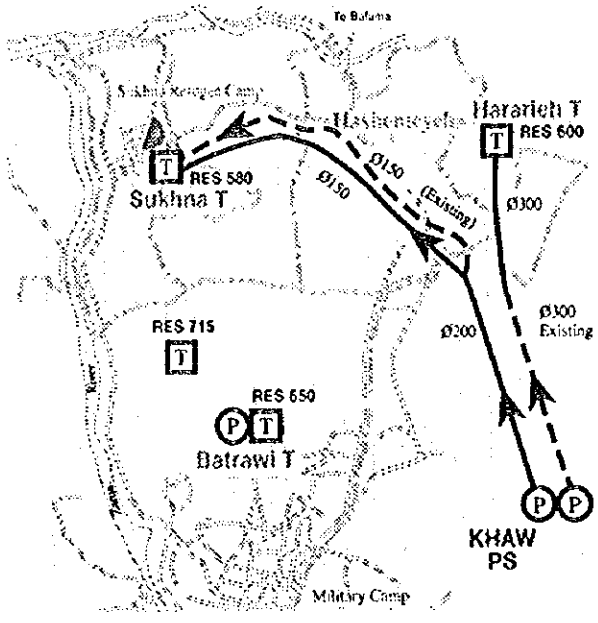

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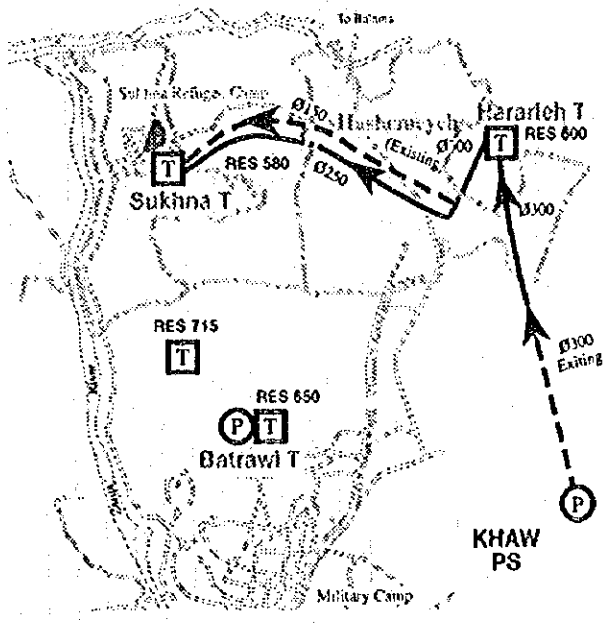
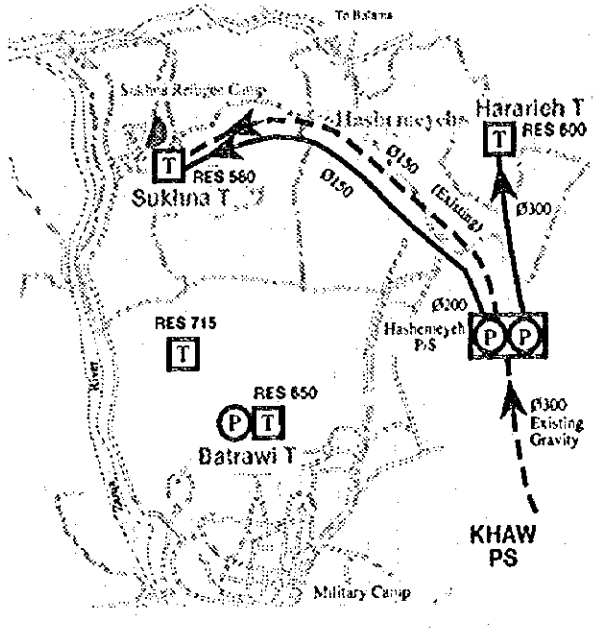


ALTERNATIVE D



Existing : - - - -

New : ——

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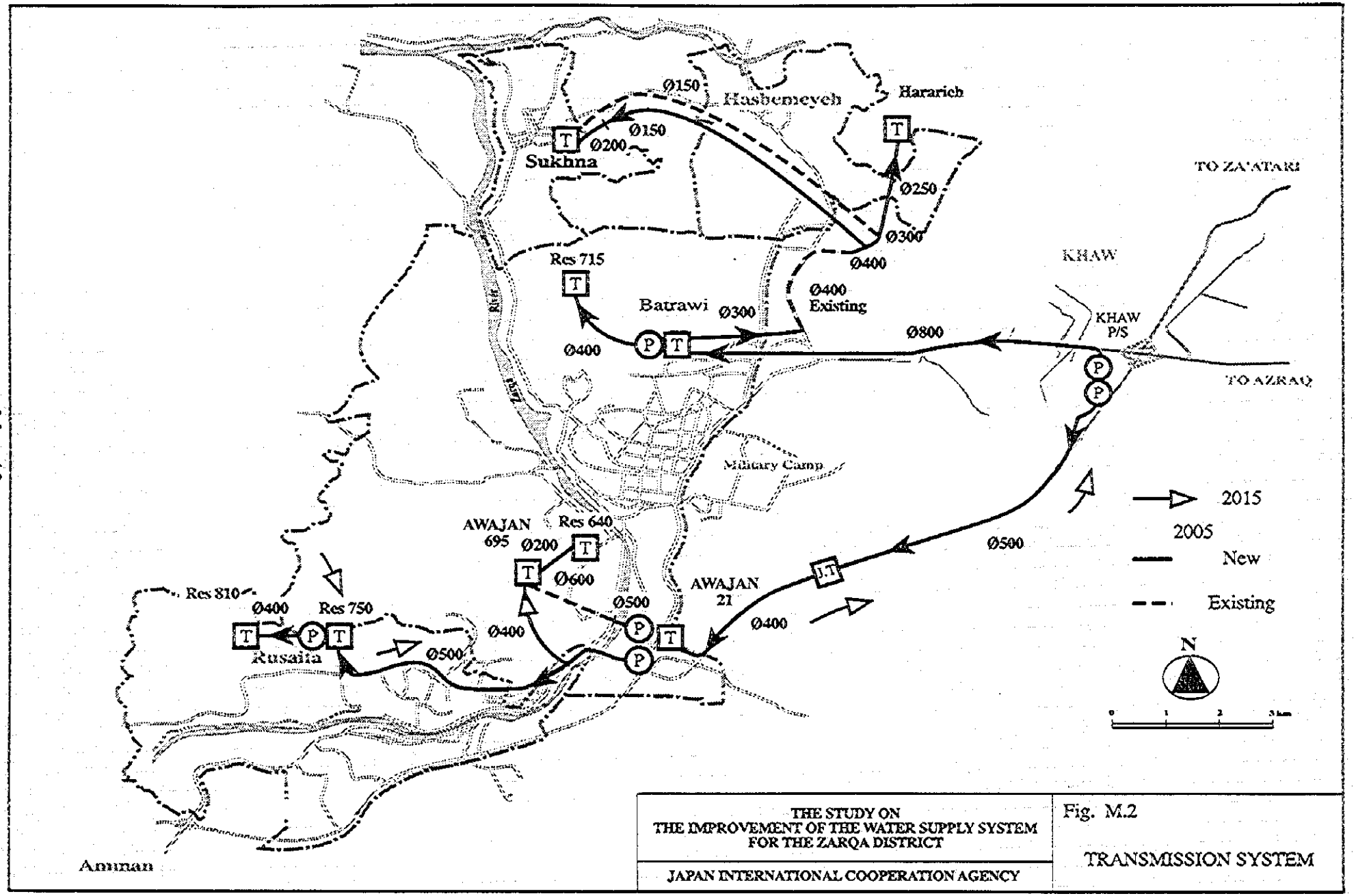
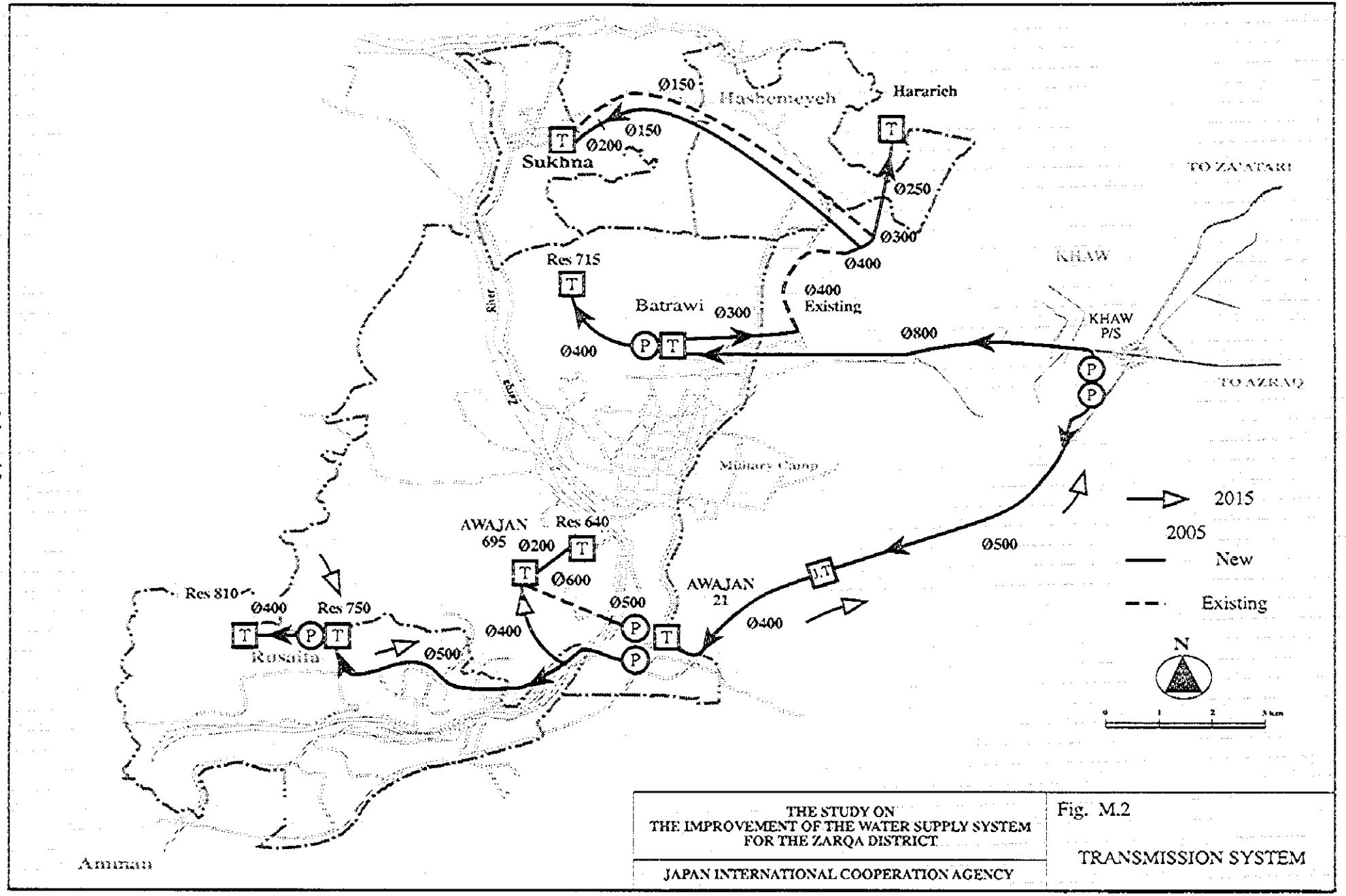
Fig.- M.1
KHAW TO HASHEMEYEH
SUKHNA ZONES
ALTERNATIVES



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. M.2
JAPAN INTERNATIONAL COOPERATION AGENCY	TRANSMISSION SYSTEM



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. M.2
JAPAN INTERNATIONAL COOPERATION AGENCY	TRANSMISSION SYSTEM

PART-II

FEASIBILITY STUDY

N. POPULATION AND WATER DEMAND BY ZONE

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APPENDIX N POPULATION AND WATER DEMAND BY ZONE

1 POPULATION BY ZONE

Population of each municipality has been forecast in "Part I Long Term Development Plan". This subsection attempts to distribute the projected total population to smaller unit of zones which are key inputs to feasibility study of Stage I Project.

Quoted from Part I, future population at 2005 are reproduced in table below:

Projected Population in the Study Area

Municipality	1994	1994 - 2000	2000	2000 - 2005	2005
Zarqa Mun.	344,524	2.8%	406,600	2.5%	460,000
Sukna Mun.	9,764	4.4%	12,600	3.9%	15,300
Hashemeyeh Mun.	13,038	4.7%	17,200	4.0%	20,900
Rusaifa Mun.	131,130	4.0%	165,900	3.3%	195,200
Schenuller	36,218	2.7%	42,500	2.4%	47,900
Total Study Area	534,674	3.2%	644,800	2.8%	739,300

Source: JICA Study Team

Future population by zone is estimated in due consideration of the present population density and future potential development in the Study Area within the projected total population frame. A flow chart for population distribution was prepared as shown in Fig.-N1 which is briefed hereunder.

The population census conducted in 1994 contains the population data for 67 sub-areas (zones) in the Study area as given in Table- N1. Population census sub-areas are shown in Fig.- N2.

This table shows that population density in 1994 substantially varies by zone from a high value of 510 persons/ha to a low value of less than 5 persons/ha. As observed in the past trend of population growth in each municipality, it is likely to reduce its growth rate particularly in highly populated areas. Instead, low and middle density areas will attract population and develop with a higher growth rate. Hence, all zones are grouped into 4 groups according to the population densities. They are:

G1 .... High population density (more than 290 person/ha),
G2 .... High medium population density (290 - 170 persons/ha),
G3 .... medium population density (170 - 10 persons/ha), and
G4 .... Low population density (less than 10 persons/ha),

which are also presented in Fig.-N3. G1 Group includes high density sub-areas in Zarqa municiaplity and Shennuler, while G2 Group contains subareas in Rusaifa and Zarqa municipalities. G4 group is an area where no development is expected due to the topographical limits.

By applying the different growth rates for each group, 2005 population of each zone is first estimated and then a population gap to the total was proportionally distributed to each zone based on magnitude of population. The zonal population thus estimated are given also in Table - N1.

2 WATER DEMAND BY ZONE

Multiplying the above population by same unit water consumption as that in VI. Projection of Population and Water Demand of Part I Long Term Development Plan, water demand by zone was computed. Unit water consumption applied is as follows:

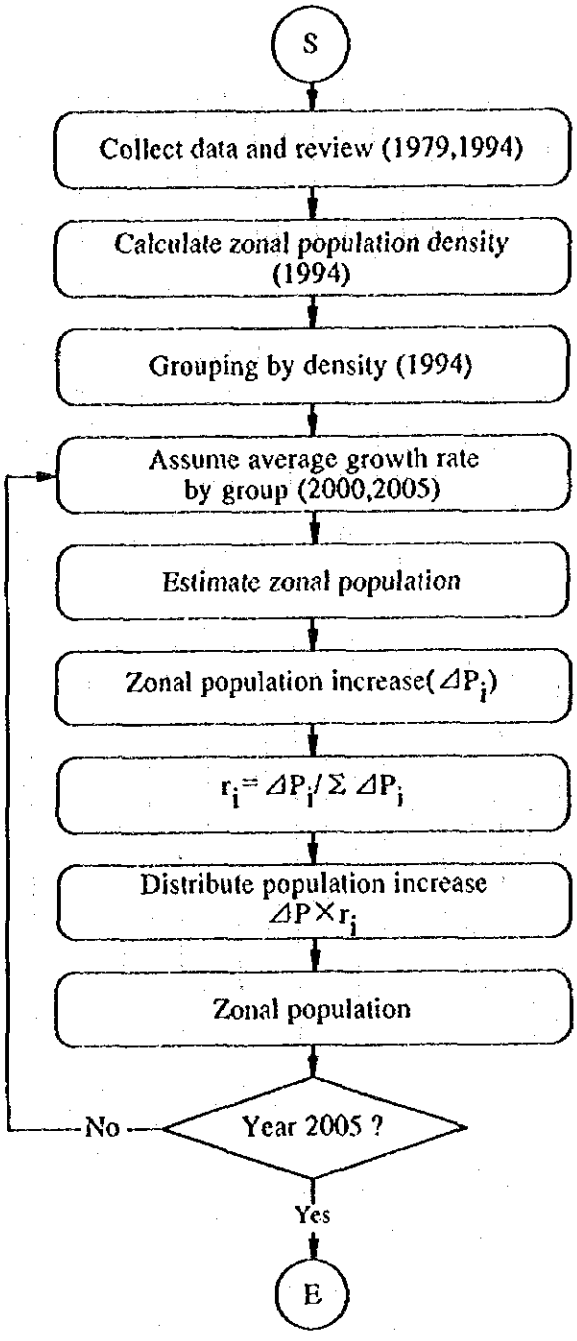
1) Daily average demand: 118 lpcd
2) Daily maximum demand: 142 lpcd

In computing water demand, any aerial change in unit water consumption was not considered because of its little variation by area. And population not served by water supply system are assumed negligible as compared to the total population.

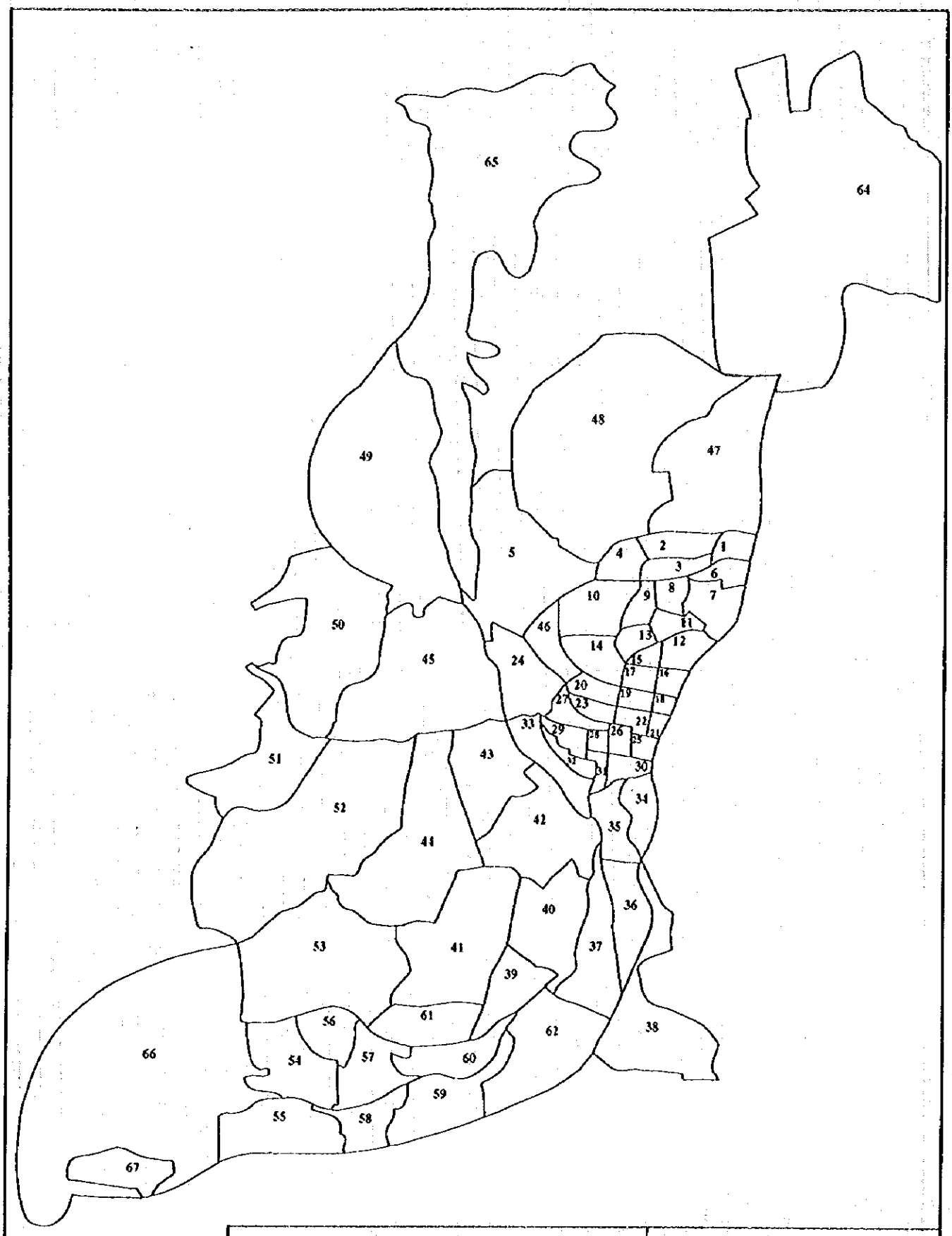
The outputs of the water demand estimation are to compute nodal demand of pipe network model developed. From its objectives, the above procedures may be allowed. Table N2 gives the results of water demand by zone estimated.

Figures

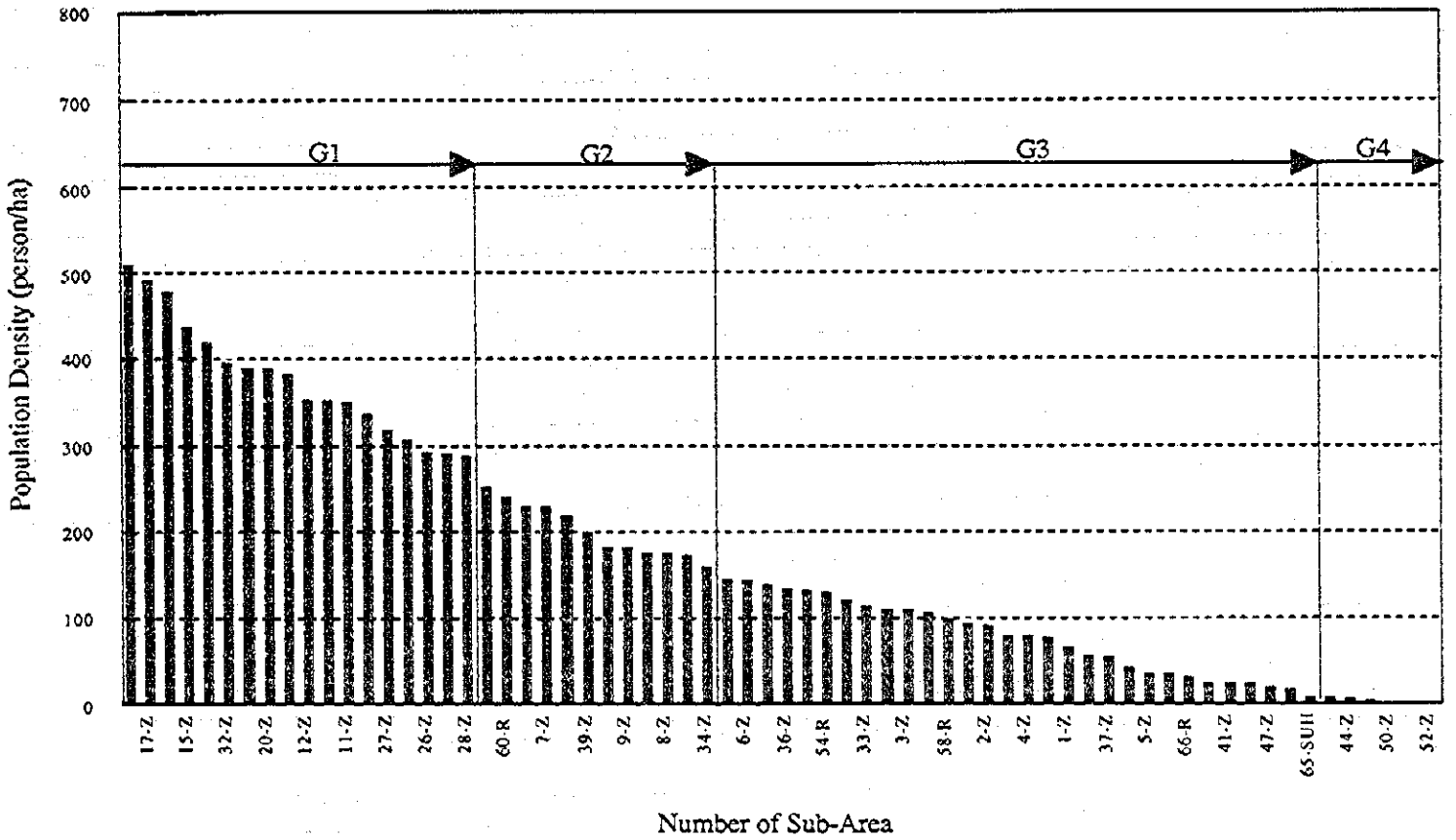
Population Distribution



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. - N1 WORK FLOW FOR POPULATION DISTRIBTUION



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig . - N2
JAPAN INTERNATIONAL COOPERATION AGENCY	CENSUS ZONES IN STUDY AREA



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. - N3 POPULATION DENSITY AND GROUPING
JAPAN INTERNATIONAL COOPERATION AGENCY	

Tables

Table - N1 ZONAL POPULATION (1994 Census and 2005 Distributed)

Unit	Municipality	Land Area (1,000m2)	P1995	Den1995 (/ha)	P2005 Dist
17	Z	185	9,444	510	11,910
23	Z	142	6,984	492	8,808
15	Z	123	5,877	478	7,412
16	Z	160	6,992	437	8,818
32	Z	155	6,472	418	8,162
67	SCH	917	36,218	395	45,675
20	Z	225	8,751	389	11,036
29	Z	246	9,555	388	12,050
12	Z	350	13,358	382	16,846
35	Z	500	17,658	353	22,269
11	Z	234	8,242	352	10,394
19	Z	140	4,910	351	6,192
27	Z	249	8,355	336	10,537
13	Z	188	5,960	317	7,516
26	Z	145	4,460	308	5,625
18	Z	101	2,957	293	3,729
28	Z	106	3,071	290	3,873
22	Z	161	4,656	289	5,872
60	R	667	16,842	253	23,010
56	R	463	11,162	241	15,250
7	Z	446	10,173	228	13,899
46	Z	454	10,354	228	14,146
39	Z	589	12,751	216	17,421
25	Z	122	2,432	199	3,323
9	Z	228	4,143	182	5,660
21	Z	114	2,055	180	2,808
8	Z	240	4,179	174	5,709
14	Z	434	7,534	174	10,293
34	Z	441	7,608	173	10,394
57	R	837	13,275	159	19,443
6	Z	226	3,271	145	4,791
31	Z	147	2,100	143	3,076
36	Z	738	10,222	139	14,972
24	Z	828	11,076	134	16,222
54	R	1,153	15,210	132	22,277
61	R	834	10,731	129	15,717
33	Z	631	7,592	120	11,120
40	Z	1,529	17,151	112	25,120
3	Z	269	2,926	109	4,286
42	Z	1,765	19,036	108	27,881
58	R	777	8,139	105	11,921
30	Z	260	2,520	97	3,691
2	Z	407	3,793	93	5,555
55	R	985	8,878	90	13,003
4	Z	331	2,611	79	3,824
43	Z	1,829	14,408	79	21,103
1	Z	212	1,600	75	2,343
59	R	926	6,016	65	8,811
37	Z	1,169	6,382	55	9,347
53	R	3,649	19,133	52	28,023
5	Z	2,708	11,444	42	16,761
10	Z	810	2,844	35	4,165
66	R	6,933	23,782	34	34,832
38	Z	1,966	6,015	31	8,810
41	Z	2,530	5,984	24	8,764
64	HAS	6,161	13,936	23	20,411
47	Z	2,820	6,378	23	9,342
45	Z	3,307	6,012	18	8,805
65	SUH	5,595	9,764	17	14,301
62	R	1,716	1,327	8	1,680
44	Z	3,132	2,405	8	3,044
51	Z	3,136	1,482	5	1,876
50	Z	5,223	2,234	4	2,827
48	Z	6,242	1,190	2	1,506
52	Z	4,959	654	1	828
49	Z	5200	0	0	139
		90,465	334,674	59	739,256

Table - N2 ZONAL WATER DEMAND (2005)

Unit	P2005 Dist	Day Average (m3)	Day Maximum (m3)
17	11,910	1,648	1,977
23	8,808	1,218	1,462
15	7,412	1,025	1,230
16	8,818	1,220	1,464
32	8,162	1,129	1,355
67	45,675	6,318	7,582
20	11,036	1,527	1,832
29	12,050	1,667	2,000
12	16,846	2,330	2,796
35	22,269	3,081	3,697
11	10,394	1,438	1,725
19	6,192	857	1,028
27	10,537	1,458	1,749
13	7,516	1,040	1,248
26	5,625	778	934
18	3,729	516	619
28	3,873	536	643
22	5,872	812	975
60	23,010	3,183	3,820
56	15,250	2,110	2,532
7	13,899	1,923	2,307
46	14,146	1,957	2,348
39	17,421	2,410	2,892
25	3,323	460	552
9	5,660	783	940
21	2,808	388	466
8	5,709	790	948
14	10,293	1,424	1,709
34	10,394	1,438	1,725
57	19,443	2,690	3,228
6	4,791	663	795
31	3,076	426	511
36	14,972	2,071	2,485
24	16,222	2,244	2,693
54	22,277	3,082	3,698
61	15,717	2,174	2,609
33	11,120	1,538	1,846
40	25,120	3,475	4,170
3	4,286	593	711
42	27,881	3,857	4,628
58	11,921	1,649	1,979
30	3,691	511	613
2	5,555	768	922
55	13,003	1,799	2,158
4	3,824	529	635
43	21,103	2,919	3,503
1	2,343	324	389
59	8,811	1,219	1,463
37	9,347	1,293	1,552
53	28,023	3,877	4,652
5	16,761	2,319	2,782
10	4,165	576	691
66	34,832	4,818	5,782
38	8,810	1,219	1,462
41	8,764	1,212	1,455
64	20,411	2,824	3,388
47	9,342	1,292	1,551
45	8,805	1,218	1,462
65	14,301	1,978	2,374
62	1,680	232	279
44	3,044	421	505
51	1,876	260	311
50	2,827	391	469
48	1,506	208	250
52	828	115	137
49	139	19	23
TOTAL	739,256	102,263	122,716

O. FACILITIES FOR NEW DEVELOPMENT AREA

APPENDIX O FACILITIES FOR NEW DEVELOPMENT AREA

1 Zarqa 1 - 3 Development Project near Awajan

The area under the Zarqa 1,2 and 3 projects (refer to page O-26, Appendix, Interim Report) are out of the Study Area but the water is definitely better supplied from the Zarqa water supply system. Therefore, the water supply system is planned here. The project scope is as follows;

Served Area	:	424 ha
Population in 2015	:	33,480 persons

Water demand is estimated at 5,156 m3/day using the same planning criteria in the master plan. The ground elevations in the served area range from 610 to 660 m. Hydraulically, this area is supplied from Awajan 695 reservoir but this idea is not recommended. Instead, the separate zoning is proposed.

Demand in 2015	:	5,156 m^3/day (Daily maximum)
Ground level in served area	:	610 - 660 m

Water is boosted from the junction tank (ground reservoir) to the elevated tank. 200 m3 capacity elevated tank shall be added to the ground reservoir. The required reservoir capacity is incorporated with the junction tank. The elevation tank is constructed with water level of 695 m at the highest hill of 675 m. The planned Khaw pumps and transmission line can accommodate the increased demand.

1) Pumping station

Total Head	:	21 m
Number of pump	:	2 duty and 1 standby
Water flow	:	1.8 m^3/min. per unit
Motor output	:	11 kW per unit

2) Transmission line (from junction tank to Res 675)

D=300 mm, L=1,155 m, I=3m/km

3) Distribution line

D=300 mm, L=1,155 m

D=250 mm, L=5,250 m

D=150 mm, L=2,300 m
D=100 mm, L=2,400 m

4) Junction tank

20 m x 20 m x 5 m = 2,000 m^3

5) Construction and annual operation costs are estimated as follows:

- Construction cost: US$ 106,000
- Operation cost: US$ 9,024/year

2 Garisa Area

1. Outline of the Planning

The existing distribution pipeline of 150 mm in diameter is extended over the river Al Dulil to supply water to Om Al Suleh from Hashemeyeh service area. New Garisa area located in high land (El. + 580 m to + 630 m) at northern part of Suleh area is supplied with water by a well and under insufficient condition. The water supply condition in Hashemeyeh area is improved by the execution of Stage 1 project so that the sufficient water is expected to be supplied in Suleh area too from Hahsmeyeh service reservoir.

To supply water to New Garisa area from piped water system, the water supply system is planned. Water is taken at the end of distribution pipe in Suleh area and pumped up to a reservoir which is put on a hill place. From the reservoir, water is distributed by gravity flow to the new areas.

2. Water Supply Facilities

It is assumed that the households to be supplied are 300 with 8 persons per household and per capita consumption is 80 l/d applying it in 2005 and in adding to 30 % of unaccounted-for water. The planned flow and each facility are as follows:

1) Estimated water demand:

- Households: 300
- Persons to be supplied: 300 x 8 = 2,400
- Per capita consumption: 80 l/d
- Unaccounted-for water: 30 %

- Water demand: 2,400 x (80 + 34) l/d x 1.2 (day max. Factor) = 330 m3/d = 3.8 l/s

2) Pipes

To save the construction costs, the pipes for transmission and distribution are used with polyethylene pipe. Length by diameter is as follows:

- ø 100 mm: 1,000 m
- ø 80 mm: 200 m
- ø 50 mm: 1,400 m

3) Pump

Horizon type multi-stage turbine pump is used for the high lift.

- Pump: ø 50 x ø 40 x 0.23m^3/min. x 81 m x 7.5 kW x 2 units (1-standby) Single suction multistage
- Pump house: 4 m x 4.5 m (18 m2)

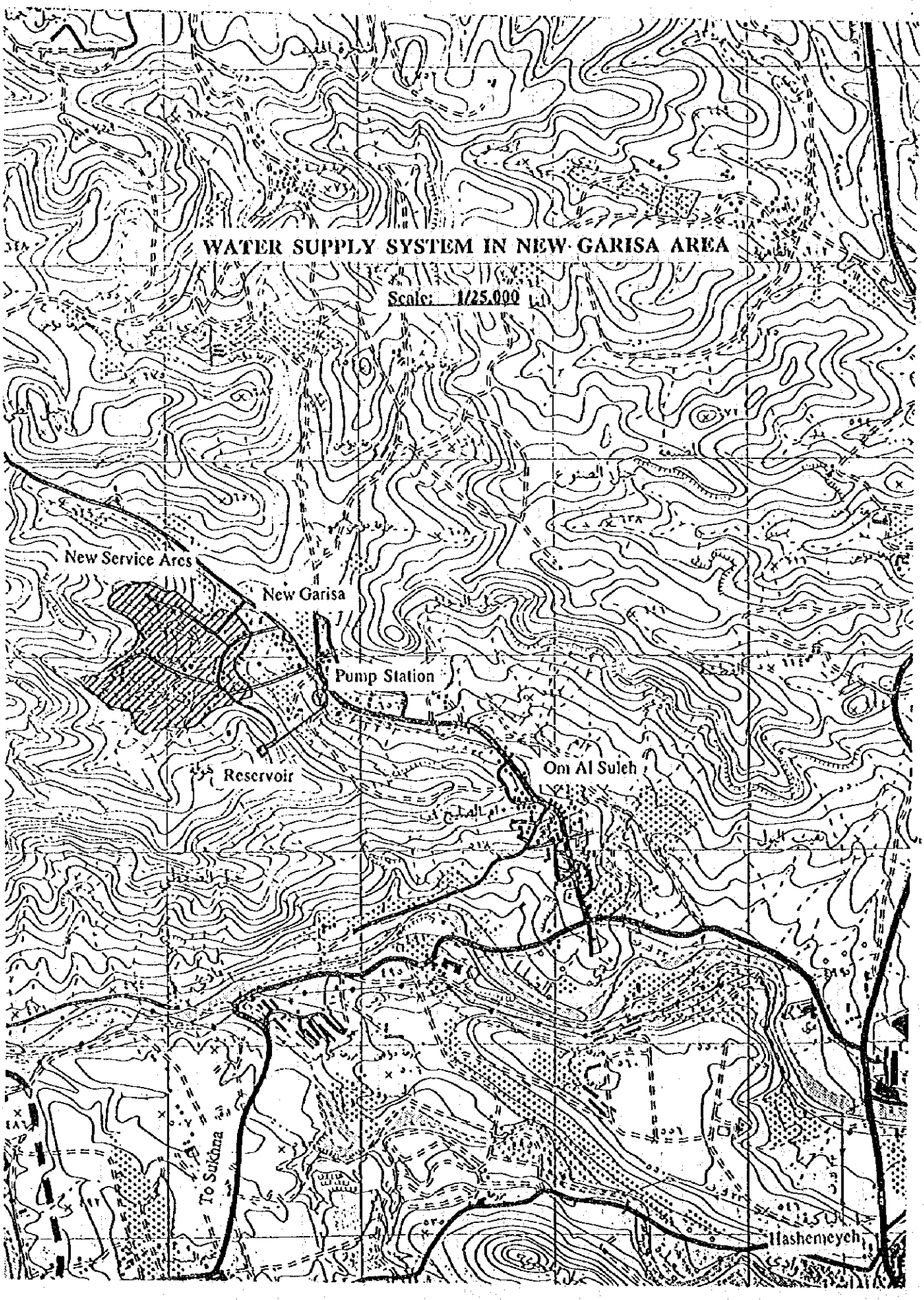
4) Service reservoir

15 hours capacity is given for day max. flow. Float valve is installed in inlet pipe for controlling inflow to the reservoir.

- Reservoir: 8.2 m x 8.2 m x 3 m (effective depth) 200 m^3
- Outlet and inlet pipes: ø 100 mm

5) Construction and annual operation costs are estimated as follows:

- Construction cost: US$ 112,600
- Operation cost: US$ 4,370/year


WATER SUPPLY SYSTEM IN NEW GARISA AREA
Scale: 1/25,000
New Service Area
New Garisa
Pump Station
Reservoir
Om Al Suleh
To Sukhna
Hashemeyeh

JICA