CHAPTER 8 FORMULATION OF EARTHQUAKE RESISTANT PLAN

On the basis of the target set in the chapter 5 and various earthquake resistant measures studied in the chapter 6, an earthquake resistant plan is formulated in this chapter.

8.1 Selection of Earthquake Resistant Measures

The earthquake resistant plan to be formulated hereunder is aiming at realization of measures for Tehran water supply system resistant to earthquake. When essential measures such as relocation of a water treatment plant are taken, the earthquake resistant plan becomes very costly, and it does not generate any increase of water sales income. These measures are excluded from the plan to be formulated hereunder, because they are apt to raise water tariff greatly in case no subsidy is given for the execution. However, these measures are briefly described in this section for the sake of future consideration. It is also important to secure emergency water supply bases, which is included in the earthquake resistant plan.

8.1.1 Measures for Upstream Facilities

Earthquake resistant measures for raw water transmission mains and water treatment plants are studied hereunder. Analysis of raw water main has not been done due to insufficient data and the scope of this work. Since these are so fundamental and important facilities to convey water to Tehran city, comments are made regarding the countermeasures against seismic forces.

As shown in *Table 8.1.1*, fault crossing points of raw water transmission mains or tunnels will be damaged in case of a great scenario earthquake. Water treatment plants No.3&4 and No.5 which are located on the faults will also be damaged. It is difficult to reinforce them completely against the earthquake or to relocate them to a safety location due to their size and necessary cost. Minimization or mitigation of the damage effect will be realistic measures. Considering location of these facilities or distance from the scenario faults, it is hardly considered for two or more systems to be damaged simultaneously by an earthquake occurrence. Therefore, countermeasures are studied on the assumption that one of the WTP systems will be damage by a scenario earthquake.

Interruption of No.1 or No.5 WTP system will not affect much to its service area because water can be transmission to the area by other alive systems, as analyzed by hydraulic simulation in section 4.3 in the main report. However, No.2 or No.3&4 systems could not be covered by others. Therefore, water transmission from the future WTP No.6 to WTP No.2, interconnection of WTP No.3 and No.4, or water transmission from WTP No.5 to No.3&4 will become necessary. Water supply by tankers should also be taken into account.

As for smaller earthquakes, structural analysis based on Code 2800 was made for water treatment facility

structures. The bearing capacity of structural members of several facilities was found to be insufficient by the analysis. There are a lot of mechanical and electrical equipment which are not fixed firmly to walls or floors. These facilities or equipment should be reinforced to earthquake resistant. Installation of shear walls, reinforcement of clarifier walls or retrofitting of brick walls will be major work items for facility reinforcement, and fixation of the equipment to walls or floors or installation of Chlorine neutralization equipment should be included in the countermeasures as studied in chapter 6 of the main report.

8.1.2 Measures for Downstream Facility

Measures for downstream facilities from clear water transmission mains to distribution networks as shown in *Table 8.1.2* are employed in the earthquake resistant plan.

As for transmission mains, their reinforcement is employed as a principal measure for minimization of damage occurrence. Estimated damage points, reliability of 70% and below, by scenario earthquakes are 23 locations at fault crossing and 30 locations at connection of pipes to massive structures, and all of estimated points are to be reinforced under the plan. The points with reliability of 70% and above at the fault crossing will be strengthened in the future. However, all of weak pipe connections to the structures will be reinforced considering easiness and inexpensive cost for execution.

Important upper section of distribution trunk mains shall be reinforced for minimization of damage occurrence although principle measure for water distribution mains is emergency water supply and restoration. Trunk mains at fault crossing and connection to structures in northern part are planned to be reinforced. Damages on other trunk mains and sub mains will be covered by emergency countermeasures.

Regarding to measures for such facilities as reservoirs and pump stations, installation of by-pass pipelines, water transmission from other alive facilities and relocation to a safe area in the distant future when their life is over will be appropriate measures which are similar to those for water treatment plant.

There are facilities and structures which are partially insufficient in bearing capacity for Code 2800 similar to the case of WTP. There are also mechanical and electrical equipment with unstable installing conditions and with possibility of second disaster occurrence. These facilities and equipment are planned to be reinforced properly.

Table 8.1.1 Countermeasures for Raw Water Main and Water Treatment Plant

	System	No.1 (Jalaliyeh)	No.2 (Kan)	No.3&4 (Tehranpars)	No.5 (Panjom)
Facilities Water Source	Main Dam	Karaj Dam	Karaj Dam	Latiyan Dam	Lar Dam
		Tareghan Dam (Sapplemental Source of Karaj Dam)			
Raw Water Main	Type and Dimensions	D1,000mm x L73km x 2sets Steel Pipelines	D2,000mm x 67km x 2sets Reinforced Concrete Pipes	D2,700mm x L9km +D3,000 x L20km Tunnel	D3,600mm x 11.3km + d2,000 x L7.2km x 2sets
	Fault Crossing	1 point near Bileghan	8 points between Bileghan and WTP No.2	2 poins between Dam and WTP No.2	
	Fault Related	North Tehran Fault	North Tehran Fault	North Tehran/Mosha	North Tehran/Mosha
	Fault Dislocation	40 - 50cm	30 - 40cm	30 - 40cm	
WTP	Capacity	$2.7m^3$/day	$8.0m^3$/day	$8.0m^3$/day	$7.5m^3$/day
	Fault Location	remote from fault	remote from fault	on the fault	on the fault
Fragility of the System	For Scenario Earthquake: Pipes	Damage estimation of raw water mains was not executed, because they are located out of the study area. However, it is considered that raw water mains and raw water tunnels would be damaged by fault dislocation.			
	WTP	Not much damage on whole WTP	Not much damage on whole WTP	WTP would be damaged by fault dislocation	
	For Historical Earthquake: Pipes	Damage estimation of raw water mains was not executed, because they are located out of the study area.			
	Code 2800: WTP	Damages on some parts of facilities and equipment	Damages on some parts of facilities and equipment	Damages on some parts of facilities and equipment	Damages on some parts of facilities and equipment
Possibility of Reinforcement or Mitigation	Coverage by Other WTP or Transmission Main When Interrupted	Water transmission from WTP No.2 and No.3&4 could almost cover WTP No.1 area.	Several zones around WTP No.2 would suffer water shortage, bacause of its capacity and higher elevation	Several zones around WTP No.3 &4 would suffer water shortage, bacause of its large capacity and insufficien transmission capacity of No.5 to	Water transmission from WTP No.3&4 and No.2 could almost cover No.5 area. Because No.3 &4 supplied No.5 area until recent years.
	Possibility of Prior Reinforcement	Not much difficult because of only one fault crossing and moderate pipe diameter	Difficult because of big diameter pipelines and many fault locations	Difficult of reinforcement for both of tunnel and WTP	Difficult of reinforcement for both of tunnel and WTP
	Other Measures for Mitigation	Not necessary	Possibility of transmission of Tareghan water, WTP No.5 and future WTP No.6 water	Large scale water transmission from WTP No.5. Interconnection of No.3 and 4	Interconnection of No.5 and future WTP No.6
Measures to be Adopted for Raw Water Main and WTP	For Scenario Earthquake: Pipes	Necessary to study in detail of reinforcement at fault crossing	Necessary to study above measures especially for minimization or mitigation of damage effects		
	WTP	No measure at present other than coverage by others.	Cover by others and emergency wate supply by tankers.	Cover by others and emergency wate supply by tankers.	No measure at present other than coverage by others.
	For Historical Earthquake: Pipes	Same study as for scenario earthquakes is considered necessary.			
	Code 2800: WTP	Parts or members of facility stuructures and equipment should be reinforced			

Table 8.1.2 Countermeasures for Water Transmission and Distribution Facilities

Facilities and Their Conditions	Numbers	Description and Inclusion in the Project
1) Clear Water Transmission Main	Target	Reinforcement for minimization of damage
General		
Dimensions		Diameter: 2000-150mm, Length: 399km
Number of fault crossing	39	Twin pipes are counted as one pipeline
Connection to structures	150	
Damage by scenario earthquake		Reliability smaller than 70% (R<70%)
Fault crossing	60%	To be implemented in the project
Connection to structures	20%	To be implemented in the project
Damage by scenario earthquake		R>70%
Fault crossing	40%	To be implemented in future stage
Connection to structures	80%	Included: larger reliability but cheap/easy implementation
2) Distribution Trunk Main	Target	Basically treated by emergency countermeasures
General		
Dimensions		Diameter: 1600-300mm, Length: 768km
Number of fault crossing	95	
Connection to structure	190	
Damage by scenario earthquake		R<70%
Fault crossing	30%	To be implemented in the project considering high priority
Connection to structures	20%	To be implemented in the project considering high priority
Damage by scenario earthquake		R<70%
Fault crossing	70%	To be implemented in future stage
Connection to structures	80%	To be implemented in future stage
3) Distribution Sub Main	Target	Treated by emergency water supply and restoration
General		
Dimensions		Diameter: 250-50mm, Length: 6385km
Number of fault crossing	552	
Damage by scenario earthquake	868	Not included in the project
4) Distribution Reservoirs	Target	Minimization of damage effect
General		
Numbers	70	Including contact tanks and clear water tanks
Numbers located on fault	9	
Damage by Scenario Fault		
Reservoir on Fault	9	By-pass installation or supply by other facilities
Insufficien Capacity by Code 2800		
Aged/Deteriorated Reservoirs	15	Reinforcement of structure members or refurbishment
5) Pump stations	Target	Minimization of damage effect
General		
Numbers	40	
Numbers located on fault	3	
Damage by Scenario Fault		
Reservoir on Fault	3	Water supply by other facilities or supply by tankers
Insufficient Capacity by Code 2800		
Aged/Deteriorated Pump House	21	Installation of share walls & reinforcement of brick walls are included in the project
6) Mechanical and Electrical Equipment		
Damage Judged by Site Survey and Foundation Bolt Strength		
Unstable and unsafety Equipment	Many	Fixation/support of equipment, installation of chlorine neutralization equipment, etc. are included in the project.

8.1.3 Selection of Draft Earthquake Resistant Plan

Individual measures for the earthquake resistant plan are employed as listed in this section. Measures for pipeline system are described in *Table 8.1.3*, measures for facilities and equipment are in *Table 8.1.3(1/3-3/3)* and measures for emergency water supply to be incorporated in the earthquake resistant plan are listed in *Table 8.1.5*.

Table 8.1.3 Measures for Earthquake Pipeline System

Facilities	Work Items for Earthquake Resistant Plan
1) Minimization of Damage Occurrence	
Water Transmission Main	
	Reinforcement of priority pipelines crossing active or secondary fault
	Reinforcement of connections of pipes to massive structures
Distribution Trunk Main	
	Reinforcement of priority pipelines crossing active or secondary fault
	Reinforcement of priority connection of pipes to massive structures
	Replacement of fragile pipelines to DIP with quake resistant joint
2) Minimization/Nitigation of Damage Effect	
Raw Water Main	
	Study of installation of interconnecting mains between respective facilities
	Study in detail on reinforcement of raw water main to WTP No.1
	Study on installation of large clear water transmission mains

Table 8.1.4 Measures for Facilities and Equipment (1/3: Facility)

Name of Facility	Installation of Share Wall	Reinforcement of Structural Member	Reinforcement of Brick Wall	Replacement of Door & Window	Fixation of Handrail	Refurbish-ment	Fixa-tion	Unification of Structure
1)Minimization of Damage Occurrence								
Intake station								
Bilagan shelter	○		○	○	○			
W.T.Plant								
No.1 Generator House	○		○	○	○			
No.2 Generator House	○		○	○	○			
No.2 Pulsator		○					○	
No.4 Chemical House Breezeway							○	
No.4 Filter Exp.Joint								○
No.5 Veneer of Chlorine House							○	
Emergency Post								
All Emergency Post Buildings	○							
Pumping House								
No.1,No.2, No.15, No.16, No.17, No.19, No.20, No.22, No.24, No.25, No.27, No.28, No.36, No.38, No.40, No.52, No.57, No.58, No.73, No.104, No.105	○		○	○	○			
Reservoir								
No.1, No.2, No.3, No.4, No.5		○						
No.6		○				○		
No.9, No.10, No.13, No.15, No.24, No.29, No.30, No.32		○						
No.16, No.20, No.23, No.25, No.27, No.28, No.33, No.37, No.38, No.40, No.41, No.51, No.53, No.57, No.58, No.63, No.72		○						
No.66						○		
2) Minimization of Damage Effect								

Note: Reinforcement of Reservoir No.16 to No.72 in the second lowest line would be made in future.

Table 8.1.4 Measures for Facilities and Equipment (2/3: Equipment)

Name of Facility	Fixation of Trans - former	Fixation of Battery	Fixation of UPS	Fixation 400V Panel	Installation of Flex. Pipe 1	Installation of Flex. Pipe 2	Fixation of Cl_2 Cylinder	Support of Surge Tank	Installation of Electric Post
1) Minimization of Damage Occurrence									
Water Source									
Bilaghan Intake						○	○		
All Well Pumps				○					
Water Treatment Plant									
No.1 , No.2, No.3	○	○	○		○	○	○		
No.4	○	○	○		○	○			
No.5	○	○	○			○			
Reservoir/Pumping Station									
No.1/P, No.14/P, No.15/P, No.16/P, No17/P, No.20/P, No.24/P No.25/P, No.26/P, No.56/P, No.57/P, No.58/P, No.114/P	○	○							
No.2/P	○	○						○	
No.4/P, No.5P, No.7, No.89/P, Tarasht, Southern Tarasht, Said Abad							○		
No.8/P, No.36/P, No.59/P, No.66/P, No.69/P				○			○		
No.12/P				○					
No.13/P, No.65/P, No.68/P	○	○		○			○		
No.19/P, No.21/P, No.40/P, No.52/P, No.73/P	○	○					○		
No.22/P	○	○						○	○
No.31							○		
No.27/P, No.28/P, No.32/P, No.34/P, No.37/P, No.38/P, No.43/P, No.71/P, No.72/P, No.74/P, No.75/P, No.80/P, No.81/P, No.90/P, No.91/P, No.93/P, No.95/P, No.101/P, No102/P, No.105/P				○					
No.96/P				○				○	

Table 8.1.4 Measures for Facilities and Equipment (3/3: Equipment)

Name of Facility	Duplicate Income Cable	Setting of Anti-flowout Fence	Neutralization Equipment	Installation of Generator	Installation of S.H. System
2) Minimization of Damage Effect					
Water Source					
Bilaghan Intake		○	○		○
All Deepwells				○	
W.T.Plant					
No.1, No.2, No.3, No.4, No.5		○	○		○
Reservoir/Pumping Station					
No.16/P, No.52/P, No.68/P, No.114/P	○				
No.1/P, No.2P, No.8/P, No.12/P, No.14/P, No.15/P, NO.16/P, No.17/P, No.20/P, No.22/P, No.24/P, No.25/P, No.26/P, No.27/P, No.28/P, No.32/P, No.34/P, No.37/P, No.38/P, No.43/P, No.56/P, No.57/P, No.58/P, No.59/P, No.71/P, No.72/P, No.74/P, No.75/P, No.80/P, No.81/P, No.90/P, No.91/P, No.92/P, No.93/P, No.95/P, No.96/P , No.101/P, No.102/P, No.105/P, No.114/P				○	
No.4/P, No.5P, No.7, No.31/P, Tarashut, Southern tarashut, Said			○		○
No.13/P, No.19/P, No.21/P, No.36/P, No.40/P, No.52/P, No.58/P, No.59/P, No.65/P, No.66/P, No.73/P, No.89/P			○	○	○

Note: S.H. System = Sodium Hypochlorite System. : Measures for future stage
Installation of generator on some wells is necessary for emergency water supply.

Table 8.1.5 Measures for Emergency Water Supply

1) Outlet Siphon Arrangement of Reservoirs for Securing Water
2) Preparation of Engine Pump for Reservoir
3) Installation of Emergency Shut-off Valve
4) Preparation of Engine Pump for Reservoir
5) Fitting of Emergency Branch Connection on Transmission Main
6) Installation of Water Tank for Wells in the Park
7) Preparation of Genarator for Wells in the Park
8) Setting of Accessaries for TWWC Wells for Emergency Water Supply
9) Preparation of Genarator for TWWC Wells
10) Installation of Emergency Water Tanks

8.2 Setting of Project Period and Target Year

Project period and target year are determined considering implementation program of JICA M/P, the future plan of TWWC and feasibility of the project.

Project period in JICA M/P is defined as 12 years, and it is divided into short term stage for the first three years, middle term stage for next four years and long term stage for the last five years. TWWC places the target period of its future plan as 2021, 15 years from the present. It is considered that 15 or 20 year period is too long as far as a realistic program is discussed.

Thus, the project period is set as 12 years after one year preparation and the target year of the project is set in 2019. Same as JICA M/P, the short term stage is set for three years from 2008 to 2010, the middle term stage is set for four years from 2011 to 2014 and the long term stage for five years from 2015 to 2019 as shown in *Table 8.2.1*.

Table 8.2.1 Proposed Project Period

Year	2007	2010	2014	2019	
Period	Preparation	Short Term	Middle Term	Long Term	Future
	1 year	3 years	4 years	5 years	

8.3 Estimation of Preliminary Project Cost

Project cost is estimated based on TWWC information, assistance of local consultants and data from "Price List of Goods and Service (MPO)". As stated earlier, work items of the earthquake resistant project consists of measures for pipeline system, facilities and equipment and emergency water supply.

Majority of the work items for the project is considered locally available but some of them would be imported from foreign countries. So, the costs are estimated dividing into local cost and foreign cost.

Thus, construction cost is preliminarily estimated as approximately US$24Million and the total project cost is estimated as US$31million as described in *Table 8.3.1*. The project cost estimated corresponds to US$2.6Million/year which is 4% of the annual water sales income in the last year. Estimated cost of each

work item is listed in *Table 8.3.2* at the end of this section.

Table 8.3.1 Preliminary Project Cost (Unit :US$)

	Cost Items	Short Term	Middle Term	Long Term	Total Cost
1	Construction Cost	3,628,600	6,243,900	12,395,200	22,267,700
	Pipelines				0
	Min. Occurrence	150,000	700,000	6,290,000	7,140,000
	Min. Effect	—	—	—	—
	Facility (Structure)				0
	Min. Occurrence	992,800	1,609,900	744,200	3,346,900
	Min. Effect	—	—	—	—
	Equipment				0
	Min. Occurrence	171,800	—	—	171,800
	Min. Effect	286,000	1,336,000	2,431,000	4,053,000
	Emergency Supply	2,028,000	2,598,000	2,930,000	7,556,000
2	Administration Fee (8 %)	290,288	499,512	991,616	1,781,416
3	Consultant Fee (10%)	362,860	624,390	1,239,520	2,226,770
4	Contingency (Approx.10%)	362,252	624,198	1,237,664	2,224,114
5	Preliminary Project Cost	4,644,000	7,992,000	15,864,000	28,500,000
6	Annual Project Cost	1,548,000	1,998,000	3,172,800	

Table 8.3.2 Preliminary Cost of Earthquake Resistant Plan (1/2) (Unit: US$)

Name of Facility & Planned Measure	Target Facility	Local Cost			Foreign Cost			Remarks
		Unit Cost	Numbers	Cost	Unit Cost	Numbers	Cost	
Pipelines								
1) Minimization of Damage Occurrence				7,140,000			0	Total: 7,140,000
Clear Water Transmission Main								
RC Pipe Reinforcement at Faults	RC1850 x 1 location	200,000	1	200,000				
DIP Reinforcement at NT.Fault	8 locations	25,000	8	200,000				
RC&DIP Reinforcenent at 2nd Fault	14 locations	15,000	14	210,000				
Connection to Massive Structure	150 locations	5,000	150	750,000				
Distribution Trunk Main								
Reinforcement of RC, CI, DIP at Fault	30 locations	10,000	30	300,000				
Connection to Massive Structure	60 locations	5,000	60	300,000				
Replacement CIP to DIP with Quake Joint	14 km	370	14,000	5,180,000				Assumed local pipe available
2) Minimization/Mitigation of Damage Effect				0			0	Measures be taken in future
Facility (Stuructures)				3,346,900			0	Total: 3,346,000
1) Minimization of Damage Occurrence				3,346,900			0	
Intake station								
Rehabilitation of Bilagan shelter		2,000	1	2,000	3,346,900			
Water Treatment Plant								
Rehabilitation of Generator House	WTP No.1	71,500	1	71,500				
Ditto	WTP No.2	35,800	1	35,800				
Reinforcenent of Pulsator	WTP No.2	28,800	1	28,800				
Fixation of Breezeway	WTP No.4	1,900	1	1,900				
Unification of Filter Structure	WTP No.4	2,900	1	2,900				
Fixation of Veneer of Cl_2 House	WTP No.5	600	1	600				
Emergency Post								
Reinforcement of Brick Wall	18 locations	11,000	18	198,000				
Pumping House								
Rehabilitation of Pumping House								
including Installation of share wall,	No.1	64,000	1	64,000				
reinforcement of brick wall, etc.	No.2	32,000	1	32,000				
Rehabilitation of Pumping House								
including Installation of share wall,	No.15	45,800	1	45,800				
reinforcement of brick wall,	No.16	34,100	1	34,100				
replacement aged door and windows	No.17	45,200	1	45,200				
and fixation of handrail	No.19	35,700	1	35,700				
	No.20	35,700	1	35,700				
	No.21	75,700	1	75,700				
	No.22	35,100	1	35,100				
	No.24	32,700	1	32,700				
	No.36	24,000	1	24,000				
	No.40	16,400	1	16,400				
	No.52	36,500	1	36,500				
	No.57	46,000	1	46,000				
	No.58	34,500	1	34,500				
	No.73	43,500	1	43,500				
				ST=540,90				
Rehabilitation of Pumping House								
	No.25	27,100	1	27,100				
	No.27	32,200	1	32,200				
	No.28	18,300	1	18,300				
	No.38	13,900	1	13,900				
	No.104	16,100	1	16,100				
	No.105	16,100	1	16,100				
				ST=123,70				
Reservoir								
Reinforcement of Reservoir								
Reinforcement of outer wall	No.1	245,300	1	245,300				
	No.2	253,400	1	253,400				
	No.3	190,100	1	190,100				
	No.4	190,100	1	190,100				
	No.5	190,100	1	190,100				
				ST=1,069,				
Refurbishment of Reservoir								
Refurbishment of deteriorated interior	No.6	461,700	1	461,700				
(No.6 includes reinforcement)	No.66	93,600	1	93,600				
Reinforcement of Reservoir								
Reinforcement of outer wall	No.9	42,700	1	42,700				
	No.10	84,300	1	84,300				
	No.13	162,900	1	162,900				
	No.15	162,900	1	162,900				
	No.24	68,900	1	68,900				
	No.29	12,900	1	12,900				
	No.30	13,100	1	13,100				
	No.32	72,800	1	72,800				
				ST=620,50				
2) Minimization/Mitigation of Damage Effect				0			0	Measures be taken in future

Table 8.3.2 Preliminary Cost of Earthquake Resistant Plan (2/2) (Unit : US$)

Name of Facility & Planned Measure	Target Facility	Local Cost			Foreign Cost			Remarks
		Unit Cost	Numbers	Cost	Unit Cost	Numbers	Cost	
Equipment				171,700			4,053,000	Total: 4,224,700
1) Minimization of Damage Occurrence				167,400			0	
Intake Station/Well								
Fixation of Cl_2 Cylinder	Bileghan	1,100	1	1,100				
Installation of Flexible Pipe 2	Bileghan	2,000	1	2,000				
Fixation of 400V Panal	All well pumps	88,000	1	88,000				
Water Treatment Plant				0				
Fixation of Transformer	WTP1, 2, 3, 4,&5	1,300	1	1,300				
Fixation ob Battery	WTP1, 2, 3, 4,&5	700	1	700				
Fixation of UPS	WTP1, 2, 3, 4,&5	200	1	200				
Installation of Flexible Pipe 1	WTP1, 2, 3,&4	1,300	1	1,300				
Installation of Flexible Pipe 2	WTP1, 2, 3, 4,&5	7,000	1	7,000				
Fixation of Cl_2 Cylinder	WTP1, 2,&3	3,300	1	3,300				
Reservoir/Pumping Station								
Fixation of Transformer	No.1, No.2, No.13, No.14, No.15, No.16, No.17, No.19, No.20, No.21, No.22, No.24, No.25, No.26, No.40, No.52, No.56, No.57, No.58, No.65, No.68, No.73, No.114	8,100	1	8,100				
Fixation of Battery	Same as above reservoirs	3,800	1	3,800				
Fixation of 400V Panel	No.8/p, No.12/p, No.13/p, No.27/p, No.28/p, No.32/P, No.34/P, No.36/p, No.37/P, No.38/P, No.43/P, No.59/P, No.66/P, No.65/P, No.68/P, No.69/p, No.71/P, No.72/P, No.74/P, No.75/P, No.80/P, No.81/P, No.90/P, No.91/P, No.93/P, No.95/P, No.96/P, No.101/P, No102/P, No.105/P	27,600	1	27,600				
Fixation of Cl_2 Cylinder	No.4/P, No.5/P, No.7, No.13/P, No.19/P, No.21/P, No.31, No.33, No.36/P, No.40/P, No.35, No.65/P, No.66/P, No.68/P, No.69/P, No.89/P, Southern Tarashut, Said Abad	20,900	1	20,900				
Support of Surge Tank	No.2/P, No.22/P, No.99/P	2,000	1	2,000				
Installation of Electric Post	No.22/P	100	1	100				
2) Minimization/Mitigation of Damage Effect				4,300			4,053,000	
Intake Station								
Setting Anti Flowout Oil Fence	Bilaghan	1,000	1	1,000				
Installation of Neutralization Equipment	Bilaghan				330,000	1	330,000	
Water Treatment Plant								
Setting Anti Flowout Oil Fence	WTP1, 2, 3, 4,&5	3,300	1	3,300				
Installation of Neutralization Equipment	WTP1&5				286,000	1	286,000	
Installation of Neutralization Equipment	WTP2, 3&4				588,000	1	588,000	
Reservoir/Pumping Station								
Duplicate Incoming Cable	No.16/P, No.52/P, No.68/P, No.114/P				132,000	1	132,000	
Installation of Neutralization Equipment	No.52/p, No.73/P				286,000	1	286,000	
Installation of Neutralization Equipment	No.4/P, No.5/P, No.7/P, No.13/P, No.19/P, No.21/P, No.31/P, No.36/P, No.40/P, No.65/P, No.66/P, No.68, No.69, No.89/P, Southern Tarashut, Said Abad				2,431,000	1	2,431,000	
Emergency Water Supply				4,477,000			3,079,000	Total: 7,556,000
Outlet Siphon Arrangement of Reservoirs	30 reservoirs	34,000	30	1,020,000				
Ditto	18 Reservoirs	34,000	18	612,000				
Preparation of Engine Pump for Reservoir	30 reservoirs	1,000	30	30,000				
Ditto	18 Reservoirs	1,000	18	18,000				
Installation of Emergency Shut-off Valve	3 locations	124,000	3	372,000	143,000	3	429,000	Mechanical Flow Sensor
Preparation of Engine Pump for Reservoir	3 locations	1,000	3	3,000				
Branch Connection on Transmission Main	11 locations	6,000	11	66,000				
Ditto	7 locations	6,000	7	42,000				
Installation of Tank for Park Well	22 parks	14,000	22	308,000				
Ditto	37 wells	14,000	37	518,000				
Preparation of Genarator for Park Well	10 parks			0	38,000	10	380,000	
Ditto	10 wells			0	38,000	10	380,000	
Ditto	9 Wells				38,000	9	342,000	
Setting Accessaries for TWWC Well	27 wells	3,000	27	81,000				
Preparation of Genarator for TWWC Well	9 wells			0	172,000	9	1,548,000	
Installation of Emergency Water Tank	32 locations	7,000	32	224,000				
Ditto	32 locations	7,000	32	224,000				
Ditto	137 locations	7,000	137	959,000				
Cost Summary				17,498,000			7,132,000	22,266,700 : Total Cost

8.4 Implementation Program

8.4.1 Stepwise Implementation Program

Priority of implementation for each work item is studied considering emergency, importance, social condition, cost and benefit. Evaluation items for the priority are summarized in *Table 8.4.1*.

Table 8.4.1 Evaluation Items for Priority of Implementation

➢ Fragile Facility - located on the fault - not fixed appropriately - already deteriorated - made of fragile material ➢ If damaged, facility operation stops ➢ If damaged, suffers casualties ➢ If damaged, bigger loss occurs ➢ If damaged, secondary disaster occurs	➢ Damage of upper facility causes bigger loss ➢ Facility easily retrofitted ➢ Large benefit gains from small cost ➢ Improvement order among similar facilities - from aged or deteriorated items - from items affecting largely ➢ Facility for securing emergency water ➢ Facility for emergency water supply

Among the pipes as shown in *Table 8.1.1*, the following water transmission mains are considered as the highest priority items for earthquake resistant pipeline:

- Large diameter concrete, steel and ductile iron pipelines across the scenario/active fault, and
- Large diameter concrete pipelines across the secondary fault.

Next will be reinforcement of middle and smaller pipelines across the secondary fault.

It is indispensable to know exact locations of the existing faults for execution of reinforcement works of the above pipeline. IIEES announced its implementation of the fault investigation. TWWC is necessary to perform a detail survey of the faults in cooperation with IIEES soon, because such kind of survey requires long time, which will be three to four years. Therefore, these reinforcement works will be implemented in the middle-term after the fault investigation.

If it is found to be difficult to know their locations by the investigation, replacement of the existing RC (reinforced concrete) pipelines from WTP No.2 with SP (steel pipe) should be done.

Strengthening of connecting sections between pipeline and massive structure should also be executed urgently. The strengthening work of the connecting sections or pipe joints could be made easily without stoppage of water flow therein. The strengthening work of joint reliability, which is smaller than 70%, is planned to be implemented in the short term period. Considering inexpensive cost and easy execution, the remaining connecting sections is planned to be implemented in both of middle and long term periods although their reliability exceeds 70%.

Replacement of the existing cast iron pipes with ductile iron pipes of earthquake proof joint will be

implemented in the long term stage.

As for reinforcement of distribution mains, it is set in the target to be covered by emergency countermeasures. However, pipe crossing at fault and connecting to structures both in northern part of the city, where effect of the scenario earthquake is estimated to be large, are planned to be reinforced in the long term period.

It is not practical to strengthen such facilities as treatment plants and pumping stations located on the fault completely against an earthquake. Although it is not realistic, relocation of the facilities is the sole measure, if complete avoidance of damage is the aim, and this would be done in future. Realistic plan is to install a by-pass pipeline or water transmission from the other facilities. These matters are mentioned in section 8.4.2.

Besides the facilities mentioned above, there are ones which need partial reinforcement or refurbishment of the components. Reinforcement of some facilities in treatment plants No.2 and No.4 of insufficient bearing capacity, reinforcement of the oldest pump houses No.1 and No.2 and refurbishment of deteriorated distribution reservoirs No.6 and No.66 will require most urgent implementation.

As for priority among similar facilities, reinforcement of reservoirs No.1 to No.5 is scheduled to be executed in middle term stage because necessary data to analyze their aseismicity are not available during the study period although these reservoirs have similar service period as reservoir No.6 and they are considered to have a similar structure. Their data should be found before implementation.

As shown in *Table 8.4.2*, reinforcement of reservoirs No.9, No.10, No.11, etc. is scheduled to be implemented in the long term stage, while reservoirs No.16, No.20, No.23, etc., are not included in the project. The former reservoirs are rather aged facilities constructed before 1970 and the latter is rather new facilities with enough bearing capacity which have been confirmed by analysis of reservoir No.23.

As for equipment, the majority are not properly fixed to massive structures. This fact may be due to easiness of handling of such equipment. However, it would be damaged and would sometimes cause secondary disasters in case of an earthquake occurrence. As the cost for fixing such equipment is not high, it is expected to be implemented in near future. Especially, fixing the chlorine cylinders could not wait, for their damage may cause casualties by leak of toxic chlorine gas. Installation of anti-flowout fences for generator's fuel should also be done urgently to minimize possibility of fire occurrence.

Duplication of the incoming electric cables for pumping stations No.16, No52 and No.68 will be executed in the next stage, and neutralization equipment of chlorine gas is planned to be installed accordingly.

Preparation for emergency water supply is one of the high priority items for implementation. Target of

maximum access distance by citizens in an earthquake disaster is set as 1.0km as described in chapter 5. Realization of the target in a short period needs huge amount of work volume and project cost. Thus, target distance for the short term stage is set as 2.0km. Priority work items for the new target are to be implemented in the short term stage. By implementation of the remaining work items, original target is fulfilled in the year 2019.

Summing up the above work priorities, implementation program is established as shown in *Table 8.4.2*. Project cost in each stage is calculated as shown in *Table 8.3.1* and average annual project cost is approximately US$2.5Million as stated earlier.

Table 8.4.2 Implementation Program of Earthquake Resistant Plan (1/2)

Name of Facility & Planned Measure	Target Facility	Short-term	Middle-term	Long-term
Pipelines				
Clear Water Transmission Main				
RC Pipe Reinforcement at Faults	RC1850 x 1 location		■	
DIP Reinforcement at NT.Fault	8 locations		■	
RC&DIP Reinforcenent at 2nd Fault	14 locations			■
Connection to Massive Structure	30+60+60 locations	■	■	■
Distribution Trunk Main				
Reinforcement of RC, CI, DIP at Fault	30 locations		■	
Connection to Massive Structure	60 locations		■	
Replace CIP to DIP with Earthquake Joint	14 km			■
Facility (Stuructures)				
Intake station				
Rehabilitation of Bilagan shelter		■		
Water Treatment Plant				
Rehabilitation of Generator House	WTP No.1& No.2	■		
Reinforcement of Pulsator & Fix Troughs	WTP No.2	■		
Fixation of Chemical House Breezeway	WTP No.4	■		
Unification of Filter Structure	WTP No.4	■		
Fixation of Veneer of Cl2 House	WTP No.5	■		
Emergency Post				
Reinforcement of Brick Wall	18 locations	■		
Pumping House				
Rehabilitation of Pumping House	No.1 & No.2	■		
Rehabilitation of Pumping House	No.15, No.16, No.17, No.19, No.20, No.22, No.24, No.27, No.28, No.36, No.38, No.40, No.52, No.57, No.58, No.73		■	
Rehabilitation of Pumping House	No.27, No.28, No.38			■
Reservoir				
Reinforcement of Reservoir	No.1, No.2, No.3		■	
	No.4, No.5		■	
Reinforcement and Refurbishment	No.6	■		
Refurbishment of Reservoir	No.66	■		
Reinforcement of Reservoir	No.9, No.10, No.11, No.13, No.15, No.24, No.30, No.32			■
Equipment				
Intake Station/Well				
Fixation of Cl_2 Cylinder	Bilaghan	■		
Installation of Flexible Pipe 2	Bilaghan	■		
Fixation of 400V Panal	All well pumps	■		
Setting Anti Flowout Oil Fence	Bilaghan	■		
Installation of Neutralization Equipment	Bilaghan		■	
Water Treatment Plant				
Fixation of Transformer	WTP1, 2, 3, 4,&5	■		
Fixation ob Battery	WTP1, 2, 3, 4,&5	■		
Fixation of UPS	WTP1, 2, 3, 4,&5	■		
Installation of Flexible Pipe 1	WTP1, 2, 3,&4	■		
Installation of Flexible Pipe 2	WTP1, 2, 3, 4,&5	■		
Fixation of Cl_2 Cylinder	WTP1, 2,&3	■		
Setting Anti Flowout Oil Fence	WTP1, 2, 3, 4,&5	■		
Installation of Neutralization Equipment	WTP1&5	■		
Installation of Neutralization Equipment	WTP2, 3&4		■	
Reservoir/Pumping Station				
Fixation of Transformer	No.1, No.2, No.13, No.14, No.15, No.16, No.17, No.19, No.20, No.21, No.22, No.24, No.25, No.26, No.40, No.52, No.56, No.57, No.58, No.65, No.68, No.73, No.114	■		
Fixation of Battery	Same as above reservoirs	■		

Table 8.4.2 Implementation Program of Earthquake Resistant Plan (2/2)

Name of Facility & Planned Measure	Target Facility	Short-term	Middle-term	Long-term
Fixation of 400V Panel	No.8/p, No.12/p, No.13/p, No.27/p, No.28/p, No.32/P, No.34/P, No.36/p, No.37/P, No.38/P, No.43/P, No.59/P, No.66/P, No.65/P, No.68/P, No.69/p, No.71/P, No.72/P, No.74/P, No.75/P, No.80/P, No.81/P, No.90/P, No.91/P, No.93/P, No.95/P, No.96/P, No.101/P, No102/P, No.105/P			
Fixation of Cl_2 Cylinder	No.4/P, No.5/P, No.7, No.8/P, No.13/P, No.19/P, No.21/P, No.31, No.36/P, No.40/P, No.52/P, No.59/P, No.65/P, No.66/P, No.68/P, No.69/P, No.73/ P, No.74/P, No.89/P, Tarashut, Southern Tarashut, Said Abad			
Support of Surge Tank	No.2/P, No.22/P, No.99/P			
Installation of Electric Post	No.22/P			
Duplicate Incoming Cable	No.16/P, No.52/P, No.68/P, No.114/P			
Installation of Neutralization Equipment	No.4/P, No.5/P, No.7/P, No.13/P, No.19/P, No.21/P, No.31/P, No.36/P, No.40/P, No.52/P, No.58/P, No.59/P, No.65/P, No.66/P, No.73/P, No.89/P, Tarashut, Southern Tarashut, Said Abad			
Emergency Water Supply				
Outlet Siphon Arrangement of Reservoirs	32 reservoirs			
Ditto	17 Reservoirs			
Preparation of Engine Pump for Reservoir	32 reservoirs			
Ditto	17 Reservoirs			
Installation of Emergency Shut-off Valve	1			
Preparation of Engine Pump for Reservoir	1			
Branch Connection on Transmission Main	11 locations			
Ditto	7 locations			
Installation of Tank for Park Well	24 parks			
Ditto	35 wells			
Preparation of Genarator for Park Well	10 parks			
Ditto	16 wells			
Installation of Tank for TWWC Well	28 wells			
Preparation of Genarator for TWWC Well	9 wells			
Installation of Emergency Water Tank	32 locations			
Ditto	137 locations			

8.4.2 Measures for the Future

As described in Section 7.1, such measures as contributing greatly to earthquake resistant facilities but costly and time consuming, which are excluded from the project, are briefly mentioned hereunder for future reference. These measures are also summarized in *Table 8.4.3*.

(1) Pipeline System

Derived from the result of hydraulic analysis made in Section 4.3, the biggest water shortage is brought about by operation interruption of treatment plant 2. Stoppage of plants No.3 & 4 would follow the above. Major cause for the interruption would be the plant facility damage by fault dislocation in case of plants No.3 & 4. But in case of plant No.2, the major cause would be damage of fault crossing point of d2000mm concrete raw water mains which are located upstream of the plant.

Reinforcement of the raw water main at the fault crossing point is considered urgent. But because of large pipe diameter, high pressure and difficulty in acquisition of land for the reinforcement work, its implementation needs careful consideration. The followings will be alternative measures for the above, and it is necessary for selection of the appropriate measure to perform a comprehensive comparative study including the alternative measures in the future:

- to install a by-pass pipeline on the raw water mains to plant No.1 and to connect the line to plant No.2 (shortest distance of the by-pass line is approximately 1km) and to treat surplus raw water at plant No.2,
- to install a by-pass transmission main to cover water shortage area of plant No.2 from the future treatment plant No.6,
- to install a transmission main conveying Taleghan raw water from Bileghan intake station to plant No.2, and
- to install a large diameter clear water transmission main from plant No.5 extending the existing d1,600 or d1,700mm steel pipeline to the west.

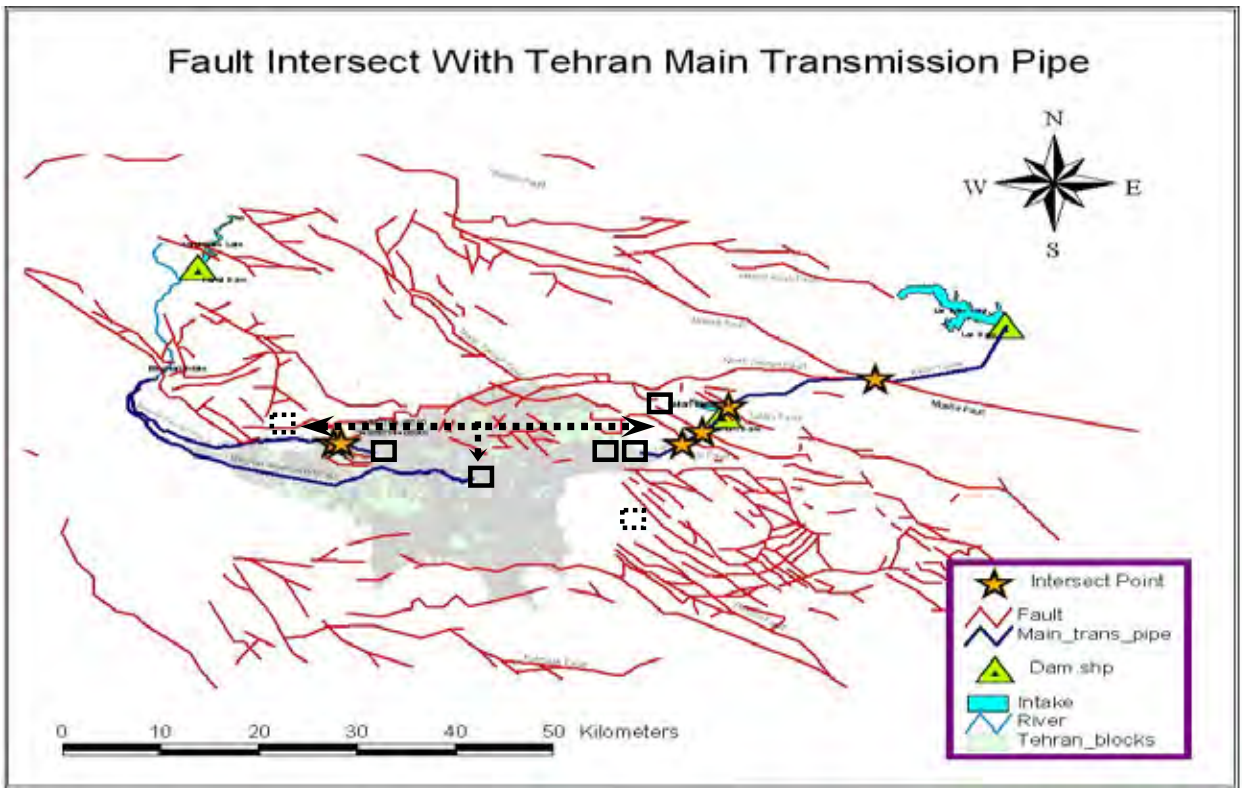
In case of interruption of plants No.3 & 4, several distribution reservoirs/reservoir zones will suffer from water shortage. Installation of a large transmission main from plant No.5 may solve this problem. In case when a future water transmission plan is prepared, study of installation of the main should also be studied in detail.

As a measure for the distant future, there is an idea to install a large and deep transmission main/tunnel connecting all of the plants. This is the similar idea employed in Kobe water supply system, Japan after the Great Hanshin earthquake.

Table 8.4.3 Necessary Countermeasures for the Future

Name of Facility & Measures	Target Facility	Remarks
Pipelines		
Raw Water Mains		
Reinforcement of d1000mm SP	Mains to WTP No.1	Detailed Study is required.
Mitigation of Damage Effect by By-pass, etc.	Mains to WTP No.2	Detailed Study is required.
Installation of Interconnecting Main	From WTP No.6 to 2	Measures as mentioned in the main report should be studied.
Installation of Interconnecting Main	From WTP No.6 to 5	Study should be done.
Raw Water Tunnels and Pipelines in East Area	Conduits to WTP 3&4, No.5	Study should be done.
Clear Water Transmission Mains		
Reinforcement of Pipes on Faults	16-17 locations	Pipes on Secondary Faults
Replacement of RCP (d1800 & 1350mm) with SP	Pipelines from WTP No.2	Replacement should be made in the project, if no fault investivation is made.
Installation of Interconnecting Main	WTP No.5 to WTP No.3&4	Study should be done with Hydralic Model to be up-dated.
Installation of Interconnecting Main	Connecting Several WTPs	Study should be done in the Future.
Distribution Trunk Mains		
Reinforcement of Pipes on Faults	Approximately 65 locations	Number of locations should be surveyed.
Reinforcement of Pipe Connection to Structures	Approximately 130 locations	Number of locations should be surveyed.
Replacement of Cast Iron Pipes with DIP	Mains smaller than 600mm	DIP with Earthquake Resistant Joint
Replacement of other deteriorated pipelines		Should be done according to TWWC Routine Program.
Zoning (Hydraulic Isolation of Each Zone)		Detailed Study is required.
Facility (Structures)		
Dam		
Necessary Reinforcement	Latian Dam	Coordination with other Organization is necessary.
Water Treatmant Plant		
Interconnection of Two Recent WTP	WTP No.3 & No.4	Detailed Study is required.
Distribution Reservoirs		
Installation of By-pass Pipeline	Insufficient Reservoirs only	Study the Present Conditions
Reinforcement of Structure Wall	17 locations	Detailed Study should be made
Equipment		
Intake Facility		
Installation of Generators	Deep Wells	Depend on Conditions of Future Public Power System
Installation of Cl2 Neutralization Equipment	Bileghan Intake	
Water Treatmant Plant		
Installation of Cl2 Neutralization Equipment	All WTPs	
Pump Stations		
Installation of Generators	52 locations	Depend on Condition of Future Public Power System
Installation of Cl2 Neutralization Equipment	19 locations	

Although it needs huge amount of money, it is possible to transmit drinking water anywhere by pumpage and the main also works as large water bases.



Note: ☐ shows the existing water treatment plant, ⬚ shows future plant

Figure 8.4.1 An Idea of Interconnecting Main

(2) Facility

As for facilities crossing or located near a fault, at first measuring the exact location of the fault shall at first be performed. By identifying exact location between a facility and a fault, stoppage of operation of damaged portion of the facilities or change in flow direction using a by-pass pipeline, or connection of possible facilities especially in case of plants No3 & 4 should be carefully studied in the future.

As the supply area of plant No.5 has been supplied by plant No.3 & 4 until recent years before No.5 put into operation, interruption of No.5 operation does not affect much and the area will be almost covered by plants No.3 & 4. However, extension of service area of No.5 to the north, to a higher land by construction of housing is very rapid and covering of the area by plants No.3 & 4 becomes difficult in the future. Plan of water supply to such an area as mentioned above shall be carefully prepared taking into consideration a flexible transmission system including loop pipeline system or transmission network.

(3) Equipment

In Tehran water supply system, huge number of pumps such as well pumps (354 wells as shown in *Table 2.3.3*) and transmission pumps (40 pump stations by TWWC data) are in operation. However,

equipment of generators is limited to very important facilities such as water treatment plants. Generators are normally installed to increase stability and reliability of power supply in all of the power sources.

As the number of pumps is huge, maintenance of the generator which must be made in every month needs large man power and cost. Installation of generators should be studied taking future public power supply scheme and conditions and future idea of co-generation into account.

However, the followings are employed in the earthquake resistant plan:

- Acquisition of nine (9) generators for deep wells for emergency water supply, and
- Duplication of incoming electric cables for pump station No.16, No.52, No.68 and No.114 which are currently receiving power supply from only one source.

It is planned that conversion of disinfection equipment to sodium hypochlorite system will be executed in the distant future, because such measures as fixing of chlorine cylinders and installation of neutralization equipment are planned to be implemented in the project. However, it is desirable to study its implementation taking Japanese experience of the chlorine equipment conversion as described previously in Section 2.3.1 into account.

(4) Emergency Water Supply

As shown in *Table 2.3.7* in the previous chapter, TWWC plans to construct 17 distribution reservoirs in the future. According to progress of the construction, amount of water secured in earthquake disaster increases, and the increase will affect the installation of the other emergency water basis. It is desirable to formulate concrete future construction plan of distribution reservoirs and to prepare an action plan for emergency water supply on the basis of the above construction plan.

CHAPTER 9 Economic Analysis for Project Evaluation and Financial Planning

9.1 Economic Analysis for Project Evaluation

9.1.1 Objectives and Basic Concepts for Economic Analysis

It is widely accepted that the rationale of the economic analysis for a project evaluation is designed to enhance the social welfare of a society in terms of the optimum use of scarce resources among different policy objectives. The analysis is based on the assessment of economic values of both benefits and costs of a project, using the cost-benefit methodology. On the other hand, financial viability as well as project risks is also assessed to verify the sustainability of the delivery of economic benefits accrued from the project.

Benefits obtained from a water supply project are normally regarded as values which are equivalent to at least the cost of alternative means of meeting its water consumption needs. In other words, one of major benefits of a water supply project is to avoid the cost of alternative supply in addition to the improvement in hygiene and safety. On the contrary, an earthquake resistant project which aims at strengthening functions of critical lifelines is based on the assessment of the scale of avoiding losses and damages caused by the occurrence of the scenario earthquake. Furthermore, the following factors should be taken into account in evaluating the specific earthquake resistant project.

a) The earthquake resistant project itself does not substantially increase the amount of water supply, and, as a result, it also does not generate any additional cash revenues from users.

b) The benefits of the earthquake resistant project are uncertain due to the fact that it depends on the frequency and scale of the occurrence probability of the scenario earthquake.

c) The earthquake resistant project significantly contributes to the national interest through the protection of the lifelines of the capital.

Figure 9.1.1 illustrates the image of the basic concept of benefits for the earthquake resistant project. Generally, benefits of an earthquake resistant project derive from the reduction in the number of days required for the restoration from the scenario earthquake. More concretely, these benefits will be quantified in the form of the monetary value of avoiding i) the loss of the value added in the damaged area by the water supply interruption, ii) the additional cost of workers required for the restoration, and iii) the additional cost of workers required for the emergency water supply.

These benefits will be converted to monetary values by using the unit values of these losses and additional costs. Taking into account both benefits and costs, the Economic Internal Rate of Return (EIRR), the Benefit Cost Ratio (B/C) and the Net Present Value (NPV) will be computed to judge the

economic viability of the earthquake resistant project.

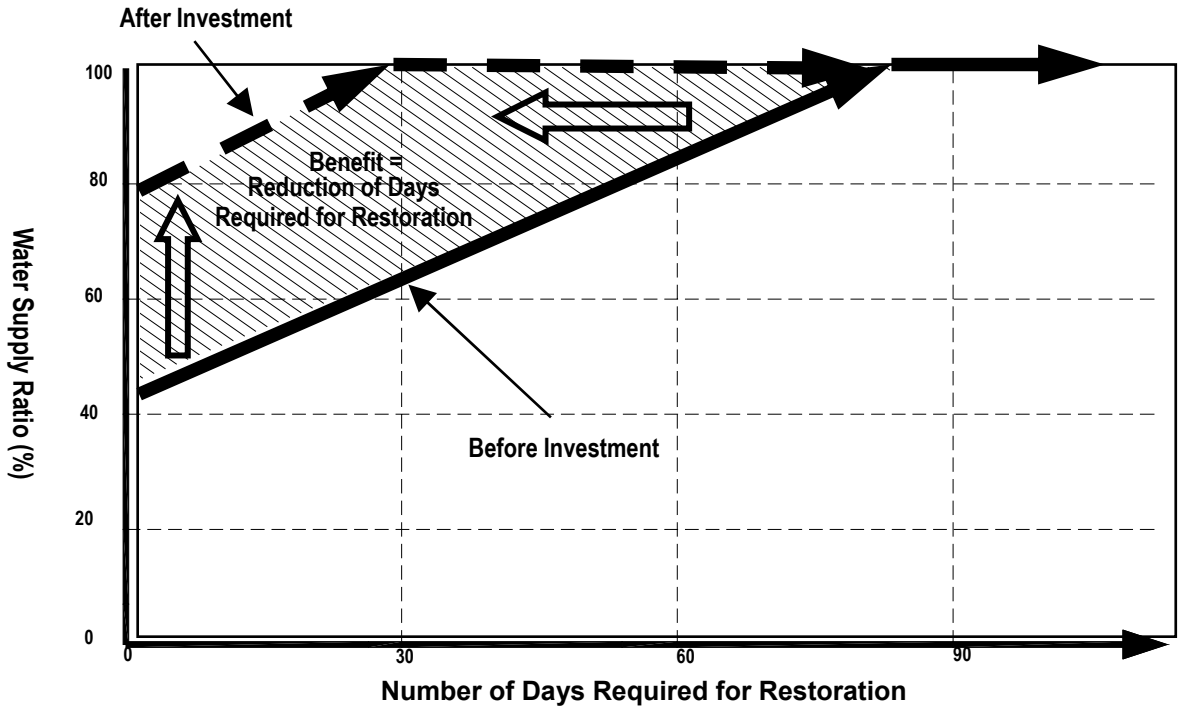


Figure 9.1.1 Basic Concept of Benefits for Earthquake Resistant Project

When the calculated sums of the benefits are converted to the annual monetary value, the probable maximum loss (PML) method will be employed. The PML method is traditionally based on the assumption that the worst case scenario earthquake might occur in a certain period of time. In the PML method, the controlling fault which causes the worst-level earthquake is determined. An earthquake event of a specified magnitude associated with an estimated return period is then assumed to occur on this fault, and this event is employed as the basis of the loss analysis. In this project, the North Tehran Fault is regarded as the controlling fault provoking the worst case scenario earthquake. In other words, the probability for any fault to cause the worst case scenario is stated as the likelihood one will occur within a period of time, usually expressed as 50, 100, 200 or 500 years. However, the fact that an earthquake might only occur once in 500 years does not mean that it will not occur tomorrow. A more accurate expression is that there is a 1 in 500 chance that it will occur in any given year. Therefore, the annual monetary value of benefits can be calculated based on the assumption that the chances are same in the given period of time. The formula for the calculation of the annual monetary value of benefits is as below.

Annual Monetary Value of Benefits = Total Avoidance of Losses and Additional Costs / Probable Period of Time for the Worst Case Scenario Earthquake

9.1.2 Presumptions

The below parameters are employed as general benchmarks for the economic evaluation of the planned earthquake resistant project.

a) Project Life

The project life to evaluate the benefit stream as well as the cost stream is fixed at 50 years, taking into account the durability of major earthquake resistant project components such as facilities and pipelines.

b) Cut-off Rate

Although a cut-off rate, which is a benchmark or a criteria to judge whether the calculated internal rate of return is feasible or not, is often fixed at 10 to 12 percent level in case of investment projects in developing countries, the cut-off rate for this specific earthquake resistant project is fixed at 5 percent, taking into account the fact that the improvement of the earthquake resistant function is one of the most important basic needs in terms of protecting the lifelines of the nation's capital.

c) Residual Value

The residual values of pipelines are not taken into account, since they are negligible at the last year of the project life.

d) Prices

All the costs and benefits are valued in constant prices as of July 2006. The foreign exchange rate is fixed at Rs 9,186 against USD, which is the official rate of the Central Bank of Iran as of the end of July 2006.

e) Standard Conversion Factor (SCF)

A conversion factor is the ratio between the economic price value and the financial price value for a project output or input. Domestic market prices are generally over-evaluated higher than border price equivalent values. Instead of adjusting border price equivalent values upward, using the shadow exchange rate factor (SERF), the domestic market price values of project items can be adjusted downward. This can be done using the standard conversion factor (SCF), which is simply the inverse of the SERF. It represents the extent to which market prices are over-evaluated against border price equivalent values. The SCF of 0.970 at the latest similar study is employed in this specific evaluation.

f) Shadow Wage Rate (SWR)

The shadow wage rate (SWR) is an estimate of the economic price of labor. The SWR of 0.500 at the latest similar study is employed in this specific evaluation.

9.1.3 Project Benefits

In accordance with the basic concept of the benefits for the earthquake resistant project discussed in *Section 9.1.1*, the benefits for the earthquake resistant project are estimated in the form of the monetary

values through the below steps.

(1) Estimation of Number of Beneficiaries

In an attempt to provide the baseline data for the calculation of the benefits, the number of beneficiaries as well as the relevant data is collected. The current number of the service population as of May 2006 connected to the TWWC city-wide water supply system is estimated at 6,938,734. The service area is divided into 6 service districts, and the number of service population as well as the number of meters by the category of users in each district is tabulated as *Table 9.1.1* and *Table 9.1.2*, respectively.

Table 9.1.1 Number of Service Population in Districts in Tehran City

District	Number of Service Population
1	93,153
2	130,940
3	82,140
4	141,037
5	129,770
6	154,464
Total	6,938,734

Source: TWWC 2006

Table 9.1.2 Number of Meters in Tehran City

District	Residential Users	Mixed Users	Commercial and Industrial Users	Construction Users	Government and Public Users	Others	Total
1	93,153	4,473	5120	3,850	725	1,591	108,912
2	130,940	11,537	11,242	3,123	751	2,347	159,940
3	82,140	5,095	6,550	2,658	375	1,632	98,450
4	141,037	11,043	17,780	3,576	442	2,972	176,850
5	129,770	11,576	10,262	2,777	314	2,711	157,410
6	154,464	16,514	9,304	2,080	324	2,747	185,433
Total	731,504	60,238	60,258	18,064	2,931	14,000	886,995

Source: TWWC 2006

(2) Estimation of Benefits

1) Reduction of Value Added Loss by Water Supply Interruption

In accordance with the decrease in the number of damaged points as well as mitigation of seriousness of damages after the occurrence of the scenario earthquake, the number of the service population affected by the water supply interruption will be significantly decreased, thereby leading to approximately 2.2 million reduction in the number of the affected population. It should be noticed that while the initial interruption ratio for the water supply before the earthquake resistant investment is estimated at 44.2%, the ratio after the investment will be considerably decreased to 25.0%. The comparison between "with project" and "without project" in the number of the service population affected by the water supply interruption is tabulated as per *Table 9.1.3*. The down-sizing in the affected population will make it possible to avoid the massive amount of the value added loss during the interruption period. Consequently, while the water supply interruption might continue even until the 82nd day after the earthquake occurrence in case of "without project", the interruption will be terminated just within one month in case of "with project".

Table 9.1.3 Service Population Affected by Water Supply Interruption

The Number of Days after Earthquake	Without Project	With Project	Difference
1st day	3,994,553	1,738,083	2,256,470
15th day	3,458,205	1,075,447	2,382,758
30th day	1,315,797	0	1,315,797
45th day	802,904	0	802,904
60th day	386,100	0	386,100
75th day	76,000	0	76,000
90th day	0	0	0

Source: Estimated by JICA Study Team

Based on the minimum wage of the unskilled labor, the unit value for the value added loss by the water supply interruption is theoretically calculated at USD 3.84 per capita per day, taking into account the ratio of the economically active population, the shadow wage rate and the unemployment ratio in the country. The formula to calculate the unit value of the value added loss by the interruption is as per *Table 9.1.4*.

Table 9.1.4 Formula to Calculate Unit Value of Value Added Loss by Water Supply Interruption

Calculation Item	Calculation Formula
Minimum Wage for Unskilled Labor per Person per Day	A
Ratio of Economically Active Population	B
SWR (Shadow Wage Rate)	C
Unemployment Rate	D
Unit Value for Value Added Loss per Person per Day	E = A x B x C x D

Source: JICA Study Team

2) Reduction of Cost for Restoration

The number of the required workers for the restoration works will be also decreased to a large extent in response to the decrease in the number of damaged points and the mitigation in the degree of damages. It is estimated that while the total number of worker-days required for the restoration activities of all the damaged pipelines in case of "without project" is estimated at 44,268, the number of worker-days required in case of "with project" is 18,468, leading to the massive down-sizing by 25,800 worker-days. The comparison between "with project" and "without project" in the accumulated required number of workers for the restoration activities is tabulated as per *Table 9.1.5*. The reduction in the affected population will be able to save a sizable amount of the cost for the restoration activities during the interruption period. Consequently, while the cost for the restoration activities might be borne even until the 82nd day after the earthquake occurrence in case of "without project", the cost will not be required just after one month in case of "with project".

Table 9.1.5 Accumulated Number of Required Worker-Days for Restoration

The Number of Days after Earthquake	Without Project	With Project	Difference
1st to 15th days	10,260	9,720	540
16th to 30th days	10,068	8,748	1,320
31st to 45th days	9,720	0	9,720
46th to 60th days	9,360	0	9,360
61st to 75th days	4,356	0	4,356
76th to 90th days	504	0	504
Total	44,268	18,468	25,800

Source: Estimated by JICA Study Team

More specifically, the comparison between "with project" and "without project" on the accumulated required number workers for the restoration works of transmission mains, distribution mains and distribution sub-mains/service connections is as per *Table 9.1.6*, *Table 9.1.7* and *Table 9.1.8*, respectively.

Table 9.1.6 Accumulated Number of Required Worker-Days for Restoration (Transmission Main)

The Number of Days after Earthquake	Without Project	With Project	Difference
1st to 15th days	540	0	540
16th to 30th days	444	0	444
31st to 45th days	0	0	0
46th to 60th days	0	0	0
61st to 75th days	0	0	0
76th to 90th days	0	0	0
Total	984	0	984

Source: Estimated by JICA Study Team

Table 9.1.7 Accumulated Number of Required Worker-Days for Restoration (Distribution Main)

The Number of Days after Earthquake	Without Project	With Project	Difference
1st to 15th days	6,840	3,348	3,492
16th to 30th days	3,996	0	3,996
31st to 45th days	504	0	504
46th to 60th days	0	0	0
61st to 75th days	0	0	0
76th to 90th days	0	0	0
Total	11,340	0	7,992

Source: Estimated by JICA Study Team

Table 9.1.8 Accumulated Number of Required Worker-Days for Restoration (Distribution Sub-main and Service Connections)

The Number of Days after Earthquake	Without Project	With Project	Difference
1st to 15th days	2,880	6,372	-3,492
16th to 30th days	5,628	8,748	-3,120
31st to 45th days	9,216	0	9,216
46th to 60th days	9,360	0	9,360
61st to 75th days	4,356	0	4,356
76th to 90th days	504	0	504
Total	31,944	15,120	16,824

Source: Estimated by JICA Study Team

Based on the minimum wage of the unskilled labor, the unit value for the additional cost of a worker is estimated at USD 9.74 per worker per day, taking into account the shadow wage rate in the country. The formula to calculate the unit value of the additional cost per worker per day for the restoration is as per *Table 9.1.9*.

Table 9.1.9 Formula to Calculate Unit Value of Additional Cost per Worker per Day for Restoration

Calculation Item	Calculation Formula
Minimum Wage for Unskilled Labor per Person per Day	A
SWR (Shadow Wage Rate)	B
Unit Value of Additional Cost per Worker per Day	C = A x B

Source: JICA Study Team

3) Reduction of Cost for Emergency Water Supply

The number of the required workers for the emergency water supply will be also decreased to a large extent in response to the decrease in the number of damaged points and mitigation in the degree of damages. It is estimated that while the total number of worker-days required for the emergency water supply in case of "without project" is estimated at 13,083, the number of worker-days required in case of "with project" is 5,412, leading to the significant reduction by 7,671 worker-days. The comparison between "with project" and "without project" in the accumulated required number of workers for the emergency water supply is tabulated in *Table 9.1.10*. The reduction in the affected population will save a considerable amount of the cost for the emergency water supply during the interruption period. Consequently, while the cost for the emergency water supply might be borne even until the 82nd day after the earthquake occurrence in case of "without project", the cost will not be required after one month in case of "with project".

Table 9.1.10 Accumulated Number of Required Worker-Days for Emergency Water Supply

The Number of Days after Earthquake	Without Project	With Project	Difference
1st to 15th days	4,758	3,963	795
16th to 30th days	3,504	1,449	2,055
31st to 45th days	2,427	0	2,427
46th to 60th days	1,740	0	1,740
61st to 75th days	597	0	597
76th to 90th days	57	0	57
Total	13,083	5,412	7,671

Source: Estimated by JICA Study Team

Based on the minimum wage of the unskilled labor, the unit value for the additional cost of a worker is estimated at USD 9.74 per worker per day, taking into account the shadow wage rate in the country. In the same manner as the cost for the restoration, the formula to calculate the unit value of the additional cost per worker per day for the emergency water supply is as per *Table 9.1.11*.

Table 9.1.11 Formula to Calculate Unit Value of Additional Cost per Worker per Day for Emergency Water Supply

Calculation Item	Calculation Formula
Minimum Wage for Unskilled Labor per Person per Day	A
SWR (Shadow Wage Rate)	B
Unit Value of Additional Cost per Worker per Day	C = A x B

Source: JICA Study Team

(3) Conversion to Annual Benefits

The cases for the earthquake occurrence probabilities which are the calculation basis for the conversion to annual benefits are summarized in *Table 9.1.12*. The details of the cases will be discussed in *section 9.1.5 and 9.1.6*.

Table 9.1.12 Earthquake Occurrence Probabilities and Coefficients for Conversion to Annual Benefits

Case	Earthquake Occurrence Probability	Coefficients for Conversion to Annual Benefits
Case A	Once per 500 years	0.002
Case B	Once per 400 years	0.0025
Case C	Once per 300 years	0.0033
Case D	Once per 200 years	0.005
Case E	Once per 100 years	0.01
Case F	Once per 50 years	0.02

Source: JICA Study Team

By applying the above coefficients and the relevant conversion factors, the annual benefits on financial price basis are calculated and converted to the annual benefits on economic price basis, as *Table 9.1.13* shows. The gestation period for generating the benefits will be taken into account in accordance with the disbursement of the investment cost. The detailed calculations of benefits as well as the benefit accrual streams of all the cases are as per attached *Appendix 10.1 to 10.16*.

Table 9.1.13 Annual Benefits on Financial and Economic Price Basis

Case	Total Financial Benefit (USD)	Conversion Factor	Total Economic Benefit (USD)
Case A	811,725	0.970	787,374
Case B	1,014,657	0.970	984,217
Case C	1,339,347	0.970	1,229,167
Case D	2,029,314	0.970	1,968,434
Case E	4,058,627	0.970	3,936,868
Case F	8,117,254	0.970	7,873,737

Source: Calculated by JICA Study Team

9.1.4 Project Costs

The financial costs for the planned earthquake resistant project are estimated in accordance with the required amount of investment as well as relevant unit prices of three major project components of facilities/equipment, pipelines and emergency water supply. The outline of the project cost is summarized in Table 9.1.14. The total project cost including 8 percent administration fee as well as 10 percent consulting fee and relevant contingencies is estimated at USD 28,500 thousand. The calculated financial costs are converted to the economic costs by using the respective conversion factors. The detailed cost streams are as per attached *Appendix 10.17 to 10.20*.

Table 9.1.14 Summary of Project Costs

No.	Cost Item	Project Cost (USD)
1	Facilities and Equipment	7,571,700
2	Pipelines	7,140,000
3	Emergency Water Supply	7,556,000
4	Total Investment Cost	22,267,700
5	Administration Fee	1,781,416 (Total Investment Cost x 8%)
6	Consulting Fee	2,226,770 (Total Investment Cost x 10%)
7	Contingencies	2,224,114 (Total Investment Cost x Approximately 10%)
8	Total Project Cost	28,500,000

Source: Estimated by JICA Study Team

(1) Investment Costs

The total investment cost for the planned earthquake resistant project is estimated at USD 22,267.7 thousand, which is composed of facilities/equipment, pipelines and emergency water supply with the following breakdown for the period of short-term, medium-term and long-term time frames. The financial investment costs are converted to the economic costs by using the respective conversion factors.

Table 9.1.15 Investment Schedule

Term	Year	Facilities and Equipment (USD)	Pipelines (USD)	Emergency Water Supply (USD)	Financial Cost (USD)	Economic Cost (USD)
Short-term	2008	483,533	50,000	676,000	1,209,533	1,123,619
	2009	483,533	50,000	676,000	1,209,533	1,123,619
	2010	483,533	50,000	676,000	1,209,533	1,123,619
Medium-term	2011	736,475	175,000	649,500	1,560,975	1,440,350
	2012	736,475	175,000	649,500	1,560,975	1,440,350
	2013	736,475	175,000	649,500	1,560,975	1,440,350
	2014	736,475	175,000	649,500	1,560,975	1,440,350
Long-term	2015	635,040	1,258,000	586,000	2,479,040	2,205,860
	2016	635,040	1,258,000	586,000	2,479,040	2,205,860
	2017	635,040	1,258,000	586,000	2,479,040	2,205,860
	2018	635,040	1,258,000	586,000	2,479,040	2,205,860
	2019	635,040	1,258,000	586,000	2,479,040	2,205,860

Source: Estimated by JICA Study Team

(2) Replacement Costs

The replacement costs for the facilities and equipment are taken into account for the renewal of components whose service period is 30 years after the initial investment, and the maximum replacement cost is estimated at USD 486,200 for the year 2045 to 2049.

Table 9.1.16 Replacement Cost for Facilities and Equipment

Year	Total Financial Replacement Cost (USD)	Conversion Factor for Replaced Facilities and Equipment	Total Economic Replacement Cost (USD)
2038	152,600	0.9306	142,006
2039	152,600	0.9306	142,006
2040	152,600	0.9306	142,006
2041	334,000	0.9306	310,812
2042	334,000	0.9306	310,812
2043	334,000	0.9306	310,812
2044	334,000	0.9306	310,812
2045	486,200	0.9306	452,446
2046	486,200	0.9306	452,446
2047	486,200	0.9306	452,446
2048	486,200	0.9306	452,446
2049	486,200	0.9306	452,446

Source: Estimated by JICA Study Team

(3) Operation and Maintenance Cost

The operation and maintenance costs for pipelines as well as facilities are not included, since the investment on these project components does not require the additional operation and maintenance activities. The operation and maintenance cost for the emergency water supply equipment is estimated at USD 4,680 per annum after the full installation of those equipment.

9.1.5 Results of Economic Analysis on Basic Scenario Approach

(1) Concept of Basic Scenario Approach and Calculations of Economic Indicators

By using the benefit stream as well as the cost stream, EIRR (Economic Internal Rate of Return), BCR (Benefit Cost Ratio) and NPV (Net Present Value) for the base case are calculated as per *Table 9.1.17*. These economic indicators are calculated on the conditions that the earthquake occurrence probability is fixed at the same level as the scenario earthquake whose occurrence probability*[1)] is assumed as once per 500 years, and this first approach is called ***"Basic Scenario Approach"***. It reveals that the EIRR for the base case is calculated at 0.62 percent which is far below the cut-off rate, reflecting the lower probability of the scenario earthquake. The BCR and the NPV are also calculated based on the discount rate of 5 percent, indicating the lower economic viability of the base case.

Table 9.1.17 Calculations of EIRR, BCR and NPV

Case	Earthquake Occurrence Probability	EIRR (%)	BCR (D.R.=0.05)	NPV (Thousand USD) (D.R.=0.05)
Base Case	P = 0.002	0.62	0.502	-9,908

Source: Calculated by JICA Study Team

(2) Results of Sensitivity Analysis

Sensitivity analysis is a simple method to assess the effects of adverse changes on conditions surrounding a project, involving changing the value of one or more selected variables and calculating the changes in the economic indicators. In this economic analysis, the increase in the total cost by 10 percent, the decrease in the total benefit accrual by 10 percent, and the combination of both risks are assessed. The results are as per attached *Table 9.1.18*.

Table 9.1.18 Sensitivity Analysis on EIRR, BCR and NPV

Indicator	Unit	Earthquake Occurrence Probability	Base Case	Risk 1 (Cost = 10% up)	Risk 2 (Benefit = 10% up)	Risk 3 (Both Risks)
EIRR	%	P = 0.002	0.62	0.03	0.02	-0.51
BCR	Ratio	P = 0.002	0.502	0.452	0.451	0.411
NPV	Thousand USD	P = 0.002	-9,908	-12,097	-10,905	-12,894

Source: Calculated by JICA Study Team

9.1.6 Results of Economic Analysis on Risk Premium Based Approach

(1) Basic Concept of Risk Premium Based Approach

The second approach is that the economic analysis is based on actually traded earthquake occurrence probabilities in the earthquake risk market such as the earthquake reinsurance market. It is widely noticed that risks of the earthquake occurrence probabilities are being evaluated much higher (e.g. 2.5 times to 5 times) than the occurrence probability of the scenario earthquake. In other words, earthquake occurrence

NOTE - Occurrence probability of Scenario Earthquake*[1)] : Occurrence probability of earthquake, which has the same intensity level of scenario earthquake, can be assumed as around 2,000 years by observing Figure 3.4.1, which is obtained from "Research Project for Strengthening and Control of Tehran Gas Network Against Earthquake Phase 2". Since there are four scenario earthquakes, the occurrence probability for one of them is tentatively assumed as one-forth of 2,000, i.e.500 years for the economic analysis purpose in the Study.

risks are economically evaluated in the actual earthquake risk market at 2.5 to 5 times as much as the theoretical earthquake scenario. Therefore, the economic indicators under the additional cases considering those risk premiums are calculated for further analysis. *Table 9.1.19* shows the actually traded risks of earthquake occurrence probabilities as well as the additional cases for the economic analysis.

Table 9.1.19 Actually Traded Risks of Earthquake Occurrence Probabilities and Additional Cases for Economic Analysis

Case	Earthquake Occurrence Probability	Description	Level of Risk
Base Case (Case A)	P = 0.002	Scenario Earthquake (once per 500 years)	Basic Scenario Risk
Premium Case 1 (Case B)	P = 0.0025	Once per 400 years	Risk between Basic Scenario Risk and Lower Limit of Actually Traded Risk
Premium Case 2 (Case C)	P = 0.0033	Once per 300 years	Risk between Basic Scenario Risk and Lower Limit of Actually Traded Risk
Premium Case 3 (Case D)	P = 0.005	Once per 200 years	Lower Limit of Actually Traded Risk
Premium Case 4 (Case E)	P = 0.01	Once per 100 years	Upper Limit of Actually Traded Risk

Source: Categorized by JICA Study Team

It can be safely argued that, economically, the earthquake occurrence probability in this specific project could be evaluated 2.5 to 5 times as highly as the base case. More specifically, Case D (once per 200 years) and Case E (once per 100 years) are actually traded risks in the earthquake risk market. Consequently, the economic indicators in these additional cases are calculated on the conditions that the earthquake occurrence probabilities range from the scenario earthquake level (once per 500 years) to the upper limit level of the actually traded risks (once per 100 years), and this second approach is called ***"Risk Premium Based Approach"***.

(2) Results of Risk Premium Based Approach

In accordance with the variations of the risk premium cases, the results of the risk premium based approach reveal that although the EIRR of the base case (Case A) ranges from 0.62 percent to -0.52 percent with the negative economic viability, those of Case D and Case E are much higher than the cut-off figure of the EIRR which is fixed at 5 percent. The results are summarized in *Table 9.1.20* and illustrated in *Figure 9.1.2*.

Table 9.1.20 Risk Premiums and Calculations of EIRRs

Case	Earthquake Occurrence Probability	Base Case	Risk 1 (Cost = 10% up)	Risk 2 (Benefit = 10% up)	Risk 3 (Cost = 10% up)
Base Case (Case A)	P = 0.002 (One Occurrence in 500 years)	0.62%	0.03%	0.02%	-0.51%
Premium Case 1 (Case B)	P = 0.0025 (One Occurrence in 400 years)	1.93%	1.36%	1.30%	0.75%
Premium Case 2 (Case C)	P = 0.0033 (One Occurrence in 300 years)	3.69%	3.07%	3.00%	2.40%
Premium Case 3 (Case D)	P = 0.005 (One Occurrence in 200 years)	6.73%	5.98%	5.90%	5.19%
Premium Case 4 (Case E)	P = 0.01 (One Occurrence in 100 years)	13.53%	12.43%	12.32%	11.28%

Source: Calculated by JICA Study Team

The results of the risk premium based approach also prove that although the BCR of the base case ranges from 0.402 to 0.491, those of Case D and Case E are much higher than the cut-off figure of BCR which is fixed at 1.000. The results are summarized in *Table 9.1.21* and illustrated in *Figure 9.1.3*.

Table 9.1.21 Risk Premiums and Calculations of BCRs

Case	Earthquake Occurrence Probability	Base Case	Risk 1 (Cost = 10% up)	Risk 2 (Benefit = 10% up)	Risk 3 (Cost = 10% up)
Base Case (Case A)	P = 0.002 (One Occurrence in 500 years)	0.502	0.452	0.451	0.411
Premium Case 1 (Case B)	P = 0.0025 (One Occurrence in 400 years)	0.627	0.570	0.564	0.513
Premium Case 2 (Case C)	P = 0.0033 (One Occurrence in 300 years)	0.828	0.753	0.745	0.677
Premium Case 3 (Case D)	P = 0.005 (One Occurrence in 200 years)	1.254	1.140	1.129	1.026
Premium Case 4 (Case E)	P = 0.01 (One Occurrence in 100 years)	2.509	2.281	2.258	2.053

Source: Calculated by JICA Study Team

In the same manner, the results show that although the NPV of the base case is negative, those of Case D and Case E are positive figures. The results are summarized in *Table 9.1.22*.

Table 9.1.22 Risk Premiums and Calculations of NPVs (Unit: Thousand USD)

Case	Earthquake Occurrence Probability	Base Case	Risk 1 (Cost = 10% up)	Risk 2 (Benefit = 10% up)	Risk 3 (Cost = 10% up)
Base Case (Case A)	P = 0.002 (One Occurrence in 500 years)	-9,908	-12,097	-10,905	-12,894
Premium Case 1 (Case B)	P = 0.0025 (One Occurrence in 400 years)	-7,414	-9,402	-8,661	-10,649
Premium Case 2 (Case C)	P = 0.0033 (One Occurrence in 300 years)	-3,423	-5,411	-5,069	-7,058
Premium Case 3 (Case D)	P = 0.005 (One Occurrence in 200 years)	5,057	3,068	2,563	574
Premium Case 4 (Case E)	P = 0.01 (One Occurrence in 100 years)	29,997	28,009	25,009	23,021

Source: Calculated by JICA Study Team

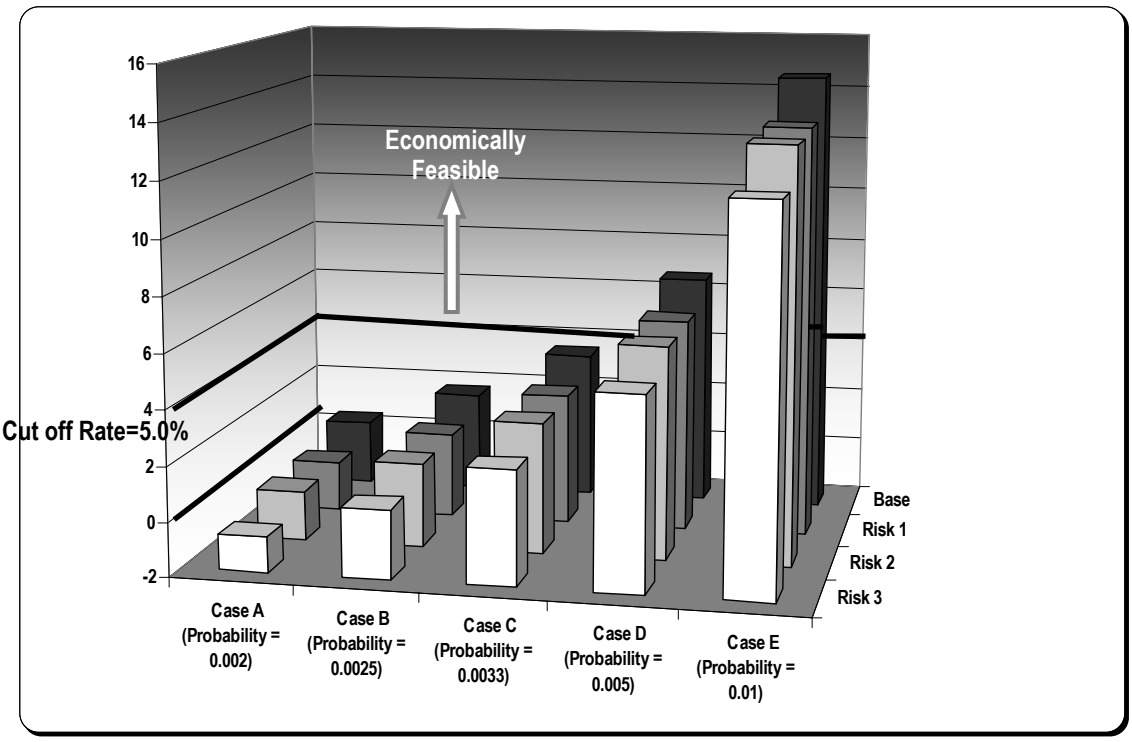


Figure 9.1.2 Results of EIRR Calculations

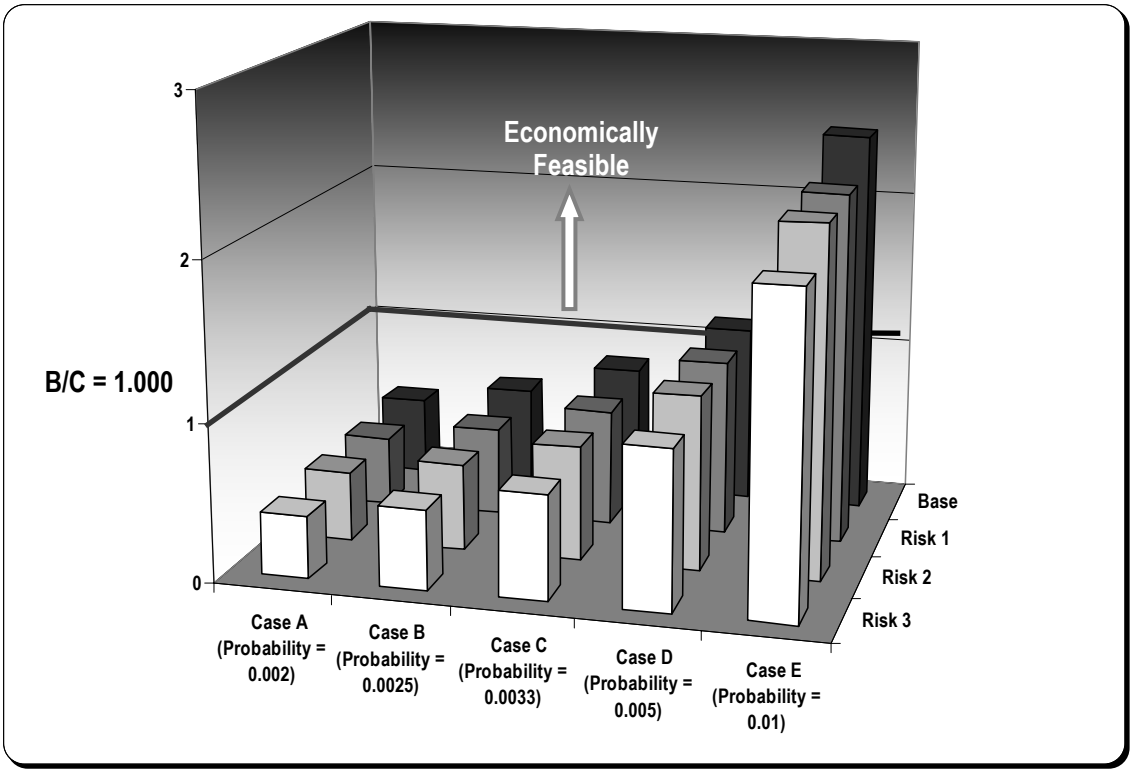


Figure 9.1.3 Results of BCR Calculations

9.1.7 Economic Analysis on Service Life Based Approach

(1) Basic Concept of Service Life Based Approach

The third approach is that the earthquake occurrence probability is fixed at the same level as the project life of 50 years regardless of the occurrence probability of the basic scenario earthquake. In other words, the earthquake occurrence probability is fixed at the level that the scenario earthquake might occur once during the project life of 50 years. *Table 9.2.23* shows the comparison of the earthquake occurrence probabilities between the basic scenario approach and the service life based approach.

Table 9.1.23 Comparison of Earthquake Occurrence Probabilities between Basic Scenario Approach and Service Life Based Approach

Case	Type of Approach	Earthquake Occurrence Probability	Description
Base Case (Case A)	Basic Scenario Approach	P = 0.002	Once per 500 years
Case F	Service Life Based Approach	P = 0.020	Once per 50 years

Source: Calculated by JICA Study Team

Consequently, economic indicators are calculated on the conditions that the earthquake occurrence probability is based on the same level as the project life of 50 years, and this third approach is called ***"Service Life Based Approach"***.

(2) Results of Service Life Based Approach

The results of the economic analysis on the service life based approach reveal that while the EIRR ranges from 20.18 percent to 23.37 percent, which are much higher than the cut-off rate, the BCR as well as the NPV also remains economically viable.

Table 9.1.24 Calculations of EIRRs on Service Life Based Approach

Case	Earthquake Occurrence Probability	Base Case	Risk 1 (Cost = 10% up)	Risk 2 (Benefit = 10% up)	Risk 3 (Cost = 10% up)
EIRR (%)	P = 0.02	23.37	21.82	21.66	20.18
BCR	P = 0.02	5.017	4.561	4.516	4.105
NPV (Thousand USD)	P = 0.02	79,878	77,890	69,902	67,914

Source: Calculated by JICA Study Team

9.1.8 Economic Analysis on Catastrophic Risk Based Approach

(1) Basic Concept of Catastrophic Risk Based Approach

The fourth approach is called ***"Catastrophic Risk Based Approach"***. In this approach, it is stressed that the catastrophic seriousness of the earthquake damages can simply justify the earthquake resistant project. This approach is based on the idea that a catastrophe which is very unlikely to occur is not a rational justification for ignoring the risk of its occurrence. However, such catastrophic risk is often ignored due to the below reasons.

a) Although a once-in-a-century event is as likely to occur at the beginning of the century as at any other time, it is less likely to occur in the first decade of the century than later.

b) Authorities concerned, given the variety of risks to which they must pay attention, are likely to have a high threshold of attention below which risks are simply ignored.

c) Users have difficulties in imagining in terms of probabilities, especially very low probabilities, which they tend to write off. Since the frequency of a catastrophic event is rare enough, this weakens political support for incurring the cost of taking precautionary measures against low-probability disasters.

However, the slight risks of terrible disasters should not be neglected if the results are serious. The risk may be slight, but if the consequences are devastating enough, the expected cost of disasters may be sufficient to warrant defensive measures regardless of the probabilities. This approach is based on the idea that uncertainty could not be an excuse for no action, especially when the expected damages would seriously play havoc with the capital city of a country.

(2) Results of Catastrophic Risk Based Approach

Even though the probability of the scenario earthquake occurrence is extremely low, the probable maximum loss by the scenario earthquake is catastrophically devastating enough once the earthquake happens. According to the estimate of damages by the scenario earthquake, the probable maximum loss is estimated at USD 407,723 thousand which is 0.247 percent and 0.665 percent of the current GDP and the gross capital formation of the country, respectively, as *Table 9.1.25* shows. Moreover, the initial water supply interruption in case of the occurrence of the scenario earthquake would remain at 44.2%, which is equivalent to 3.99 million population of the capital city. Consequently, one of the most critical lifelines of the capital city is exposed to these catastrophic risks, and the central government as well as TWWC is fully responsible for protecting those lifelines regardless of the lower probability of the scenario earthquake.

Table 9.1.25 Estimate of Total Probable Maximum Loss by Scenario Earthquake (Unit: Thousand USD)

Item	Value Added Loss by Water Supply Interruption	Additional Cost for Restoration	Additional Cost for Emergency Water Supply	Total Probable Maximum Risk
Value of Loss	407,397	251	75	407,723

Source: Estimated by JICA Study Team

9.1.9 Conclusions

(1) Results of Economic Analysis for Project Evaluation

Although the seismic risk of the scenario earthquake is relatively low and uncertain, the following 4 approaches for the economic analysis will lead to the justification of the economic feasibility of the earthquake resistant investment. The results of the detailed calculations of EIRR, FIRR, BCR and NPV of all the cases are as per attached *Appendix 10.21 to 10.44*.

a) In accordance with ***"Basic Scenario Approach"*** which is based on the assumption that the earthquake occurrence probability of the scenario earthquake is 0.002 (once per 500 years), the results reveal that the economic indicators such as EIRR is far less than the cut-off rate,

implying that the project does not seems to be economically feasible based on the basic scenario basis.

b) In accordance with ***"Risk Premium Based Approach"*** which is based on the assumption that the earthquake occurrence probability ranges from 0.005 (once per 200 years) to 0.01 (once per 100 years) referring to the actual earthquake risk market, the results prove that the economic indicators such as EIRR exceeds the cut-off rate even in case of the lower limit of the actually-traded earthquake occurrence probability of 0.005, implying that the project seems to be economically feasible based on this approach.

c) In accordance with ***"Service Life Based Approach"*** which is based on the assumption that, regardless of the risk of the scenario earthquake, the earthquake occurrence probability is fixed at the level that the scenario earthquake might occur once during the project life of 50 years, the results show that the economic indicators such as EIRR are much higher than the cut-off rate to prove the ample economic viability of the project.

d) Furthermore, even though the earthquake occurrence probability is relatively low and uncertain, the results of ***"Catastrophic Risk Based Approach"*** suggest that the project is justifiable regardless of the risk probability, indicating the catastrophic scale of the loss caused by the scenario earthquake.

These 4 steps are enough reasons to justify the massive investment on the earthquake resistant project, and the central government as well as TWWC is fully responsible for implementing this earthquake resistant project.

(2) Other Unquantifiable Socio-Economic Benefits

The economic benefits quantified in the above economic analysis do not taken into account the following unquantifiable benefits. With these unquantifiable benefits, the economic viability will be more justifiable than those nominal economic indicators.

a) A wide range of indirect and secondary losses derived from the water supply interruption by the scenario earthquake are not included.

b) The water supply interruption for longer period might increase risks of waterborne infectious diseases in the interrupted area. The earthquake resistant project will mitigate those risks by shortening the suspended period.

c) The improvement of the earthquake resistant function of the lifelines will enhance the physical asset value as well as the sense of security, thereby improving the image of the capital city and the national security.

(3) Overall Evaluation

The economic analysis based on the occurrence probability of the scenario earthquake cannot justify the massive investment on the earthquake resistant project with the lower economic indicator below the cut-off rate due to the fact that the occurrence probability is extremely low. However, the results of the economic analysis, taking into account the economically-traded probability as well as the service-life

based probability of the scenario earthquake, suggests that the earthquake resistant project is economically justifiable with the relatively higher economic indicators above the cut-off rate. Furthermore, the project could be economically viable, since the devastating scale of the maximum probable loss is considered regardless of the occurrence probability of the scenario earthquake.

In addition to the economic viability of the earthquake resistant project, there are a wide range of unquantifiable social benefits accrued from the project, thereby making the results of the economic analysis more justifiable. In conclusion, the central government as well as TWWC is fully responsible for implementing this earthquake resistant project which is economically worthwhile for the large-scale investment in the capital city of the country.

9.2 Financial Analysis for Project Evaluation and Financial Planning

9.2.1 Objectives and Methodologies for Financial Analysis and Financial Planning

(1) Objectives

The main objectives of the financial analysis and planning are to evaluate impacts on the financial status of TWWC as well as to propose the optimum financial arrangement for funding the earthquake resistant project. It is generally observed that one of core problems of the urban water supply and sanitation sector in developing countries is the chronic and weak financial performance of public entities. Under such circumstances, the additional investment on the earthquake resistant project which does not generate any cash revenues might aggravate the financial status of TWWC in the short term. In this connection, although the economic analysis might justify the implementation of the earthquake resistant project, the financial analysis is absolutely required to verify the financial soundness as well as the realistic financial planning for funding the earthquake resistant project.

(2) Basic Methodologies

Based on the above objectives, the financial analysis will be carried out in the following methodologies. All costs and benefits in the financial analysis are expressed in current terms based on financial prices which are not converted to economic prices.

a) The FIRRs (Financial Internal Rate of Return) of the selected financial cases will be calculated together with the sensitivity analysis.

b) The impacts on a wide range of TWWC's financial sustainability indicators of the selected financial cases will be estimated.

c) The impacts on the TWWC's financial statements such as the profit and loss statement as well as the balance sheet will be estimated.

d) The required amount of the subsidies as well as the tariff increase of the selected financial cases will be calculated to estimate the financial burden share between TWWC and users.

9.2.2 Current Financial Status of TWWC

(1) Historical Review on TWWC

Since TWWC became an independent and autonomous entity from TPWWC in the middle of the financial year 2004, it is required to continuously grasp the financial status of TWWC in comparison with the historical financial trend of TPWWC. *Table 9.2.1* shows the profit and loss statement of TPWWC as well as TWWC, showing the snapshot of the financial status of TWWC. The major observations from the analysis of this financial trend are summarized as below.

a) During the five-year period from the financial year 1999 to 2004, the average growth rate of the gross water revenue stood at 33.6 percent, while that of the total operating expenditure 36.2%, leading to the gap of 2.6 percent. If this difference would continuously expand, the critical benchmarks such as working ratio and operating ratio will not be financially sustainable in the long run.

b) During the five-year period from the financial year 1999 to 2004, the growth ratio of the number of new connections has been increasing by 12.0 to 19.0 percent. Although the increase in the number of new connections is desirable for the financial soundness, the massive financial dependence on connection fees to offset the annual net loss should be avoided.

c) Revenues from the tariff collection have been covering only 58.9 to 65.8 percent of the total operating cost during the five-year period from the financial year 1999 to 2004, thereby making the sound financial operation rather difficult. It is required to establish a beneficiary-pay-principle to keep TWWC's operation self-sustainable.

d) During the five-year period from the fiscal year 1999 to 2004, maintenance expenses largely fluctuate ranging from 2.1 to 31.7 percent of the total operating cost, which is not desirable to keep the reasonable performance of the operation and maintenance, Stable level of maintenance expenses as well as maintenance efficiency is one of the essential factors for the smooth financial operation of TWWC.

Table 9.2.1 Income and Expenditure Statements of TPWWC/TWWC from Fiscal Year 1999

YEAR	1,999		2,000		2,001		2,002		2,003		2,004		2005*(1)	
Total Revenue	188,997,619	100	218,416,598	100	253,442,585	100	356,874,259	100	414,149,934	100	561,828,802	100	242,947,493	100
Water Tariff	143,327,182	75.8	164,120,491	75.1	236,631,991	93.4	272,975,459	76.5	314,194,705	75.9	461,496,412	82.1	257,654,585	106.1
Tariff Adjustment	NA		NA		-49,859,997	-19.7	-7,769,149	-2.2	-19,801,298	-4.8	-93,833,222	-16.7	-32,190,949	-13.3
Installment Fee	23,542,161	12.5	31,648,329	14.5	41,531,094	16.4	63,865,598	17.9	81,638,416	19.7	8,376,445	1.5	2,176,681	0.9
Chemical Factory	13,407,607	7.1	11,553,568	5.3	11,780,359	4.6	10,644,607	3.0	19,150,429	4.6	11,686,670	2.1	762,050	0.3
Other Revenue	8,720,669	4.6	11,094,210	5.1	13,359,138	5.3	17,157,744	4.8	18,967,682	4.6	174,102,497	31.0	14,545,126	6.0
Total Expense	218,781,119	100	248,150,404	100	317,441,044	100	403,211,570	100	457,129,928	100	604,467,932	100	383,126,441	100
Personnel	21,840,118	10.0	26,145,715	10.5	33,480,051	10.5	45,074,327	11.2	52,316,788	11.4	94,438,678	15.6	175,181,947	45.7
Raw Water	22,181,429	10.1	28,912,371	11.7	40,863,110	12.9	44,399,084	11.0	70,147,845	15.3	83,951,039	13.9	52,064,950	13.6
Power	10,943,835	5.0	16,186,872	6.5	7,417,097	2.3	18,257,658	4.5	9,635,357	2.1	25,875,625	4.3	11,498,210	3.0
Chemicals	1,915,353	0.9	5,728,262	2.3	6,933,435	2.2	4,847,733	1.2	7,817,137	1.7	32,330,792	5.3	7,699,684	2.0
Maintenance	5,212,619	2.4	7,114,308	2.9	16,095,593	5.1	127,752,264	31.7	108,943,910	23.8	20,724,094	3.4	35,738,254	9.3
Others	156,687,765	71.6	164,062,876	66.1	212,651,758	67.0	162,880,504	40.4	208,268,891	45.6	347,147,704	57.4	100,943,396	26.3
1- Depreciation							*76,958,053*	*19.1*	*70,796,558*	*15.5*	*81,639,341*	*13.5*	*55,544,084*	*14.5*
2- Commission							*33,296,514*	*8.3*	*39,402,585*	*8.6*	*7,401,864*	*1.2*	*4,982,439*	*1.3*
3- Payment to Power Ministry							*5,894,097*	*1.5*	*2,668,480*	*0.6*	*7,797,047*	*1.3*	*17,500,000*	*4.6*
4- Contract with Contractor							*4,676,921*	*1.2*	*7,414,828*	*1.6*	*37,776,608*	*6.2*	*5,977,592*	*1.6*
5- Rent									*1,376,999*	*0.3*	*2,110,004*	*0.3*	*33,000*	*0.0*
6-Insurance									*2,072,787*	*0.5*	*1,581,413*	*0.3*	*292,297*	*0.1*
7-Others							*42,054,919*	*10.4*	*84,536,654*	*18.5*	*208,841,427*	*34.5*	*16,613,984*	*4.3*
Profit (Loss)	-29,783,500		-29,733,806		-63,998,459		-46,337,311		-42,979,994		-42,639,130		-140,178,948	
Revenue on tariff (1,000 Rials)	143,327,182		164,120,491		186,771,994		265,206,310		294,393,407		367,663,190		225,463,636	
Billed water (m3/year)	616,547,608		591,860,071		589,864,006		579,817,461		598,000,000		637,100,000		704,985,000	
Price per cubic meter (Rials)	232		277		317		457		492		577		320	
Cost per cubic meter (Rials)	355		419		538		695		764		949		543	

(1) 2005 data is based on the first six months of the fiscal year. (2) Note: In the mid 2004 [22/9/2004] TWWC emerged from TPWWC)

(3) Figures in italics show the expense components of "other expenses" which are significant, yet on their own do not affect profit & loss calculations.

(2) Latest Financial Status of TWWC

In order to further scrutinize the updated financial status of the present TWWC, more detailed analysis on the profit and loss statement as well as the balance sheet of TWWC for the financial year 2005 is conducted. The major findings from the latest financial statements are summarized as below.

(a) The net water sales amounted to USD 66,727 thousand, and the amount covers only 77.6 percent of the total operating cost. It is obvious that current tariff level is not adequate to provide quality water services. Nevertheless, the tariff adjustment for lower-income users has been provided for unclear extra-economic reasons. The tariff adjustment occupies approximately 16.0 percent of the gross water sales in the financial statement of 2005. Comprehensive reviews on this adjustment are required for financial viability as well as service sustainability.

(b) Under the current tariff charging system, TWWC collects monthly subscription fees, volumetric charges and connection fees. Connection fees are supposed to cover a wide range of investment costs such as reservoirs and distribution networks. The amount of the connection fees collected in the financial year 2005 stood at USD 32,956 thousand, which occupies 49.4 percent of the gross water sales in the same financial year. However, the financial dependence on collection fees is based on the idea that new users will continuously increase even in the long run. The chronic dependence on the connection fees would deteriorate the sustainable financial operation of TWWC.

(c) Although the amount of the depreciation seems to be relatively small, the nominal operating expenses do not fully include the debt services as well as the depreciation for the capital investment which TWWC requires to provide the quality water supply services. Since TWWC has not yet taken over all the debts and assets of TPWWC after the independence from TWWC and the operating cost of TWWC does not include the depreciation for the subsidized assets by the central government, the current financial statements do not imply the full cost recovery of the operating cost.

(d) In the profit and loss statement of TWWC, apart from monthly subscription fees, donated capitals are being separately collected from users as voluntary contributions of users. The amount of the donated capitals in the financial year 2005 stood at USD 26,451, which occupies 39.6 percent of the gross water sales in the same financial year. Although these are not included into the normal revenue, these donated capitals should be originally incorporated into the proper tariff scheme.

Table 9.2.2 Summarized Balance Sheet as of End of Fiscal Year 2005 (1384)

No.	Item	Thousand USD	No.	Item	Thousand USD
1	Cash	1,323	1	Account Payables	84,714
2	Account Receivables	32,321	2	Other Current Debts	18,171
3	Other Current Assets	9,722	3=1+2	Total Current Debts	102,885
4=1-2-3	Total Current Assets	43,366	4	Total Fixed Debts	10,975
5	Fixed Assets	71,532	5=3+4	Total Debts	113,860
6	Depreciation	1,963	6	Connection Fee	41,703
7	Other Assets	16,763	7	Donated Capital	37,937
8=5-6+7	Total Fixed Assets	90,258	8	Shareholders' Equity	54
9=4+8	Total Assets	133,624	9	Accumulated Loss	-59,930
			10=5+6+7+8-9	Total Debts and Equity	133,624

Source: Financial Statements of TWWC 2005

Table 9.2.3 Profit and Loss Statement of TWWC for Fiscal Year 2005 (1384)

No.	Item	Thousand USD
1	Gross Water Sales	66,727
2	Tariff Adjustment	10,708
3=1-2	Net Water Sales	56,019
4	Operating Expenses	72,151
5=3-4	Gross Profit	-16,132
6	Administrative Expenses	28,289
7=5-6	Net Profit	-44,421
8	Connection Fee	32,956
9	Contributed Capital	26,451
10=7+8+9	Comprehensive Net Profit	14,986

Source: Financial Statements of TWWC 2005

More specifically, the latest financial indicators are examined to gauge the financial sustainability of TWWC. The performance of water utilities could be evaluated using a wide range of indices such as efficiency of investment, efficiency of operations and maintenance, financial sustainability, and responsiveness to water users. Out of these indices, the below indices which represent the financial sustainability are critical to grasp the snapshot of the financial soundness of TWWC. Table 9.2.4 indicates the financial sustainability indicators of TWWC based on the its financial statements,

Table 9.2.4 Financial Sustainability Indicators of TWWC

Sustainability Indicators	Description	Current Status	Minimum Requirement	Desirable Level
Staff per 1000 Water Connections (SWC)	Total Staff / Number of Connections / 1,000	5.93	5.0 persons	-
Working Ratio (WR)	Operational Cost (excluding Depreciation) / Tariff Revenue	125.7%	Not Exceeding 100%	70% or Less
Operating Ratio (OR)	Total Operational Cost (including Depreciation) / Tariff Revenue	129.2%	Not Exceeding 120%	100% or Less
Collection Ratio (CR)	Amount of Money Collected / Total Value of Billing	90.0%	90%	100%

Source: Financial Statements of TWWC, 2005

a) **Staff per Thousand Connections (SWC)**: Operational efficiency is defined as the lowest use of inputs in the daily operation of TWWC. The number of staff per thousand connections (SWC) is a typical sustainable indicator to measure operational efficiency. A higher ratio of the indicator might imply inefficient use of staff. It is widely believed that the minimum requirement for the number of staff per thousand connections is 5.00, and the current indicator of TWWC is estimated at 5.93, which slightly exceeds the minimum requirement. However, this current figure does not include the number of staff for outsourced works such as meter reading and etc.

b) **Working Ratio (WR)**: Failure to cover the required operating cost leads to the underinvestment in assets and declining service quality to customers. A simple measure of the cost recovery is Working Ratio (WR) which is the ratio of total annual operational expenses, excluding depreciation and debt services, to total tariff revenues. A working ratio of more than 100.0 means that a utility fails to recover even its operating costs from annual revenues, while a ratio of less than 100.0 means that it covers all operating costs. It is widely accepted that the minimum requirement for WR should be 100.0, while it should be desirably less than 70.0. The current WR of TWWC is estimated at 125.7, which exceeds the minimum requirement.

c) **Operating Ratio (OR)**: On the other hand, another measure of the cost recovery is Operating

Ratio (OR) which is the ratio of total annual operational expenses, including depreciation and debt services, to total tariff revenues. It is widely accepted that the minimum requirement for WR should be 120.0, while it should be desirably less than 100.0. The current OR of TWWC is estimated at 129.2, which slightly exceeds the minimum requirement. Moreover, the current OR of TWWC does not consider the depreciation for the large-scale assets subsidized by the central government.

d) **Tariff Collection Rate (CR)**: Financial sustainability also requires timely and proper collection of water charges. A common measure of efficiency in this area is the charge collection rate. It is widely accepted that the minimum requirement and the recommended requirement of CR is 90.0 percent and 100.0 percent, respectively. The current CR of TWWC is estimated at 90.0, which is almost equivalent to the minimum requirement.

9.2.3 Cases for Financial Analysis

In an attempt to set up the basis for the financial analysis, the following conditions are employed to categorize cases for the analysis. As a result, 12 cases with a wide range of the financial variations are set up for the financial analysis.

1) Scope of Subsidies

The first condition for the categorization of the financial cases is the scope of subsidies to cover the earthquake resistant investment. Normally, the central government only covers the large-scale investment such as the construction of reservoirs and dams. Depending on the scope of subsidies provided by the central government, the following 4 cases are fixed as the first condition to categorize the financial cases.

a) Case A: No subsidies would cover the whole project cost, and all the costs would be covered by TWWC through the tariff increase and/or bank loans.

b) Case B: While the central government's subsidies would cover the investment on the planned pipelines, other project components would be covered by TWWC through the tariff increase and/or bank loans.

c) Case C: While the emergency water supply improvement would be covered by TWWC through the tariff increase and/or bank loans, the central government's subsidies would cover the investment on other project components.

d) Case D: The whole project cost would be covered by the central government's subsidies.

2) Type of Funding Sources

The second condition for the categorization of the financial cases is the type of funding sources to cover the earthquake resistant investment. Depending on the type of funding sources which stipulates repayment period, grace period and interest rate provided by the central government, the following 3 cases are set up for the financial analysis, although these cases would not imply specific international funding agencies.

a) Case 1: The portion of the overall project cost which is not covered by the tariff increase would

be financed by a very highly concessional loan with a repayment period of 40 years, a grace period of 10 years and an extremely low interest rate of 0.75 percent per annum.

b) Case 2: The portion of the overall project cost which is not covered by the tariff increase would be financed by a highly concessional loan with a repayment period of 30 years, a grace period of 10 years and a relatively low interest rate of 2.00 percent per annum.

c) Case 3: The portion of the overall project cost which is not covered by the tariff increase would be financed by the very high concessional loan with the repayment period of 20 years, a grace period of 5 years and an interest rate of 5.00 percent per annum.

As a result, the following 12 cases are set up for the financial analysis as per *Table 9.2.5*. In each case, the tariff increase coverage ranging from zero to 100.0 percent is also taken into account as the variations.

Table 9.2.5 Cases for Financial Planning

Scope of Subsidy and Financing	Very Highly Concessional Loan (Repayment Period 40 Years, Grace Period 10 Years, Interest Rate 0.75%)	Highly Concessional Loan (Repayment Period 30 Years, Grace Period 10 Years, Interest Rate 2.00%)	Semi-Commercial Loan (Repayment Period 20 Years, Grace Period 5 Years, Interest Rate 5.00%)
No Subsidy	A-1	A-2	A-3
Subsidized for Only Pipelines	B-1	B-2	B-3
Subsidized for Pipelines + Facilities/Equipment	C-1	C-2	C-3
Subsidized for All Project Components	D-1	D-2	D-3

Source: Categorized by JICA Study Team

9.2.4 Results of Financial Analysis

(1) FIRR

The FIRRs in accordance with the variations of the above financial cases are computed as per *Table 9.2.6*. Although the FIRRs of the base case together with relevant risk variations whose earthquake occurrence probabilities are equivalent to the theoretical scenario earthquake occurrence at 0.002 (once per 500 years) proves to be negative, those of Case D and Case E whose probabilities exist in the range of the actually-traded risks largely exceed the cut-off rate of 5 percent. It should be noticed that since benefits in the financial prices are not cash inflows in real monetary values, the calculated FIRRs are the conceptual financial indicators without the indicative cash flow of revenues and expenses.

Table 9.2.6 Calculations of FIRRs and Sensitivity Analysis

Case	Earthquake Occurrence Probability	Base Case	Risk 1 (Cost = 10% up)	Risk 2 (Benefit = 10% up)	Risk 3 (Cost = 10% up)
Base Case (Case A)	P = 0.0020	0.24%	-0.29%	-0.34%	-0.87%
Premium Case 1 (Case B)	P = 0.0025	1.54%	0.98%	0.92%	0.37%
Premium Case 2 (Case C)	P = 0.0033	3.26%	2.65%	2.59%	2.00%
Premium Case 3 (Case D)	P = 0.005	6.21%	5.48%	5.41%	4.72%
Premium Case 4 (Case E)	P = 0.01	12.81%	11.74%	11.63%	10.63%
Service-Life Case (Case F)	P = 0.02	22.44%	20.92%	20.76%	19.31%

Source: Calculated by JICA Study Team

(2) Impacts on Financial Sustainability Indicators

The large-scale investment on the earthquake resistant project might further aggravate the financial sustainability indicators of TWWC such as WR and OR, unless the non-subsidized portion of the project cost is fully covered by the tariff increase. The impacts on the financial sustainability indicators fluctuate in accordance with variations of the extent of coverage by the tariff increase. The results of the repayment schedule by TWWC as well as the central government of all the cases are per attached *Appendix 10.45 to 10.60*.

Table 9.2.7 indicates the impacts on the current WR based on the profit and loss statement of the financial year 2005. If the portion of the project cost which is not financed by subsidies is fully covered by the tariff increase, there would be no substantial negative impacts on the current WR. On the other hand, if the tariff coverage is not sufficient, the WR, the typical benchmark of the financial sustainability, will be further downgraded. As the worst case scenario, Case A-3 under no coverage by the tariff increase to replenish the additional burden suggests that the current WR will be worsened from 125.7 to 128.5. It should be noted that the project will further deteriorate the alarming WR of 125.7, which is considerably worse than the minimum requirement of the WR of 100.0, even if the non-subsidized portion is financed by a lower-interest rate loan.

Table 9.2.7 Impacts on Working Ratio (WR)

Case	100% Coverage by Tariff Increase	80% Coverage by Tariff Increase	60% Coverage by Tariff Increase	40% Coverage by Tariff Increase	20% Coverage by Tariff Increase	0% Coverage by Tariff Increase
A-1	125.70	126.10	126.51	126.91	127.32	127.72
A-2	125.70	126.18	126.66	127.13	127.61	128.09
A-3	125.70	126.26	126.82	127.38	127.94	128.50
B-1	125.70	126.02	126.35	126.67	127.00	127.33
B-2	125.70	126.08	126.46	126.84	127.22	127.60
B-3	125.70	126.06	126.41	126.77	127.13	127.49
C-1	125.70	125.84	125.97	126.11	126.25	126.39
C-2	125.70	125.82	125.94	126.06	126.18	126.30
C-3	125.70	125.84	125.98	126.12	126.26	126.40
D-1	125.70	125.70	125.70	125.70	125.70	125.70
D-2	125.70	125.70	125.70	125.70	125.70	125.70
D-3	125.70	125.70	125.70	125.70	125.70	125.70

Source: Calculated by JICA Study Team

Table 9.2.8 indicates the impacts on the changes of the WR on the condition that the current level is fixed at 100.00 as the benchmark based on the financial statement of the financial year 2005. The results vary in accordance with the financial cases as well as the extent of the tariff coverage. As the worst case scenario, Case A-3 under no coverage by the tariff increase to replenish the additional burden suggests that the current WR will be aggravated by 2.23 percent.

Table 9.2.8 Impacts on Changes of Working Ratio (WR)

Case	100% Coverage by Tariff Increase	80% Coverage by Tariff Increase	60% Coverage by Tariff Increase	40% Coverage by Tariff Increase	20% Coverage by Tariff Increase	0% Coverage by Tariff Increase
A-1	100.00	100.32	100.64	100.96	101.29	101.61
A-2	100.00	100.38	100.76	101.14	101.52	101.90
A-3	100.00	100.45	100.89	101.34	101.78	102.23
B-1	100.00	100.25	100.52	100.77	101.03	101.30
B-2	100.00	100.30	100.60	100.91	101.21	101.51
B-3	100.00	100.29	100.56	100.85	101.14	101.42
C-1	100.00	100.11	100.21	100.33	100.44	100.55
C-2	100.00	100.10	100.19	100.29	100.38	100.48
C-3	100.00	100.11	100.22	100.33	100.45	100.56
D-1	100.00	100.00	100.00	100.00	100.00	100.00
D-2	100.00	100.00	100.00	100.00	100.00	100.00
D-3	100.00	100.00	100.00	100.00	100.00	100.00

Source: Calculated by JICA Study Team

On the other hand, *Table 9.2.9* indicates the impacts on the current OR based on the profit and loss statement of the financial year 2005. In the same manner as the impacts on the current WR, if the portion of the project cost which is not financed by subsidies is fully covered by the tariff increase, there would be no substantial impacts on the current OR as well. As the worst case scenario, Case A-3 under no coverage by the tariff increase to offset the additional burden suggests that the current OR will be also worsened from 129.2 to 132.0. The earthquake resistant investment will further deteriorate the alarming OR of 129.2, which is worse than the minimum requirement of the WR of 120.0, even if the non-subsidized portion is financed by a lower-interest rate loan.

Table 9.2.9 Impacts on Operating Ratios (OR)

Case	100% Coverage by Tariff Increase	80% Coverage by Tariff Increase	60% Coverage by Tariff Increase	40% Coverage by Tariff Increase	20% Coverage by Tariff Increase	0% Coverage by Tariff Increase
A-1	129.20	129.61	130.01	130.42	130.82	131.22
A-2	129.20	129.68	130.16	130.64	131.12	131.60
A-3	129.20	129.76	130.32	130.88	131.44	132.00
B-1	129.20	129.48	129.75	130.03	130.30	130.58
B-2	129.20	129.53	129.85	130.18	130.50	130.83
B-3	129.20	129.58	129.96	130.34	130.73	131.11
C-1	129.20	129.34	129.48	129.61	129.75	129.89
C-2	129.20	129.32	129.44	129.56	129.68	129.80
C-3	129.20	129.34	129.48	129.62	129.76	129.90
D-1	129.20	129.20	129.20	129.20	129.20	129.20
D-2	129.20	129.20	129.20	129.20	129.20	129.20
D-3	129.20	129.20	129.20	129.20	129.20	129.20

Source: Calculated by JICA Study Team

Table 9.2.10 indicates the impacts on the changes of the OR on the condition that the current level is fixed at 100.00 as the benchmark based on the financial statement of the financial year 2005. In the same manner as the WR, the results vary in accordance with the financial cases as well as the extent of the tariff coverage. As the worst case scenario, Case A-3 under no coverage by the tariff reflection suggests that the current OR will be aggravated by 2.17 percent.

Table 9.2.10 Impacts on Changes of Operating Ratios (OR)

Case	100% Coverage by Tariff Increase	80% Coverage by Tariff Increase	60% Coverage by Tariff Increase	40% Coverage by Tariff Increase	20% Coverage by Tariff Increase	0% Coverage by Tariff Increase
A-1	100.00	100.32	100.63	100.94	101.25	101.56
A-2	100.00	100.37	100.74	101.11	101.49	101.86
A-3	100.00	100.43	100.87	101.30	101.73	102.17
B-1	100.00	100.22	100.43	100.64	100.85	101.07
B-2	100.00	100.26	100.50	100.76	101.01	101.26
B-3	100.00	100.29	100.59	100.88	101.18	101.48
C-1	100.00	100.11	100.22	100.32	100.43	100.53
C-2	100.00	100.09	100.19	100.28	100.37	100.46
C-3	100.00	100.11	100.22	100.33	100.43	100.54
D-1	100.00	100.00	100.00	100.00	100.00	100.00
D-2	100.00	100.00	100.00	100.00	100.00	100.00
D-3	100.00	100.00	100.00	100.00	100.00	100.00

Source: Calculated by JICA Study Team

(3) Impacts on Financial Statements

The redemption of the loan for the earthquake resistant investment to cover the non-subsidized portion might also have considerable negative impacts on TWWC's financial statements such as the profit/loss statement as well as the balance sheet. Those impacts fluctuate in accordance with variations of the extent of the coverage by the tariff reflection. *Table 9.2.11* and *Table 9.2.12* indicate the changes against the current debts and the total debts, respectively, based on the balance sheet as of the end of the financial year 2005. If the extent of the coverage is 100 percent, there would be no substantial changes on the current debts as well as the total debts. As the worst scenario, Case A-1 under no tariff reflection to cover the non-subsidized portion suggests that the current debts and the total debts of TWWC will be increased

by 27.58 percent and 24.92 percent, respectively.

Table 9.2.11 Estimated Changes against Current Debts in accordance with Financial Statements of 2005 (Unit: Percent)

Case	100% Coverage by Tariff Increase	80% Coverage by Tariff Increase	60% Coverage by Tariff Increase	40% Coverage by Tariff Increase	20% Coverage by Tariff Increase	0% Coverage by Tariff Increase
A-1	0.00	5.52	11.03	16.55	22.06	27.58
A-2	0.00	5.50	11.00	16.50	22.00	27.50
A-3	0.00	4.93	9.85	14.78	19.70	24.63
B-1	0.00	3.74	7.49	11.23	14.97	18.71
B-2	0.00	3.73	7.46	11.19	14.92	18.64
B-3	0.00	3.23	6.45	9.68	12.91	16.14
C-1	0.00	1.87	3.74	5.61	7.48	9.35
C-2	0.00	1.39	2.77	4.16	5.55	6.93
C-3	0.00	1.35	2.71	4.06	5.41	6.77
D-1	0.00	0.00	0.00	0.00	0.00	0.00
D-2	0.00	0.00	0.00	0.00	0.00	0.00
D-3	0.00	0.00	0.00	0.00	0.00	0.00

Source: Calculated by JICA Study Team

Table 9.2.12 Estimated Impacts on Total Debts of TWWC in accordance with Financial Statements of 2005 (Unit Percent)

Case	100% Coverage by Tariff Increase	80% Coverage by Tariff Increase	60% Coverage by Tariff Increase	40% Coverage by Tariff Increase	20% Coverage by Tariff Increase	0% Coverage by Tariff Increase
A-1	0.00	4.98	9.97	14.95	19.94	24.92
A-2	0.00	4.97	9.94	14.91	19.88	24.85
A-3	0.00	4.45	8.90	13.35	17.80	22.25
B-1	0.00	3.38	6.76	10.15	13.53	16.91
B-2	0.00	3.37	6.74	10.11	13.48	16.85
B-3	0.00	2.92	5.83	8.75	11.66	14.58
C-1	0.00	1.69	3.38	5.07	6.76	8.45
C-2	0.00	1.25	2.51	3.76	5.01	6.26
C-3	0.00	1.22	2.45	3.67	4.89	6.12
D-1	0.00	0.00	0.00	0.00	0.00	0.00
D-2	0.00	0.00	0.00	0.00	0.00	0.00
D-3	0.00	0.00	0.00	0.00	0.00	0.00

Source: Calculated by JICA Study Team

On the other hand, *Table 9.2.13* and *Table 9.2.14* indicate the impacts on the gross profit and the net profit of TWWC, respectively, based on the profit and loss statement of the financial year 2005. As the worst scenario, Case A-3 under no tariff reflection to cover the non-subsidized portion suggests that the gross profit and the net profit of TWWC will be decreased by 5.83 percent and 2.12 percent, respectively.

Table 9.2.13 Estimated Impacts on Gross Profit of TWWC in accordance with Financial Statements of 2005 (Unit: Percent)

Case	100% Coverage by Tariff Increase	80% Coverage by Tariff Increase	60% Coverage by Tariff Increase	40% Coverage by Tariff Increase	20% Coverage by Tariff Increase	0% Coverage by Tariff Increase
A-1	0.00	-0.84	-1.68	-2.53	-3.37	-4.21
A-2	0.00	-1.00	-1.99	-2.99	-3.99	-4.98
A-3	0.00	-1.17	-2.22	-3.50	-4.67	-5.83
B-1	0.00	-0.57	-1.14	-1.72	-2.29	-2.86
B-2	0.00	-0.68	-1.36	-2.03	-2.71	-3.39
B-3	0.00	-0.79	-1.59	-2.38	-3.17	-3.96
C-1	0.00	-0.29	-0.57	-0.86	-1.15	-1.43
C-2	0.00	-0.25	-0.50	-0.75	-1.00	-1.25
C-3	0.00	-0.29	-0.58	-0.88	-1.17	-1.46
D-1	0.00	0.00	0.00	0.00	0.00	0.00
D-2	0.00	0.00	0.00	0.00	0.00	0.00
D-3	0.00	0.00	0.00	0.00	0.00	0.00

Source: Calculated by JICA Study Team

Table 9.2.14 Estimated Impacts on Net Profit of TWWC in accordance with Financial Statement of 2005 (Unit: Percent)

Case	100% Coverage by Tariff Increase	80% Coverage by Tariff Increase	60% Coverage by Tariff Increase	40% Coverage by Tariff Increase	20% Coverage by Tariff Increase	0% Coverage by Tariff Increase
A-1	0.00	-0.31	-0.61	-0.92	-1.22	-1.53
A-2	0.00	-0.36	-0.72	-1.09	-1.45	-1.81
A-3	0.00	-0.42	-0.85	-1.27	-1.70	-2.12
B-1	0.00	-0.21	-0.42	-0.62	-0.83	-1.04
B-2	0.00	-0.25	-0.49	-0.74	-0.98	-1.23
B-3	0.00	-0.29	-0.58	-0.86	-1.15	-1.44
C-1	0.00	-0.10	-0.21	-0.31	-0.42	-0.52
C-2	0.00	-0.09	-0.18	-0.27	-0.36	-0.45
C-3	0.00	-0.11	-0.21	-0.32	-0.42	-0.53
D-1	0.00	0.00	0.00	0.00	0.00	0.00
D-2	0.00	0.00	0.00	0.00	0.00	0.00
D-3	0.00	0.00	0.00	0.00	0.00	0.00

Source: Calculated by JICA Study Team

(4) Amount of Subsidies and Tariff Reflections

Based on the required amount of subsides by the central government, the total amount of the loan for the non-subsidized portion by TWWC is fixed, thereby computing the maximum and average annual repayment in accordance with the variations of the financial cases.

a) In case A, where there are no subsidies by the central government and all the project costs are financed by the loan, the total amount of the loan by TWWC would be USD 28,350 thousand, leading to the maximum annual repayment amount ranging from USD 1,139 thousand to USD 2,970 thousand and the average annual repayment amount ranging from USD 680 thousand to USD 941 thousand.

b) In case B, where subsidies by the central government would cover 32.0 percent of the total project cost and the remaining 68.0 percent would be financed by the loan, the total amount of the loan by TWWC would be USD 19,391 thousand, leading to the maximum annual repayment amount ranging from USD 771 thousand to USD 1,980 thousand and the average annual repayment amount ranging from USD 462 thousand to USD 640 thousand.

c) In case C, where subsidies by the central government would cover 66.0 percent of the total project cost and the remaining 34.0 percent would be financed by the loan, the total amount of the loan by TWWC would be USD 9,700 thousand, leading to the maximum annual repayment amount ranging from USD 385 thousand to USD 791 thousand and the average annual repayment amount ranging from USD 201 thousand to USD 236 thousand.

d) In case D, where subsidies by the central government would cover all the project costs, there would be no additional financial burden for TWWC.

Table 9.2.15 Amount of Required Subsidies and Annual Repayment

No.	Amount of Subsidies (Thousand USD)	Subsidies Ratio against Total Investment (%)	Total Amount of Loan by TWWC (Thousand USD)	Maximum Annual Repayment by TWWC (Thousand USD)	Average Annual Repayment by TWWC (Thousand USD)
A-1	0	0.0	28,530	1,139	680
A-2	0	0.0	28,530	1,892	805
A-3	0	0.0	28,530	2,979	941
B-1	9,138	32.0	19,391	771	462
B-2	9,138	32.0	19,391	1,273	547
B-3	9,138	32.0	19,391	1,980	640
C-1	18,829	66.0	9,700	385	231
C-2	18,829	66.0	9,700	487	201
C-3	18,829	66.0	9,700	791	236
D-1	28,530	100.0	0	0	0
D-2	28,530	100.0	0	0	0
D-3	28,530	100.0	0	0	0

Source: Calculated by JICA Study Team

The required amount of the tariff increase by TWWC to provide the debt service for the repayment of the loan of the non-subsidized portion is also calculated in accordance with the variations of the financial cases as *Table 9.2.16* shows. The maximum tariff increase required would be 5.54 percent in case of the tariff coverage of 100 percent under Case A-3.

Table 9.2.16 Tariff Increase Required for Filling Non-Subsidized Portion (Unit: Percent)

No.	100% Coverage by Tariff Increase	80% Coverage by Tariff Increase	60% Coverage by Tariff Increase	40% Coverage by Tariff Increase	20% Coverage by Tariff Increase	0% Coverage by Tariff Increase
A-1	2.33	1.87	1.40	0.93	0.47	0.00
A-2	3.50	2.80	2.10	1.40	0.70	0.00
A-3	5.54	4.43	3.32	2.21	1.11	0.00
B-1	1.64	1.31	0.99	0.66	0.33	0.00
B-2	2.46	1.97	1.48	0.98	0.49	0.00
B-3	3.90	3.12	2.34	1.56	0.78	0.00
C-1	0.83	0.66	0.50	0.33	0.17	0.00
C-2	0.79	0.63	0.47	0.32	0.16	0.00
C-3	1.25	1.00	0.75	0.50	0.25	0.00
D-1	0.00	0.00	0.00	0.00	0.00	0.00
D-2	0.00	0.00	0.00	0.00	0.00	0.00
D-3	0.00	0.00	0.00	0.00	0.00	0.00

Source: Calculated by JICA Study Team

(5) Financial Impacts on TWWC's Revenues

Although the massive investment on the earthquake resistant project might cause a wide range of negative impacts on the financial status of TWWC, the project can avoid a huge amount of the revenue loss of

TWWC when the earthquake actually happens. As *Table 9.2.17* shows, the loss of the gross revenue to be avoided in case of the actual occurrence of the scenario earthquake is estimated at USD 2,596 thousand, which is 3.89 percent of the gross water sales of the financial year 2005. This is the positive financial impacts accrued from the earthquake resistant project ***when the scenario earthquake actually happens***.

Table 9.2.17 Avoidance of Loss of TWWC's Revenue

Item	Accumulated Number of Interrupted Population	Average Interruption Ratio during Interruption Period (%)	Average Annual Interruption Ratio (%)
Without Investment	125,796	22.67	5.09
With Investment	29,728	5.36	1.20
Impacts	96,068	17.31	3.89

Source: Calculated by JICA Study Team

9.2.5 Conclusions of Financial Analysis and Recommendations for Financial Planning

(1) Conclusions of Financial Analysis

The main objective of the financial analysis is to evaluate impacts on the financial status of TWWC as well as to propose the optimum financial arrangement for funding the earthquake resistant project. The results of the financial analysis are summarized as below.

a) It is envisaged that the massive investment on the earthquake resistant project might further worsen the financial sustainability indicators such as the working ratio and the operating ratio. If the tariff coverage is not sufficient, the project will further deteriorate the current working ratio as well as the operating ratio, which is considerably worse than the minimum requirement, even if the non-subsidized portion is financed by a lower-interest rate loan.

b) It is also concluded that the redemption of the loan for the earthquake resistant investment to cover the non-subsidized portion might also have considerable negative impacts on TWWC's financial statements such as the profit/loss statement as well as the balance sheet. The scenario under no tariff increase to cover the non-subsidized portion suggests that the current debts and the total debts of TWWC will be further deteriorated.

c) Although the massive investment on the earthquake resistant project might cause a wide range of negative impacts on the financial status of TWWC, the project can avoid a huge amount of the revenue loss of TWWC when the earthquake actually happens.

d) Apart from recommendations on the financial planning for this specific earthquake resistant project, the following financial arrangements should be separately adopted to achieve the financial soundness of TWWC in providing water supply services.

- The current tariff scheme does not support the full cost recovery for the total operating expenses of TWWC to provide city-wide quality water supply services. The tariff table should be comprehensively reviewed to cover at least the regular operational expenses as well as the non-subsidized portion of the investment cost. A wide range of counter-measures to reduce the NRW as well as to increase the current charge collection rate should be also taken to avoid the loss of tariff revenues.

- Operational efficiency should be significantly improved to achieve the full cost recovery for

the operation of TWWC. The relatively lower number of staff per thousand connections (SWC), which is an indicator to measure operational efficiency, should be attained to avoid inefficient use of staff. Efficiency for the staff utilization should be improved so as to satisfy the minimum requirement for the number of SWC which is 5.00 per thousand staff.

- Other indicators to gauge operational efficiency should be also enhanced to achieve the full cost recovery. Those indicators include Working Ratio (WR) which is the ratio of total annual operational expenses, excluding depreciation and debt services, to total tariff revenues, and the Operating Ratio (OR) which is the ratio of the operational expenses, including depreciation and debt services, to the same total tariff revenues. Especially, a wide range of overhead costs including personnel expenses for the indirect divisions of TWWC should be downsized.

e) In addition to the above basic financial recommendations, the following 4 steps are suggested to establish the realistic and sound financial plan for the earthquake resistant project.

(2) Recommendations for Financial Planning

1) To explore an acceptable level of the tariff increase for the earthquake resistant improvement based on WtP through CVM

In order to appropriately fix the optimum level of the mixture of the tariff increase and the injection of subsidies to service the repayment of the non-subsidized portion of the project, ***the first step*** for the proper financial planning is to explore an acceptable level of the tariff increase that is consistent with users' WtP (Willingness to Pay) for the additional improvement of the earthquake resistant function through this specific project. For example, the maximum tariff increase ratio in comparison with the current tariff is estimated at 5.54 percent in case of A-3, and the additional burden which is acceptable for users will be primarily estimated based on the WtP.

CVM (Contingent Valuation Method) should be employed to scientifically estimate the WtP. It is a method to assess, by using a questionnaire, how much users are willing to pay to improve the anti-earthquake functions through the project in addition to the current tariff level. The WtP estimated through CVM can provide important basic information for tariff setting. TWWC will be able to utilize the information as the basis to apply for the tariff increase in addition to the regular tariff increase reflecting the inflation rate.

2) To appropriately streamline the current tariff scheme as a precondition for the tariff increase

As a key precondition for the tariff increase to demand the additional burden of users, ***the second step*** for the financial planning is to streamline the present complicated tariff structure as the precondition of the tariff increase. The current tariff structure is too much complicated, and the rate structure should be simplified to properly recover the costs of services for different user classes by the appropriate design of the usage blocks. The determination of the costing method and the selection of the capital-financing method are separate processes for streamlining the current tariff structure.

3) To fix the optimum level of the mixture of the tariff increase and the amount of the loan by TWWC

After exploring the acceptable level of the additional tariff increase for the earthquake resistant improvement as well as streamlining the tariff, ***the third step*** is to fix the optimum level of the mixture of the tariff increase and the amount of the loan by TWWC. Within the optimum level of the users' willingness to pay for the earthquake resistant improvement based on the results of the CVM proposed in the first step, the appropriate level of the tariff increase should be fixed in accordance with available financial arrangements for the subsidies. The remaining portion which is not covered by the tariff increase would be financed by the loan by TWWC. *Table 9.2.18* indicates the possible variations of the tariff increase in accordance with the variations of available financial arrangements for the subsidies and the results of WtP.

Table 9.2.18 Variations of WtP and Tariff Increase in comparison with the Current Tariff

(Unit: Percent)

Case	100% WtP to Cover Tariff Increase	80% WtP to Cover Tariff Increase	60% WtP to Cover Tariff Increase	40% WtP to Cover Tariff Increase	20% WtP to Cover Tariff Increase	0% WtP to Cover Tariff Increase
A-1	2.33	1.87	1.40	0.93	0.47	0.00
A-2	3.50	2.80	2.10	1.40	0.70	0.00
A-3	5.54	4.43	3.32	2.21	1.11	0.00
B-1	1.64	1.31	0.99	0.66	0.33	0.00
B-2	2.46	1.97	1.48	0.98	0.49	0.00
B-3	3.90	3.12	2.34	1.56	0.78	0.00
C-1	0.83	0.66	0.50	0.33	0.17	0.00
C-2	0.79	0.63	0.47	0.32	0.16	0.00
C-3	1.25	1.00	0.75	0.50	0.25	0.00
D-1	0.00	0.00	0.00	0.00	0.00	0.00
D-2	0.00	0.00	0.00	0.00	0.00	0.00
D-3	0.00	0.00	0.00	0.00	0.00	0.00

Source: Calculated by JICA Study Team

Finally, the required amount of the loan to be arranged by TWWC should be fixed so as to fill the gap between the required amount of the investment and the possible tariff increase. The required amount of the loan by TWWC depends on the estimates of the possible tariff increase to cover the non-subsidized portion of the investment based on the results of the users' WtP. The optimum amount of the annual average loan repayment to be redeemed by TWWC might exist in the range of the amount specified in *Table 9.2.19* in accordance with the results of the users' WtP as well as the type of funding arrangement.

Table 9.2.19 Variations of Tariff Increase and Required Annual Average Loan Repayment (Thousand USD)

Case	100% WtP to Cover Tariff Increase	80% WtP to Cover Tariff Increase	60% WtP to Cover Tariff Increase	40% WtP to Cover Tariff Increase	20% WtP to Cover Tariff Increase	0% WtP to Cover Tariff Increase
A-1	0	150	300	451	601	751
A-2	0	178	356	533	711	889
A-3	0	208	416	624	832	1040
B-1	0	87	174	260	347	434
B-2	0	103	205	308	410	513
B-3	0	120	240	361	481	601
C-1	0	41	82	123	164	205
C-2	0	59	118	176	235	294
C-3	0	69	138	206	275	344
D-1	0	0	0	0	0	0
D-2	0	0	0	0	0	0
D-3	0	0	0	0	0	0

Source: Calculated by JICA Study Team

4) To establish the modernized accounting system in line with the global accounting standards and monitor the financial sustainability indicators

The fourth step is that the accounting method for TWWC should be reformed in line with the global standard of the accounting procedure for a public utility entity which is similar to that for the private sector. This step is absolutely necessary for TWWC to monitor the sound and sustainable financial operation after the large-scale investment on the earthquake resistant project. Under the improved and modernized accounting system, TWWC will be able to properly monitor the financial sustainability indicators such as SWC, WR and OR. Since the water supply entity is a revenue-oriented public service, the service provider should clearly categorize its balance of payments into an investment balance and a current account balance in accordance with the accounting method for public corporations, so as to run on a stand-alone basis. The accounting method for TWWC, unlike a method for a public agency, should be properly designed to make up for the depreciation of fixed capital stock with its revenues. The problems of the accounting procedures of TWWC to be solved in comparison with the global accounting standards are i) to include the assets which are not taken over from TPWWC in the balance sheet of TWWC, thereby reflecting the depreciations of those assets, ii) to include the assets owned by the central government in the balance sheet of TWWC, thereby reflecting the depreciations of those assets, iii) to reflect the tariff adjustment and the donated capital on the proper tariff scheme.

Table 9.2.20 Summary of Financial Indicators (Case A-1)

Indicators	Current Situation	Case: A-1					
		WTP=100%	80%	60%	40%	20%	0%
Subsidy							
Amount (USD)	0	0	0	0	0	0	0
Subsidies Ratio (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Loan and Payment							
Total Amount of Loan (USD)	28529640	28529640	28529640	28529640	28529640	28529640	28529640
Total Debt Payment (USD)	33985139	33985139	33985139	33985139	33985139	33985139	33985139
Maximum Annual Debt Payment (USD)	1138748	1138748	1138748	1138748	1138748	1138748	1138748
Average Annual Debt Payment (USD)	679703	679703	679703	679703	679703	679703	679703
Total Interest Payment (USD)	5455499	5455499	5455499	5455499	5455499	5455499	5455499
Maximum Annual Interest Payment (USD)	213585	213585	213585	213585	213585	213585	213585
Average Annual Interest Payment (USD)	109110	109110	109110	109110	109110	109110	109110
Impacts on P/L							
% of Average Annual Debt Payment on Gross Profit (Loss	0.00%	0.00%	−0.84%	−1.68%	−2.53%	−3.37%	−4.21%
% of Average Debt Annual Payment on Net Profit (Loss)	0.00%	0.00%	−0.31%	−0.61%	−0.92%	−1.22%	−1.53%
% of Average Tariff Increase on Gross Profit (Loss)	0.00%	−8.10%	−6.48%	−4.86%	−3.24%	−1.62%	0.00%
% of Average Tariff Increase on Net Profit (Loss)	0.00%	−2.94%	−2.35%	−1.77%	−1.18%	−0.59%	0.00%
Impacts on B/S							
% of Maximum Outstanding Debt on Current Debt	0.00%	0.00%	5.52%	11.03%	16.55%	22.06%	27.58%
% of Maximum Outstanding Debt on Total Debt	0.00%	0.00%	4.98%	9.97%	14.95%	19.94%	24.92%
Sustainability Indicators							
NRW Rate (%)	23.7	23.7	23.7	23.7	23.7	23.7	23.7
Tariff Collection Rate (%)	90.0	90.0	90.0	90.0	90.0	90.0	90.0
SWC (Staff per Thousand Water Connectipons)	5.93	5.93	5.93	5.93	5.93	5.93	5.93
WR (Working Ratio) (%)	125.70%	125.70%	126.10%	126.51%	126.91%	127.32%	127.72%
OR (Operating Ratio) (%)	129.20%	129.20%	129.61%	130.01%	130.42%	130.82%	131.22%
Tariff Information							
Required Increase in Tariff per Service Population (USD)	0.00	0.19	0.15	0.11	0.08	0.04	0.00
% of Required Increase on Present Tariff	0.00%	2.33%	1.87%	1.40%	0.93%	0.47%	0.00%
Annual Water Sales (USD)	56000790	57307877	57046459	56785042	56523625	56262207	56000790
Number of Service Population	6938734	6938734	6938734	6938734	6938734	6938734	6938734
Number of Connections	886995	886995	886995	886995	886995	886995	886995
Number of Residential Connection	731504	731504	731504	731504	731504	731504	731504
Annual Tariff per Service Population	8.07	8.26	8.22	8.18	8.15	8.11	8.07
Annual Tariff per Connections	63.14	64.61	64.31	64.02	63.72	63.43	63.14
Annual Tariff per Residential Connnections	76.56	78.34	77.99	77.63	77.27	76.91	76.56

Table 9.2.21 Summary of Financial Indicators (Case A-2)

Indicators	Current Situation	Case: A-2					
		WTP=100%	80%	60%	40%	20%	0%
Subsidy							
Amount (USD)	0	0	0	0	0	0	0
Subsidies Ratio (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Loan and Payment							
Total Amount of Loan (USD)	28529640	28529640	28529640	28529640	28529640	28529640	28529640
Total Debt Payment (USD)	40226792	40226792	40226792	40226792	40226792	40226792	40226792
Maximum Annual Debt Payment (USD)	1892225	1892225	1892225	1892225	1892225	1892225	1892225
Average Annual Debt Payment (USD)	804536	804536	804536	804536	804536	804536	804536
Total Interest Payment (USD)	11697152	11697152	11697152	11697152	11697152	11697152	11697152
Maximum Annual Interest Payment (USD)	569045	569045	569045	569045	569045	569045	569045
Average Annual Interest Payment (USD)	233943	233943	233943	233943	233943	233943	233943
Impacts on P/L							
% of Average Annual Debt Payment on Gross Profit (Loss	0.00%	0.00%	−1.00%	−1.99%	−2.99%	−3.99%	−4.98%
% of Average Debt Annual Payment on Net Profit (Loss)	0.00%	0.00%	−0.36%	−0.72%	−1.09%	−1.45%	−1.81%
% of Average Tariff Increase on Gross Profit (Loss)	0.00%	−12.13%	−9.70%	−7.28%	−4.85%	−2.43%	0.00%
% of Average Tariff Increase on Net Profit (Loss)	0.00%	−4.41%	−3.53%	−2.64%	−1.76%	−0.88%	0.00%
Impacts on B/S							
% of Maximum Outstanding Debt on Current Debt	0.00%	0.00%	5.50%	11.00%	16.50%	22.00%	27.50%
% of Maximum Outstanding Debt on Total Debt	0.00%	0.00%	4.97%	9.94%	14.91%	19.88%	24.85%
Sustainability Indicators							
NRW Rate (%)	23.7	23.7	23.7	23.7	23.7	23.7	23.7
Tariff Collection Rate (%)	90.0	90.0	90.0	90.0	90.0	90.0	90.0
SWC (Staff per Thousand Water Connectipons)	5.93	5.93	5.93	5.93	5.93	5.93	5.93
WR (Working Ratio) (%)	125.70%	125.70%	126.18%	126.66%	127.13%	127.61%	128.09%
OR (Operating Ratio) (%)	129.20%	129.20%	129.68%	130.16%	130.64%	131.12%	131.60%
Tariff Information							
Required Increase in Tariff per Service Population (USD)	0.00	0.28	0.23	0.17	0.11	0.06	0.00
% of Required Increase on Present Tariff	0.00%	3.50%	2.80%	2.10%	1.40%	0.70%	0.00%
Annual Water Sales (USD)	56000790	57958318	57566812	57175307	56783801	56392296	56000790
Number of Service Population	6938734	6938734	6938734	6938734	6938734	6938734	6938734
Number of Connections	886995	886995	886995	886995	886995	886995	886995
Number of Residential Connection	731504	731504	731504	731504	731504	731504	731504
Annual Tariff per Service Population	8.07	8.35	8.30	8.24	8.18	8.13	8.07
Annual Tariff per Connections	63.14	65.34	64.90	64.46	64.02	63.58	63.14
Annual Tariff per Residential Connnections	76.56	79.23	78.70	78.16	77.63	77.09	76.56

Table 9.2.22 Summary of Financial Indicators (Case A-3)

Indicators	Current Situation	Case: A-3					
		WTP=100%	80%	60%	40%	20%	0%
Subsidy							
Amount (USD)	0	0	0	0	0	0	0
Subsidies Ratio (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Loan and Payment							
Total Amount of Loan (USD)	28529640	28529640	28529640	28529640	28529640	28529640	28529640
Total Debt Payment (USD)	47073906	47073906	47073906	47073906	47073906	47073906	47073906
Maximum Annual Debt Payment (USD)	2978957	2978957	2978957	2978957	2978957	2978957	2978957
Average Annual Debt Payment (USD)	941478	941478	941478	941478	941478	941478	941478
Total Interest Payment (USD)	18544266	18544266	18544266	18544266	18544266	18544266	18544266
Maximum Annual Interest Payment (USD)	1309091	1309091	1309091	1309091	1309091	1309091	1309091
Average Annual Interest Payment (USD)	370885	370885	370885	370885	370885	370885	370885
Impacts on P/L							
% of Average Annual Debt Payment on Gross Profit (Loss	0.00%	0.00%	−1.17%	−2.33%	−3.50%	−4.67%	−5.83%
% of Average Debt Annual Payment on Net Profit (Loss)	0.00%	0.00%	−0.42%	−0.85%	−1.27%	−1.70%	−2.12%
% of Average Tariff Increase on Gross Profit (Loss)	0.00%	−19.20%	−15.36%	−11.52%	−7.68%	−3.84%	0.00%
% of Average Tariff Increase on Net Profit (Loss)	0.00%	−6.98%	−5.58%	−4.19%	−2.79%	−1.40%	0.00%
Impacts on B/S							
% of Maximum Outstanding Debt on Current Debt	0.00%	0.00%	4.93%	9.85%	14.78%	19.70%	24.63%
% of Maximum Outstanding Debt on Total Debt	0.00%	0.00%	4.45%	8.90%	13.35%	17.80%	22.25%
Sustainability Indicators							
NRW Rate (%)	23.7	23.7	23.7	23.7	23.7	23.7	23.7
Tariff Collection Rate (%)	90.0	90.0	90.0	90.0	90.0	90.0	90.0
SWC (Staff per Thousand Water Connectipons)	5.93	5.93	5.93	5.93	5.93	5.93	5.93
WR (Working Ratio) (%)	125.70%	125.70%	126.26%	126.82%	127.38%	127.94%	128.50%
OR (Operating Ratio) (%)	129.20%	129.20%	129.76%	130.32%	130.88%	131.44%	132.00%
Tariff Information							
Required Increase in Tariff per Service Population (USD)	0.00	0.45	0.36	0.27	0.18	0.09	0.00
% of Required Increase on Present Tariff	0.00%	5.54%	4.43%	3.32%	2.21%	1.11%	0.00%
Annual Water Sales (USD)	56000790	59100459	58480525	57860591	57240657	56620724	56000790
Number of Service Population	6938734	6938734	6938734	6938734	6938734	6938734	6938734
Number of Connections	886995	886995	886995	886995	886995	886995	886995
Number of Residential Connection	731504	731504	731504	731504	731504	731504	731504
Annual Tariff per Service Population	8.07	8.52	8.43	8.34	8.25	8.16	8.07
Annual Tariff per Connections	63.14	66.63	65.93	65.23	64.53	63.83	63.14
Annual Tariff per Residential Connnections	76.56	80.79	79.95	79.10	78.25	77.40	76.56

Table 9.2.23 Summary of Financial Indicators (Case B-1)

Indicators	Current Situation	Case: B-1					
		WTP=100%	80%	60%	40%	20%	0%
Subsidy							
Amount (USD)	9138348	9138348	9138348	9138348	9138348	9138348	9138348
Subsidies Ratio (%)	32.03%	32.03%	32.03%	32.03%	32.03%	32.03%	32.03%
Loan and Payment							
Total Amount of Loan (USD)	19391292	19391292	19391292	19391292	19391292	19391292	19391292
Total Debt Payment (USD)	23099452	23099452	23099452	23099452	23099452	23099452	23099452
Maximum Annual Debt Payment (USD)	770622	770622	770622	770622	770622	770622	770622
Average Annual Debt Payment (USD)	461989	461989	461989	461989	461989	461989	461989
Total Interest Payment (USD)	3708160	3708160	3708160	3708160	3708160	3708160	3708160
Maximum Annual Interest Payment (USD)	145087	145087	145087	145087	145087	145087	145087
Average Annual Interest Payment (USD)	74163	74163	74163	74163	74163	74163	74163
Impacts on P/L							
% of Average Annual Debt Payment on Gross Profit (Loss	0.00%	0.00%	−0.57%	−1.14%	−1.72%	−2.29%	−2.86%
% of Average Debt Annual Payment on Net Profit (Loss)	0.00%	0.00%	−0.21%	−0.42%	−0.62%	−0.83%	−1.04%
% of Average Tariff Increase on Gross Profit (Loss)	0.00%	−5.70%	−4.56%	−3.42%	−2.28%	−1.14%	0.00%
% of Average Tariff Increase on Net Profit (Loss)	0.00%	−2.07%	−1.66%	−1.24%	−0.83%	−0.41%	0.00%
Impacts on B/S							
% of Maximum Outstanding Debt on Current Debt	0.00%	0.00%	3.74%	7.49%	11.23%	14.97%	18.71%
% of Maximum Outstanding Debt on Total Debt	0.00%	0.00%	3.38%	6.76%	10.15%	13.53%	16.91%
Sustainability Indicators							
NRW Rate (%)	23.7	23.7	23.7	23.7	23.7	23.7	23.7
Tariff Collection Rate (%)	90.0	90.0	90.0	90.0	90.0	90.0	90.0
SWC (Staff per Thousand Water Connectipons)	5.93	5.93	5.93	5.93	5.93	5.93	5.93
WR (Working Ratio) (%)	125.70%	125.70%	125.97%	126.25%	126.52%	126.80%	127.07%
OR (Operating Ratio) (%)	129.20%	129.20%	129.48%	129.75%	130.03%	130.30%	130.58%
Tariff Information							
Required Increase in Tariff per Service Population (USD)	0.00	0.13	0.11	0.08	0.05	0.03	0.00
% of Required Increase on Present Tariff	0.00%	1.64%	1.31%	0.99%	0.66%	0.33%	0.00%
Annual Water Sales (USD)	56000790	56921146	56737075	56553003	56368932	56184861	56000790
Number of Service Population	6938734	6938734	6938734	6938734	6938734	6938734	6938734
Number of Connections	886995	886995	886995	886995	886995	886995	886995
Number of Residential Connection	731504	731504	731504	731504	731504	731504	731504
Annual Tariff per Service Population	8.07	8.20	8.18	8.15	8.12	8.10	8.07
Annual Tariff per Connections	63.14	64.17	63.97	63.76	63.55	63.34	63.14
Annual Tariff per Residential Connnections	76.56	77.81	77.56	77.31	77.06	76.81	76.56

Table 9.2.24 Summary of Financial Indicators (Case B-2)

Indicators	Current Situation	Case: B-2					
		WTP=100%	80%	60%	40%	20%	0%
Subsidy							
Amount (USD)	9138348	9138348	9138348	9138348	9138348	9138348	9138348
Subsidies Ratio (%)	32.03%	32.03%	32.03%	32.03%	32.03%	32.03%	32.03%
Loan and Payment							
Total Amount of Loan (USD)	19391292	19391292	19391292	19391292	19391292	19391292	19391292
Total Debt Payment (USD)	27341721	27341721	27341721	27341721	27341721	27341721	27341721
Maximum Annual Debt Payment (USD)	1272636	1272636	1272636	1272636	1272636	1272636	1272636
Average Annual Debt Payment (USD)	546834	546834	546834	546834	546834	546834	546834
Total Interest Payment (USD)	7950430	7950430	7950430	7950430	7950430	7950430	7950430
Maximum Annual Interest Payment (USD)	386436	386436	386436	386436	386436	386436	386436
Average Annual Interest Payment (USD)	159009	159009	159009	159009	159009	159009	159009
Impacts on P/L							
% of Average Annual Debt Payment on Gross Profit (Loss	0.00%	0.00%	−0.68%	−1.36%	−2.03%	−2.71%	−3.39%
% of Average Debt Annual Payment on Net Profit (Loss)	0.00%	0.00%	−0.25%	−0.49%	−0.74%	−0.98%	−1.23%
% of Average Tariff Increase on Gross Profit (Loss)	0.00%	−8.54%	−6.83%	−5.12%	−3.42%	−1.71%	0.00%
% of Average Tariff Increase on Net Profit (Loss)	0.00%	−3.10%	−2.48%	−1.86%	−1.24%	−0.62%	0.00%
Impacts on B/S							
% of Maximum Outstanding Debt on Current Debt	0.00%	0.00%	3.73%	7.46%	11.19%	14.92%	18.64%
% of Maximum Outstanding Debt on Total Debt	0.00%	0.00%	3.37%	6.74%	10.11%	13.48%	16.85%
Sustainability Indicators							
NRW Rate (%)	23.7	23.7	23.7	23.7	23.7	23.7	23.7
Tariff Collection Rate (%)	90.0	90.0	90.0	90.0	90.0	90.0	90.0
SWC (Staff per Thousand Water Connectipons)	5.93	5.93	5.93	5.93	5.93	5.93	5.93
WR (Working Ratio) (%)	125.70%	125.70%	126.02%	126.35%	126.67%	127.00%	127.33%
OR (Operating Ratio) (%)	129.20%	129.20%	129.53%	129.85%	130.18%	130.50%	130.83%
Tariff Information							
Required Increase in Tariff per Service Population (USD)	0.00	0.20	0.16	0.12	0.08	0.04	0.00
% of Required Increase on Present Tariff	0.00%	2.46%	1.97%	1.48%	0.98%	0.49%	0.00%
Annual Water Sales (USD)	56000790	57379137	57103468	56827798	56552129	56276459	56000790
Number of Service Population	6938734	6938734	6938734	6938734	6938734	6938734	6938734
Number of Connections	886995	886995	886995	886995	886995	886995	886995
Number of Residential Connection	731504	731504	731504	731504	731504	731504	731504
Annual Tariff per Service Population	8.07	8.27	8.23	8.19	8.15	8.11	8.07
Annual Tariff per Connections	63.14	64.69	64.38	64.07	63.76	63.45	63.14
Annual Tariff per Residential Connnections	76.56	78.44	78.06	77.69	77.31	76.93	76.56

Table 9.2.25 Summary of Financial Indicators (Case B-3)

Indicators	Current Situation	Case: B-3					
		WTP=100%	80%	60%	40%	20%	0%
Subsidy							
Amount (USD)	9138348	9138348	9138348	9138348	9138348	9138348	9138348
Subsidies Ratio (%)	32.03%	32.03%	32.03%	32.03%	32.03%	32.03%	32.03%
Loan and Payment							
Total Amount of Loan (USD)	19391292	19391292	19391292	19391292	19391292	19391292	19391292
Total Debt Payment (USD)	31995631	31995631	31995631	31995631	31995631	31995631	31995631
Maximum Annual Debt Payment (USD)	1979802	1979802	1979802	1979802	1979802	1979802	1979802
Average Annual Debt Payment (USD)	639913	639913	639913	639913	639913	639913	639913
Total Interest Payment (USD)	12604340	12604340	12604340	12604340	12604340	12604340	12604340
Maximum Annual Interest Payment (USD)	866402	866402	866402	866402	866402	866402	866402
Average Annual Interest Payment (USD)	252087	252087	252087	252087	252087	252087	252087
Impacts on P/L							
% of Average Annual Debt Payment on Gross Profit (Loss	0.00%	0.00%	−0.79%	−1.59%	−2.38%	−3.17%	−3.96%
% of Average Debt Annual Payment on Net Profit (Loss)	0.00%	0.00%	−0.29%	−0.58%	−0.86%	−1.15%	−1.44%
% of Average Tariff Increase on Gross Profit (Loss)	0.00%	−13.52%	−10.82%	−8.11%	−5.41%	−2.70%	0.00%
% of Average Tariff Increase on Net Profit (Loss)	0.00%	−4.91%	−3.93%	−2.95%	−1.97%	−0.98%	0.00%
Impacts on B/S							
% of Maximum Outstanding Debt on Current Debt	0.00%	0.00%	3.23%	6.45%	9.68%	12.91%	16.14%
% of Maximum Outstanding Debt on Total Debt	0.00%	0.00%	2.92%	5.83%	8.75%	11.66%	14.58%
Sustainability Indicators							
NRW Rate (%)	23.7	23.7	23.7	23.7	23.7	23.7	23.7
Tariff Collection Rate (%)	90.0	90.0	90.0	90.0	90.0	90.0	90.0
SWC (Staff per Thousand Water Connectipons)	5.93	5.93	5.93	5.93	5.93	5.93	5.93
WR (Working Ratio) (%)	125.70%	125.70%	126.08%	126.46%	126.84%	127.22%	127.60%
OR (Operating Ratio) (%)	129.20%	129.20%	129.58%	129.96%	130.34%	130.73%	131.11%
Tariff Information							
Required Increase in Tariff per Service Population (USD)	0.00	0.31	0.25	0.19	0.13	0.06	0.00
% of Required Increase on Present Tariff	0.00%	3.90%	3.12%	2.34%	1.56%	0.78%	0.00%
Annual Water Sales (USD)	56000790	58183348	57746837	57310325	56873813	56437302	56000790
Number of Service Population	6938734	6938734	6938734	6938734	6938734	6938734	6938734
Number of Connections	886995	886995	886995	886995	886995	886995	886995
Number of Residential Connection	731504	731504	731504	731504	731504	731504	731504
Annual Tariff per Service Population	8.07	8.39	8.32	8.26	8.20	8.13	8.07
Annual Tariff per Connections	63.14	65.60	65.10	64.61	64.12	63.63	63.14
Annual Tariff per Residential Connnections	76.56	79.54	78.94	78.35	77.75	77.15	76.56

Table 9.2.26 Summary of Financial Indicators (Case C-1)

Indicators	Current Situation	Case: C-1					
		WTP=100%	80%	60%	40%	20%	0%
Subsidy							
Amount (USD)	18829221	18829221	18829221	18829221	18829221	18829221	18829221
Subsidies Ratio (%)	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%
Loan and Payment							
Total Amount of Loan (USD)	9700419	9700419	9700419	9700419	9700419	9700419	9700419
Total Debt Payment (USD)	11555417	11555417	11555417	11555417	11555417	11555417	11555417
Maximum Annual Debt Payment (USD)	385127	385127	385127	385127	385127	385127	385127
Average Annual Debt Payment (USD)	231108	231108	231108	231108	231108	231108	231108
Total Interest Payment (USD)	1854999	1854999	1854999	1854999	1854999	1854999	1854999
Maximum Annual Interest Payment (USD)	72555	72555	72555	72555	72555	72555	72555
Average Annual Interest Payment (USD)	37100	37100	37100	37100	37100	37100	37100
Impacts on P/L							
% of Average Annual Debt Payment on Gross Profit (Loss	0.00%	0.00%	−0.29%	−0.57%	−0.86%	−1.15%	−1.43%
% of Average Debt Annual Payment on Net Profit (Loss)	0.00%	0.00%	−0.10%	−0.21%	−0.31%	−0.42%	−0.52%
% of Average Tariff Increase on Gross Profit (Loss)	0.00%	−2.88%	−2.30%	−1.73%	−1.15%	−0.58%	0.00%
% of Average Tariff Increase on Net Profit (Loss)	0.00%	−1.04%	−0.84%	−0.63%	−0.42%	−0.21%	0.00%
Impacts on B/S							
% of Maximum Outstanding Debt on Current Debt	0.00%	0.00%	1.87%	3.74%	5.61%	7.48%	9.35%
% of Maximum Outstanding Debt on Total Debt	0.00%	0.00%	1.69%	3.38%	5.07%	6.76%	8.45%
Sustainability Indicators							
NRW Rate (%)	23.7	23.7	23.7	23.7	23.7	23.7	23.7
Tariff Collection Rate (%)	90.0	90.0	90.0	90.0	90.0	90.0	90.0
SWC (Staff per Thousand Water Connectipons)	5.93	5.93	5.93	5.93	5.93	5.93	5.93
WR (Working Ratio) (%)	125.70%	125.70%	125.84%	125.97%	126.11%	126.25%	126.39%
OR (Operating Ratio) (%)	129.20%	129.20%	129.34%	129.48%	129.61%	129.75%	129.89%
Tariff Information							
Required Increase in Tariff per Service Population (USD)	0.00	0.07	0.05	0.04	0.03	0.01	0.00
% of Required Increase on Present Tariff	0.00%	0.83%	0.66%	0.50%	0.33%	0.17%	0.00%
Annual Water Sales (USD)	56000790	56464961	56372127	56279293	56186458	56093624	56000790
Number of Service Population	6938734	6938734	6938734	6938734	6938734	6938734	6938734
Number of Connections	886995	886995	886995	886995	886995	886995	886995
Number of Residential Connection	731504	731504	731504	731504	731504	731504	731504
Annual Tariff per Service Population	8.07	8.14	8.12	8.11	8.10	8.08	8.07
Annual Tariff per Connections	63.14	63.66	63.55	63.45	63.34	63.24	63.14
Annual Tariff per Residential Connnections	76.56	77.19	77.06	76.94	76.81	76.68	76.56

Table 9.2.27 Summary of Financial Indicators (Case C-2)

Indicators	Current Situation	Case: C-2					
		WTP=100%	80%	60%	40%	20%	0%
Subsidy							
Amount (USD)	18829221	18829221	18829221	18829221	18829221	18829221	18829221
Subsidies Ratio (%)	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%
Loan and Payment							
Total Amount of Loan (USD)	7140000	7140000	7140000	7140000	7140000	7140000	7140000
Total Debt Payment (USD)	10067400	10067400	10067400	10067400	10067400	10067400	10067400
Maximum Annual Debt Payment (USD)	487052	487052	487052	487052	487052	487052	487052
Average Annual Debt Payment (USD)	201348	201348	201348	201348	201348	201348	201348
Total Interest Payment (USD)	2927400	2927400	2927400	2927400	2927400	2927400	2927400
Maximum Annual Interest Payment (USD)	142750	142750	142750	142750	142750	142750	142750
Average Annual Interest Payment (USD)	58548	58548	58548	58548	58548	58548	58548
Impacts on P/L							
% of Average Annual Debt Payment on Gross Profit (Loss	0.00%	0.00%	−0.25%	−0.50%	−0.75%	−1.00%	−1.25%
% of Average Debt Annual Payment on Net Profit (Loss)	0.00%	0.00%	−0.09%	−0.18%	−0.27%	−0.36%	−0.45%
% of Average Tariff Increase on Gross Profit (Loss)	0.00%	−2.74%	−2.19%	−1.64%	−1.10%	−0.55%	0.00%
% of Average Tariff Increase on Net Profit (Loss)	0.00%	−1.00%	−0.80%	−0.60%	−0.40%	−0.20%	0.00%
Impacts on B/S							
% of Maximum Outstanding Debt on Current Debt	0.00%	0.00%	1.39%	2.77%	4.16%	5.55%	6.93%
% of Maximum Outstanding Debt on Total Debt	0.00%	0.00%	1.25%	2.51%	3.76%	5.01%	6.26%
Sustainability Indicators							
NRW Rate (%)	23.7	23.7	23.7	23.7	23.7	23.7	23.7
Tariff Collection Rate (%)	90.0	90.0	90.0	90.0	90.0	90.0	90.0
SWC (Staff per Thousand Water Connectipons)	5.93	5.93	5.93	5.93	5.93	5.93	5.93
WR (Working Ratio) (%)	125.70%	125.70%	125.82%	125.94%	126.06%	126.18%	126.30%
OR (Operating Ratio) (%)	129.20%	129.20%	129.32%	129.44%	129.56%	129.68%	129.80%
Tariff Information							
Required Increase in Tariff per Service Population (USD)	0.00	0.06	0.05	0.04	0.03	0.01	0.00
% of Required Increase on Present Tariff	0.00%	0.79%	0.63%	0.47%	0.32%	0.16%	0.00%
Annual Water Sales (USD)	56000790	56442845	56354434	56266023	56177612	56089201	56000790
Number of Service Population	6938734	6938734	6938734	6938734	6938734	6938734	6938734
Number of Connections	886995	886995	886995	886995	886995	886995	886995
Number of Residential Connection	731504	731504	731504	731504	731504	731504	731504
Annual Tariff per Service Population	8.07	8.13	8.12	8.11	8.10	8.08	8.07
Annual Tariff per Connections	63.14	63.63	63.53	63.43	63.33	63.24	63.14
Annual Tariff per Residential Connnections	76.56	77.16	77.04	76.92	76.80	76.68	76.56

Table 9.2.28 Summary of Financial Indicators (Case C-3)

Indicators	Current Situation	Case: C-3					
		WTP=100%	80%	60%	40%	20%	0%
Subsidy							
Amount (USD)	18829221	18829221	18829221	18829221	18829221	18829221	18829221
Subsidies Ratio (%)	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%
Loan and Payment							
Total Amount of Loan (USD)	7140000	7140000	7140000	7140000	7140000	7140000	7140000
Total Debt Payment (USD)	11781000	11781000	11781000	11781000	11781000	11781000	11781000
Maximum Annual Debt Payment (USD)	790507	790507	790507	790507	790507	790507	790507
Average Annual Debt Payment (USD)	235620	235620	235620	235620	235620	235620	235620
Total Interest Payment (USD)	4641000	4641000	4641000	4641000	4641000	4641000	4641000
Maximum Annual Interest Payment (USD)	351000	351000	351000	351000	351000	351000	351000
Average Annual Interest Payment (USD)	92820	92820	92820	92820	92820	92820	92820
Impacts on P/L							
% of Average Annual Debt Payment on Gross Profit (Loss	0.00%	0.00%	−0.29%	−0.58%	−0.88%	−1.17%	−1.46%
% of Average Debt Annual Payment on Net Profit (Loss)	0.00%	0.00%	−0.11%	−0.21%	−0.32%	−0.42%	−0.53%
% of Average Tariff Increase on Gross Profit (Loss)	0.00%	−4.34%	−3.47%	−2.60%	−1.73%	−0.87%	0.00%
% of Average Tariff Increase on Net Profit (Loss)	0.00%	−1.58%	−1.26%	−0.95%	−0.63%	−0.32%	0.00%
Impacts on B/S							
% of Maximum Outstanding Debt on Current Debt	0.00%	0.00%	1.35%	2.71%	4.06%	5.41%	6.77%
% of Maximum Outstanding Debt on Total Debt	0.00%	0.00%	1.22%	2.45%	3.67%	4.89%	6.12%
Sustainability Indicators							
NRW Rate (%)	23.7	23.7	23.7	23.7	23.7	23.7	23.7
Tariff Collection Rate (%)	90.0	90.0	90.0	90.0	90.0	90.0	90.0
SWC (Staff per Thousand Water Connectipons)	5.93	5.93	5.93	5.93	5.93	5.93	5.93
WR (Working Ratio) (%)	125.70%	125.70%	125.84%	125.98%	126.12%	126.26%	126.40%
OR (Operating Ratio) (%)	129.20%	129.20%	129.34%	129.48%	129.62%	129.76%	129.90%
Tariff Information							
Required Increase in Tariff per Service Population (USD)	0.00	0.10	0.08	0.06	0.04	0.02	0.00
% of Required Increase on Present Tariff	0.00%	1.25%	1.00%	0.75%	0.50%	0.25%	0.00%
Annual Water Sales (USD)	56000790	56700767	56560771	56420776	56280781	56140785	56000790
Number of Service Population	6938734	6938734	6938734	6938734	6938734	6938734	6938734
Number of Connections	886995	886995	886995	886995	886995	886995	886995
Number of Residential Connection	731504	731504	731504	731504	731504	731504	731504
Annual Tariff per Service Population	8.07	8.17	8.15	8.13	8.11	8.09	8.07
Annual Tariff per Connections	63.14	63.92	63.77	63.61	63.45	63.29	63.14
Annual Tariff per Residential Connnections	76.56	77.51	77.32	77.13	76.94	76.75	76.56

Table 9.2.29 Summary of Financial Indicators (Case D-1)

Indicators	Current Situation	Case: D-1					
		WTP=100%	80%	60%	40%	20%	0%
Subsidy							
Amount (USD)	28529640	28529640	28529640	28529640	28529640	28529640	28529640
Subsidies Ratio (%)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Loan and Payment							
Total Amount of Loan (USD)	0	0	0	0	0	0	0
Total Debt Payment (USD)	0	0	0	0	0	0	0
Maximum Annual Debt Payment (USD)	0	0	0	0	0	0	0
Average Annual Debt Payment (USD)	0	0	0	0	0	0	0
Total Interest Payment (USD)	0	0	0	0	0	0	0
Maximum Annual Interest Payment (USD)	0	0	0	0	0	0	0
Average Annual Interest Payment (USD)	0	0	0	0	0	0	0
Impacts on P/L							
% of Average Annual Debt Payment on Gross Profit (Loss	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% of Average Debt Annual Payment on Net Profit (Loss)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% of Average Tariff Increase on Gross Profit (Loss)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% of Average Tariff Increase on Net Profit (Loss)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Impacts on B/S							
% of Maximum Outstanding Debt on Current Debt	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% of Maximum Outstanding Debt on Total Debt	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sustainability Indicators							
NRW Rate (%)	23.7	23.7	23.7	23.7	23.7	23.7	23.7
Tariff Collection Rate (%)	90.0	90.0	90.0	90.0	90.0	90.0	90.0
SWC (Staff per Thousand Water Connectipons)	5.93	5.93	5.93	5.93	5.93	5.93	5.93
WR (Working Ratio) (%)	125.70%	125.70%	125.70%	125.70%	125.70%	125.70%	125.70%
OR (Operating Ratio) (%)	129.20%	129.20%	129.20%	129.20%	129.20%	129.20%	129.20%
Tariff Information							
Required Increase in Tariff per Service Population (USD)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% of Required Increase on Present Tariff	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Annual Water Sales (USD)	56000790	56000790	56000790	56000790	56000790	56000790	56000790
Number of Service Population	6938734	6938734	6938734	6938734	6938734	6938734	6938734
Number of Connections	886995	886995	886995	886995	886995	886995	886995
Number of Residential Connection	731504	731504	731504	731504	731504	731504	731504
Annual Tariff per Service Population	8.07	8.07	8.07	8.07	8.07	8.07	8.07
Annual Tariff per Connections	63.14	63.14	63.14	63.14	63.14	63.14	63.14
Annual Tariff per Residential Connnections	76.56	76.56	76.56	76.56	76.56	76.56	76.56

Table 9.2.30 Summary of Financial Indicators (Case D-2)

Indicators	Current Situation	Case: D-2					
		WTP=100%	80%	60%	40%	20%	0%
Subsidy							
Amount (USD)	28529640	28529640	28529640	28529640	28529640	28529640	28529640
Subsidies Ratio (%)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Loan and Payment							
Total Amount of Loan (USD)	0	0	0	0	0	0	0
Total Debt Payment (USD)	0	0	0	0	0	0	0
Maximum Annual Debt Payment (USD)	0	0	0	0	0	0	0
Average Annual Debt Payment (USD)	0	0	0	0	0	0	0
Total Interest Payment (USD)	0	0	0	0	0	0	0
Maximum Annual Interest Payment (USD)	0	0	0	0	0	0	0
Average Annual Interest Payment (USD)	0	0	0	0	0	0	0
Impacts on P/L							
% of Average Annual Debt Payment on Gross Profit (Loss	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% of Average Debt Annual Payment on Net Profit (Loss)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% of Average Tariff Increase on Gross Profit (Loss)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% of Average Tariff Increase on Net Profit (Loss)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Impacts on B/S							
% of Maximum Outstanding Debt on Current Debt	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% of Maximum Outstanding Debt on Total Debt	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sustainability Indicators							
NRW Rate (%)	23.7	23.7	23.7	23.7	23.7	23.7	23.7
Tariff Collection Rate (%)	90.0	90.0	90.0	90.0	90.0	90.0	90.0
SWC (Staff per Thousand Water Connectipons)	5.93	5.93	5.93	5.93	5.93	5.93	5.93
WR (Working Ratio) (%)	125.70%	125.70%	125.70%	125.70%	125.70%	125.70%	125.70%
OR (Operating Ratio) (%)	129.20%	129.20%	129.20%	129.20%	129.20%	129.20%	129.20%
Tariff Information							
Required Increase in Tariff per Service Population (USD)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% of Required Increase on Present Tariff	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Annual Water Sales (USD)	56000790	56000790	56000790	56000790	56000790	56000790	56000790
Number of Service Population	6938734	6938734	6938734	6938734	6938734	6938734	6938734
Number of Connections	886995	886995	886995	886995	886995	886995	886995
Number of Residential Connection	731504	731504	731504	731504	731504	731504	731504
Annual Tariff per Service Population	8.07	8.07	8.07	8.07	8.07	8.07	8.07
Annual Tariff per Connections	63.14	63.14	63.14	63.14	63.14	63.14	63.14
Annual Tariff per Residential Connnections	76.56	76.56	76.56	76.56	76.56	76.56	76.56

Table 9.2.31 Summary of Financial Indicators (Case D-3)

Indicators	Current Situation	Case: D-3					
		WTP=100%	80%	60%	40%	20%	0%
Subsidy							
Amount (USD)	28529640	28529640	28529640	28529640	28529640	28529640	28529640
Subsidies Ratio (%)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Loan and Payment							
Total Amount of Loan (USD)	0	0	0	0	0	0	0
Total Debt Payment (USD)	0	0	0	0	0	0	0
Maximum Annual Debt Payment (USD)	0	0	0	0	0	0	0
Average Annual Debt Payment (USD)	0	0	0	0	0	0	0
Total Interest Payment (USD)	0	0	0	0	0	0	0
Maximum Annual Interest Payment (USD)	0	0	0	0	0	0	0
Average Annual Interest Payment (USD)	0	0	0	0	0	0	0
Impacts on P/L							
% of Average Annual Debt Payment on Gross Profit (Loss	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% of Average Debt Annual Payment on Net Profit (Loss)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% of Average Tariff Increase on Gross Profit (Loss)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% of Average Tariff Increase on Net Profit (Loss)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Impacts on B/S							
% of Maximum Outstanding Debt on Current Debt	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% of Maximum Outstanding Debt on Total Debt	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sustainability Indicators							
NRW Rate (%)	23.7	23.7	23.7	23.7	23.7	23.7	23.7
Tariff Collection Rate (%)	90.0	90.0	90.0	90.0	90.0	90.0	90.0
SWC (Staff per Thousand Water Connectipons)	5.93	5.93	5.93	5.93	5.93	5.93	5.93
WR (Working Ratio) (%)	125.70%	125.70%	125.70%	125.70%	125.70%	125.70%	125.70%
OR (Operating Ratio) (%)	129.20%	129.20%	129.20%	129.20%	129.20%	129.20%	129.20%
Tariff Information							
Required Increase in Tariff per Service Population (USD)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% of Required Increase on Present Tariff	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Annual Water Sales (USD)	56000790	56000790	56000790	56000790	56000790	56000790	56000790
Number of Service Population	6938734	6938734	6938734	6938734	6938734	6938734	6938734
Number of Connections	886995	886995	886995	886995	886995	886995	886995
Number of Residential Connection	731504	731504	731504	731504	731504	731504	731504
Annual Tariff per Service Population	8.07	8.07	8.07	8.07	8.07	8.07	8.07
Annual Tariff per Connections	63.14	63.14	63.14	63.14	63.14	63.14	63.14
Annual Tariff per Residential Connnections	76.56	76.56	76.56	76.56	76.56	76.56	76.56

CHAPTER 10 SOCIAL AND ENVIRONMENTAL CONSIDERATION

10.1 Organization in Charge for Environemtal Issue

In IRI, the Department of Environment (DOE) is responsible for the protection and enhancement of the environment, the prevention and control of any form of pollution or degradation leading to the disturbance of environmental balance, and for conducting all matters related to wildlife and the aquatic biota of the territorial waters. The Vice President of the IRI, who directs the daily operations of the DOE heads the department with 4 deputies.

The DOE is responsible for 10 national parks with a total area of 1,277,560 hectares, five national monuments covering 1,798 hectares, 25 wild life refuge measuring 1,921,504 hectares, 47 protected areas spread over 4,813,086 hectares and 17 wetlands. The sum of these areas equals to 8,013,948 hectares or 5% of the entire land area.

Each province of Iran has a DOE provincial directorate, which monitors all the aspects of environmental protection and the implementation of the department's programs. The DOE is in-charge for defining the national regulations and standards for preserving and enhancing the quality of environment.

The Environmental Protection Act (1974) is the major law for environmental conservation in IRI. The Supreme Council of the Environment is a legislative body that enacts relevant regulations for the environmental protection. It is chaired by the President of the Islamic Republic and the other members of the council are the Ministers of Agriculture, Foreign Affairs, Industry, Interior, Health and Medical Education, the Heads of the Department of Administration and Planning and the Institute of Standard and Industrial Research.

10.2 Legal Framework

10.2.1 National Constitution

The Article 50 of National Constitution of IRI that has been approved by the parliament in 1979 stipulates "Preservation of the Environment" and it states as follows:

"The protection of environment, in which the present and future generations must lead an ever-improving community life, is a public obligation. Therefore, economic or other activities which cause pollution or other irreversible damage to environment are prohibited".

10.2.2 Relevant Laws and Regulations Concerning Environment and Water Issues

All of the laws and regulations concerning the environmental related issues are based on the above National Constitution. The laws and regulations related to the water pollution, distribution and

environment of dam/reservoir and natural resources management are summarized as below:

(1) Legislation Enforced by the DOE

The DOE is responsible for the protection and enhancement of the environment, the prevention and control of any form of pollution or degradation leading to the disturbance in the environmental balance.

- The Law of Hunting and Fishing (1974 and amended in 1996)
- Aquatic Resources Conservation and Utilization (1995)
- The Law Concerning the Farms and Orchards Land Use (1995)
- The Regulation for the Prevention of Water Pollution (1994)
- Environmental Impact Study Guidelines (1997), approved by Environmental Supreme Council
- Wastewater Discharge Standards (1994)
- Environment Conservation and Rehabilitation Act (1974 and amended in 1982)

(2) Other Legislations Concerning Water Supply

The major laws and regulations other than the above concerning water supply and its related activities including planning, operation and construction are summarized as follows:

- Fundamental Law of Water (1962): stipulates any water resource belongs to the Nation.
- The Law of Fair Distribution of Water (1982): stipulates roles and duties of MOE which is competent organization to administrate water resource. In addition, pumping up of groundwater more than 25 cubic meters per day is subject to the approval by the DOE.
- The Law of Water and Wastewater Company (1990)
- The Law of Solid Waste

10.2.3 Legal Provisions of EIA

EIA in Iran is enabled by Note 82 of the Law for the Second State Economical, Social and Cultural Development Plan of 1994, amended by Note 105 of the Third Development Plan. It is implemented through Decree 138 dated 12/04/1994, of the Environmental Protection High Council (EPHC). Detailed requirements under the law are defined in the Code of Practice dated 23/12/1997, issued by the EPHC.

The enabling law requires that large manufacturing and service projects be subject to EIA prior to implementation at the feasibility and implementation stages, and gives the EPHC power to determine both the interpretation of what is a large project and the pattern of the assessment. The EPHC has defined that the following projects are subject to EIA:

- Petroleum industries of any kind
- Refineries
- Power stations with capacity of more than 100 MW
- Steel industries
    - Units of melted materials with a capacity of 300,000 ton/year

  - Units of forming with a capacity of 100,000 tons/year
- Dams of more than 15m high with area more than 400 ha.
- Dams which keep pollutant materials in any measure should be evaluated by the environmental office.
- Man-made lakes with area more than 400 ha area
- The size of the lakes that breed fish with an area of less than 400 ha should be supervised by the department of agriculture.
- Irrigation and drainage projects with an area of more than 5,000 ha
- Airports with a landing area of more than 2,000m2
- Projects of oil or gas pipeline transportation

The competent body for approving EIA reports is defined in Note 2 of Decree 138 as the DOE. The DOE passes the approved report, together with any recommendations it may make, to the government directorate responsible for the project.

This enables execution of the project to begin. Article 9 of the Code of Practice states that if project execution is found to be inconsistent with the assessment, the DOE shall notify the relevant ministry, and that any controversy shall be resolved by decision of the President.

Article 9 of the decree requires the establishment of a scientific committee to coordinate affairs related to EIA, under the chairmanship of the Head of DOE. This includes scientific experts selected by DOE as well as representatives of other environment-related government departments. There is no specific requirement for this committee to contribute to review of EIA reports or project decision-making, but its constitution enables it to do so, through the inclusion of a representative of the ministry or organization related to the assessed project.

10.2.4 Administrative Framework and Procedure of EIA

The DOE has established an EIA Bureau under a Director General. The Bureau has approximately 15 staff in the national office in Tehran. The DOE also has offices in each province, mainly with one member of professional staff but up to three in major cities, who contribute to EIA at the screening stage.

Applications for development approval or "Brief Plan" are submitted to the local DOE offices, which screen them for whether an EIA is required. If the project falls within one of the above categories subject to EIA, the developer is required to submit a "Brief EIA Report", as defined in DOE guidelines.

The completed "Brief EIA Report" is submitted to the local DOE office and passed to the national office in Tehran for review. This may be accepted without further assessment, or the DOE may, within 20 days, require further consideration of sensitive issues. The DOE then has 3 months from receipt to give its comments on the final report. The report may be accepted, rejected, or approved with recommended

conditions.

Article 6 of the Code of Practice requires that EIA reports be prepared by individuals or organizations whose qualifications are approved by the related authorities, and provides for DOE to publish a preliminary list until such time as qualified practitioners are well established. A general qualification system for consultants is operated by the Ministry of Budgeting and Planning, but with no specific requirements for EIA. *Figure 10.1.1* outlines the procedure for EIA in IRI

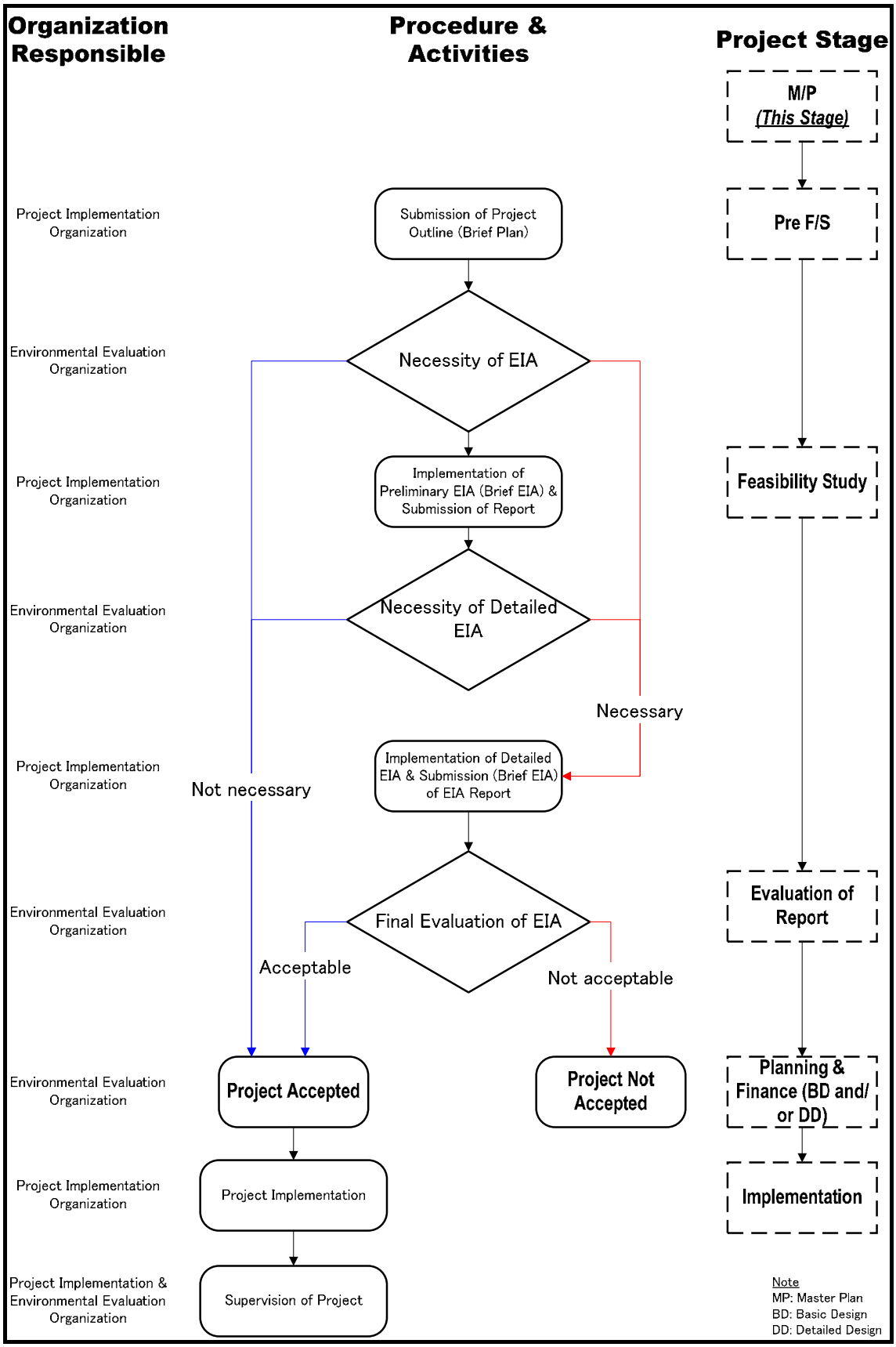


Figure 10.1.1 Procedure for EIA in IRI

10.3 Evaluation of Impacts

10.3.1 Project Description

Table 10.3.1 gives a brief explanation of the description of the Earthquake-resistant plan (refer to the relevant chapter & section of this report for further details):

Table 10.3.1 Summary of Project Description

Item	*Contents*		*Chapter to be refered to for further details:*
Name of the Project	"Earthquake-resistant Plan for the Water Supply System in Tehran Municipality", which consists of the following major componetnts: ✓ Earthquake Resistant Measures for Pipeline Systems ✓ Earthquake Resistant Measures for Facilities and Eauipment ✓ Preparation of Emergency Water Supply Bases		✓ Chapter 1 ✓ Chapter 6
Background	Water Supply in Tehran Municipality: ✓ faces rapid growth of water demand because of poplulation increase, with limited water resource and arid climate ✓ is requied to reduce NRW (UFW) to meet water demand ✓ situated in earthquake-prone zone and necessary to be prepared for future earthquake disaster		✓ Chapter 1
Project Location	Tehran Municipality (Districts No.1 to 20)		✓ Chapter 1 ✓ Chapter 9
Project Area	Approximately 450 km^2 (Districts No.1 to 20)		✓ Chapter 1
Executive Organization	TPWWC and TWWC, Ministry of Energy		
Beneficiary	Approximately 6.9 million people		✓ Chapter 8
Type and Contents of the Project	Earthquake Resistant Measures for Pipeline Systems	Modification & reinforcement of existing transmission pipe	✓ Chapter 6 ✓ Chapter 7
	Earthquake Resistant Measures for Facilities and Equipment	Modification & reinforcement of existing facilities & equipment	✓ Chapter 6 ✓ Chapter 7
	Preparation of Emergency Water Supply Bases	Utilize existing facilities, with modification and small-scale construction of tanks & storehouse	✓ Chapter 6 ✓ Chapter 7

10.3.2 Existing Environmental Condition of the Project Area

Figure 10.3.1 shows land use and Figure 10.3.2 shows topographical feature of the project area. As shown in these figures, project area is highly steep from north to south and most of the project area is occupied by residential and commercial buildings.

Table 10.3.2 gives a brief explanation of the existing environmental condition in project area:

Table 10.3.2 Summary of Existing Environmental Condition

Item	*Contents*
Social Condition	✓ urbanized area with the total population of approximately 6.9 million ✓ rapid water demand growth and experienced severe water supply restriction in summer in 2001
Natural Condition	✓ situated in earthquake-prone zone and there are many active faults within and the sorrounding area ✓ slopes down from north to south, with approximately 700 m of vertical drop ✓ situated in semi-arid climate, with below 300 mm of the average annual rainfall. ✓ many reported cases caused by severe air pollution ✓ constant traffic jam

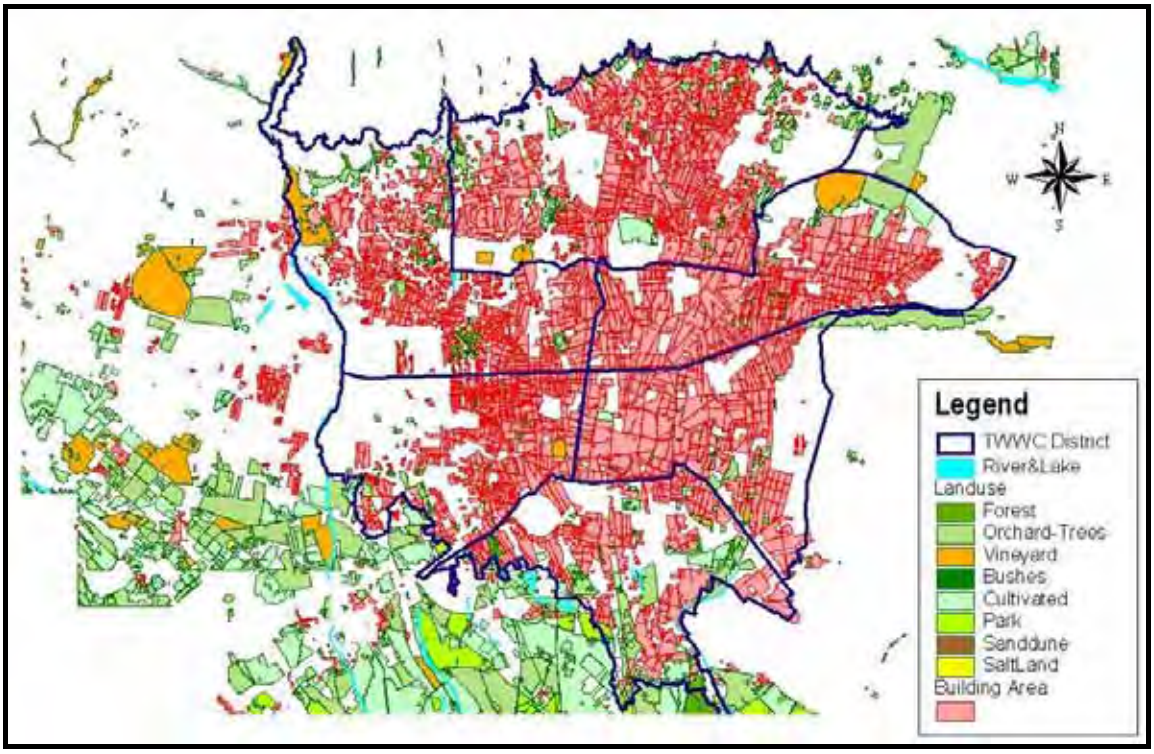


Figure 10.3.1 Land Use of the Project Area

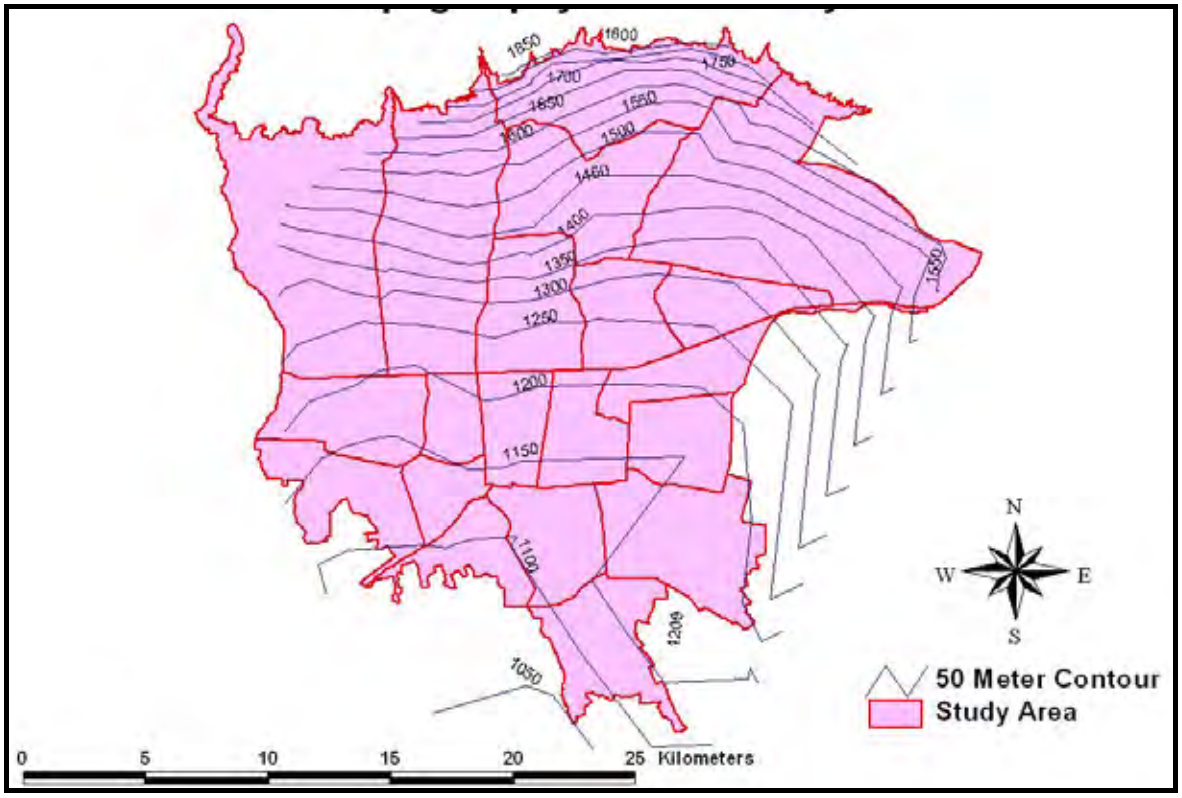


Figure 10.3.2 Topographical Feature of the Project Area

10.3.3 Evaluation of Impacts and Mitigation Measures

Preliminary "Joint Screening and Scoping" with the counterpart staff was conducted at the beginning stage of the Study, with reference to both Iranian environmental relevant regulations and the "JICA's Social and Environment Guideline (2004)". The result of "Joint Screening and Scoping" with the counterpart staff, which is conducted at the beginning stage of the Study, was reviewed again after the confirmation of the contents of the Earthquake-resistant Plan. *Table 10.3.3 and Table 10.3.4* summarizes the final result of the evaluation.

Table 10.3.3 Result of Joint Screening and Scoping

No.	*Environmental Items*	*Classification*	*Evaluation Remarks*
	Social Environment		
1.	Resettlement/Land Ownership	D	As this project is a rehabilitaion of existing water supply facilities, no large-scale land acquisition is expected. New constructions for emergency water tank, storehouse and concrete tank are expected in existing area owned by TWWC or public parks.
2.	Economic Activities	D	No economic structure change will be expected.
3.	Traffic/Public Facilities	B	Open excavation work could require traffic block during construction stage.
4.	Split of Communities	D	Proposed project is not of significantly large scale. Hence, no significant impact is expected.
5.	Cultural Property	D	No construction work is expected in and around holy place.
6.	Water Rights and Rights of Common	D	No new exloitation of water resource is expected.
7.	Public Health Condition	D	Proposed project will contribute to prevent degradation of sanitary condition after the disaster.
8.	Waste	B	Excavated soil will be generated during piping work. However, it is properly disposed at soil & waste dumping site, which is reserved with huge enough area in southern part of Tehran City.
9.	Hazards (Risk)	D	No large-scale reclamation is expected.
	Natural Environment		
10.	Topography and Geology	D	No large-scale reclamation is expected.
11.	Soil Erosion	D	No large-scale reclamation is expected.
12.	Groundwater	D	Polluted soil material will not be imported to the proposed site. In addition, proposed project will contribute to reduce excessive pumping in case emergency water supply work is being conducted after an severe earthquake disaster.
13.	Hydrological Situation	D	Wastewater infiltrate to underground.
14.	Coastal Zone	D	Proposed site is not costal area.
15.	Fauna and Flora	D	No precious species of fauna and flora were found in/around area. Proposed project area is urban area
16.	Meteorology	D	No large-scale construction enough to affect micro-climate is expected.
17.	Landscape	D	No significant impact on landscape is expected.
	Pollution		

18.	Air Pollution	D	No major emission due to construction is expected.
19.	Water Pollution	B	Muddy waste water would be generated depending on sites during construction stage.
20.	Soil Pollution	D	No construction work or facilities causing soil pollution will be expected.
21.	Noise and Vibration	B	Noise and vibration would be generated during construction and operation stage. Impact during construction stage can be minimized by proper design/planning.
22.	Land Subsidence	D	As this project is a rehabilitaion of the existing water supply facilities, no new large-scale withdraw of groundwater is expected.
23.	Offensive Odor	D	No major emission due to construction is expected

Note: Evaluation categories:

A: Serious impact *B: Somewhat impact*

C: Light impact *D: Negligible or no impact and excluded from IEE and EIA*

Table 10.3.4 Overall Evaluations

No.	*Impact Items*	*Recommendations for Further Evaluation to Prevent Negative Impacts*
3.	Traffic/Public Facilities	Raw water transmission route parallels along broad highway and has enough space but rehabilitation work of some treated water transmission and distribution pipelines could require traffic block during construction stage.
8.	Waste	Excavated material will be generated during piping work. However, it is properly disposed at soil & waste dumping site, which is reserved with huge enough area in southern part of Tehran City. Therfore it is not regarded as serious impact.
19.	Water Pollution	Muddy and murky waste water could be generated in some construction sites depending on site conditions. Impact during construction stage can be minimized by proper design/planning.
21.	Noise and Vibration	Noise and vibration would be generated during construction stage. Impact during construction stage can be minimized by proper design/planning.
Conclusion		The results of IEE on the Earthquake-resistant Plan for the Water Supply System in Tehran Municipality indicate that the proposed project has positive social impacts on the project area. Neverthless, following items should be taken into account in detailed design and construction stage: ✓ Traffic jam during construction stage. ✓ Waste during construction stage. ✓ Noise, dust and vibration during construction stage.

10.4 Public Transparency

In response to the recommendation by the JST to hold stakeholder meeting, counterpart side took the opportunity for the Technical Transfer Seminar held on 19st August, 2006, to disseminate the result of the Study to public, with a special emphasis on the contents of "Earthquake-resistant Plan for the Water Supply System in Tehran Municipality" including the result of environmental evaluation for the proposed project. Invitations were widely given to the representatives of many different sectors/fields as follows therefore public transparency of this project can be regarded as well-maintained:

- Department of Environmental Protection in Tehran Province
- TDMO
- Public utility sectors concern (electricity, gas, firefighting and traffic department)
- Military, Red Crescent Society, water companies in other neighboring provinces (expected supporters in case of emergency)
- Professors of university and private consultant engineers (who could give comment or advise for the project from technical viewpoint)
- District representatives in Tehran Municipality (who can be representatives for beneficiaries)
- Media representatives

Following table gives detailed breakdown of participants.

Table 10.4.1 List of Participants for Technical Transfer Seminar

Organization	*Number of participants*
DOE	1
TDMO	2
Tehran Power Supply Company	3
Tehran Gas Company	3
Fire Fighting Organization	2
Traffic Department	1
Milirary	2
Red Crescent	1
Nerighboring City/Province's Water Company	11
University	15
Consulting Engineer	3
Municipality	21
Mass Media	2
IIEES	1
Islamic Council of Tehran	1
Ministry of Foreign Affairs	2
MPO	2
MOE	1
WO	4
NWWC	5
TPWWC	4
TWWC	17
TWWC (CP)	10
Other Parties Concern	10
Embassy of Japan	1
JICA Officials	3
JICA Study Team (including supporting local staff)	11
Total	***139***

Following table summarizes questions/comments made by the participants and responses/answers made by the Study Team.

Table 10.4.2 Summary of Questions/Comments and Answers

Manor Comments/Questions	*Answers*
How significant is the role of ground water? We must reserve it. Do you have recommendations for preserving the quality of drinking water?	The current capacity of groundwater is sufficient for emergency usage. TWWC will shift water source from groundwater to surface water and then the current capacity will be preserved. As for water quality there is problem of nitrate especially in the South. We make plans to use emergency water tanks for keeping treated surface water where the water quality of well is not good and use well water for other purposes.
How do you think the reliability of your ground motion analysis and damage estimation? Do you have recommendations for further studies?	Ground motion is derived using fault displacement model which is commonly used for strong earthquake anticipation. Therefore results of earthquake motion analysis are quite reliable. Pipelines & facilities database was made on the basis of GIS system so it is relatively accurate and updated.
Why the study did not evaluate damage of the dams for Teheran water supply system?	Dams are very important facilities for water supply system but unfortunately they are not included in our scope of work. However we have evaluated the flexibility of the water supply system when upstream of water treatment plant, which include dams, are damaged.
Nitrates concentration of groundwater will be changed after earthquake. Have you considered this or not?	This is an important issue. In 1995 earthquake in Kobe, water quality changed of river water and dam has changed a lot. Water quality in pipes also can be changed due to change of flow direction. We advised consumer to boil water before drinking. As for nitrate, there might be increase of nitrate concentration in the contaminated area. When we find high nitrate by TWWC Laboratories, treated surface water of good quality shall be supplied from emergency tanks or by water tankers.

How to involve citizens for assistance after earthquake crisis?	We need assistance for emergency water supply from citizens. The work will be simple and require short training. TDMO is now carrying out pilot projects for training citizens on emergency activities under assistance of SDC (Organization of Swiss). It will be useful to coordinate with TDMO for training citizens for emergency water supply.
Please tell us about the roles which other groups such as military force or Red Crescent play.	In Japan there was a rule that military forces could work upon the decision of the prefecture governor. In Kobe military waited 1 to 2 days for the request by the governor before starting their assistance in water supply. It is very important to prepare suitable rules beforehand in order to expedite assistance. The percentage of military involvement for water works was less than 10%, but it was very useful for evacuation or rescue of those trapped. In the Case of Tehran, TDMO explains that we cannot decide the assistance of Military at the moment though we might expect the clearance of road by removing pebbles and cars for securing access to the required sites. We expect Red Crescent for emergency water supply but the involvement will not beso big as cased of Bam and other cities
Hospital wastewater & industrial wastewater might contaminate water. Why no discussion has been made about nano filtration?	We did not recommended the on-site water treatment just after earthquake disaster due to maintenance problem and cost. When water quality is not suitable for drinking, it is better to avoid using it.

What are the lessons we can learn from earthquakes in Japan which might be applicable to Iran and what are the similarities?	Damage and countermeasures in urban area is different from rural areas. As you know Kobe earthquake was an urban disaster, and Bam earthquake was a rural one. Recently we had Nigata rural area earthquake. Lessons learned from Kobe are much different than Nigata area. In Nigata's case, some areas were isolated and we used the helicopter for securing transportation. At every 2 minutes helicopters took persons to disaster stricken area which is much different story. As for Tehran, support from other cities is required. Since the situation might become complicated, efforts of all earthquake disaster organizations should be concentrated in Tehran. It shall be noted that we should not depend on centralized water resources and several water sources shall be kept. Alternative water resources are important to reduce or mitigate water shortage during earthquake.
We have studied and developed new system for emergency stop of chlorine in water treatment plants. Nevertheless our reports have not reached JICA despite our trial on correspondence with TWWC and JICA. How do you think about emergency stop of chlorine?	In our study we prepared 3 step plan for improvement of chlorine dosing system. At first, chlorine cylinder shall be fixed firmly with bolts and then auto stop valves shall be fixed at the outlet of the cylinder. In the 2nd step introduction of neutralization equipment are recommended in our plan. As the 3rd step, it is recommended to convert chlorine gas to calcium hypochlorite. In Japan the conversion has almost finished and most of the water work facilities nowadays use calcium hypochlorite for chlorination.

10.5 Comparison of With & Without Project Alternatives

In comparison with the "With Project" and the "Without Project" alternatives, discussed in the relevant section, following conclusions can be retrieved:

- With the proposed project, initial water supply suspended population could be decreased from 4.0 million to 1.7 million, according to the simulation study discussed in Chapter 8.
- With the proposed project, required time for restoration work for water supply system can be cut down from 82 days to 30 days as discussed in 8.1 of Chapter 8.
- With the proposed project, necessary amount of drinking water (at least 89 L, equivalent to one week consumption per one evacuee) can be reserved after the earthquake disaster as discussed in 8.2 of Chapter 8.

- With the proposed project, secondary disaster such as gas leak from chlorine facility or fire caused by oil leak, which could break out at the locations shown in "Figure 6.3.3 Secondary Disaster Map" can be prevented.

10.6 Conclusion

According to the Iranian local regulation, the proposed project would not require full scale EIA. Further, this project does not need involuntary relocation caused by large-scale land acquisition or exploitation of new water resource. Nevertheless, there are several items which should be taken into account to meet JICA's Social & Environmental Guidelines such as:

- Traffic jam during construction stage
- Waste water during construction stage
- Noise, dust and vibration during construction stage

Above predicted negative impacts are not prolonged and limited in construction stage therefore they can be avoided or mitigated as long as proper consideration would be given and incorporated in design and construction stage. Recommended mitigation measures for possible negative impacts by the implementation of the project are given as *Table 10.4.1*:

Table 10.6.1 Proposed Mitigation Measures

Possible Negative Impacts	*Evaluation*	*Proposed Mitigating / Optimizing Measures*
Impacts on traffic	Negative but temporary and can be minimized	✓ Submission of transport plan for the work by the contractor of civil work ✓ Mutual agreement and coordination with relevant competent department responsible for traffic. ✓ Arrangement of adequate precaution and safety measures ✓ Appropriate repair and reinstatement work
Waste water discharge	Negative but temporary and can be minimized	✓ Special attention to surrounding condtions of construction site. ✓ Consideration of introducing small scale on-site treatment facility with an sedimentation, coagulation and rapid sand filtration treatment unit, when necessary.
Noise, dust and vibration	Negative but temporary and can be minimized	✓ Sprinkling of water to avoid generation of dust ✓ Respect of work hours

By means of implementing the proposed project, following positive impacts are expected:

- Secondary disaster prevention after the earthquake disaster.
- Reservation of necessary amount of drinking water after the earthquake disaster.

- Faster restoration after the earthquake disaster.
- Reduce initial water supply suspended population would be reduced, according to the simulation.

Accordingly, implementation of the proposed project is concluded as follows:

- Implementation of proposed project does not have adverse impact on the existing environment in the Study Area
- Proposed project would contribute to the prevention or mitigation of environmental damage, which would be caused by secondary disaster such as chlorine gas leak or fire case.

CHAPTER 11 EVALUATION OF EARTHQUAKE-RESISTANT PLAN AND RECOMMENDATIONS

A water supply project is normally planned to satisfy increase of water demand and to increase water sales income. On the other hand, the benefit of an earthquake resistant project, which aims at strengthening functions of lifelines, is avoidance of losses and damages caused by the occurrence of the earthquake. Therefore, in evaluation of the earthquake resistant plan, the following factors should be taken into account:

- The earthquake resistant project itself does not increase the amount of water supply, and, as a result, it does not generate any additional cash revenues from users.
- The benefits of the earthquake resistant project are uncertain due to the fact that it depends on the occurrence probability of the earthquake.
- The earthquake resistant project contributes to the national interest through the protection of the capital's lifelines.

The earthquake resistant project hereunder includes not only an earthquake resistant plan for facilities but also emergency water supply and restoration plans.

11.1 Socio-economic Evaluation

Socio-economic effects to be generated by the execution of the earthquake resistant project are as follows:

- Initial water supply interrupted population would decrease by 2.2 million, and emergency restoration period would decrease by approximately 50 days.
- Tehran citizens could have emergency water supply of 3 lpcd right after an earthquake and the amount increases as time goes on,
- Citizen could access drinking water with maximum distance of 1 km and it decreases as time elapses,
- Citizens could have normal water supply conditions within one month after an earthquake,
- Tehran citizens of 98 million man-days could be relieved from water shortage by execution of the earthquake resistant project, and
- Benefit of the project is preliminarily estimated as US$407million.

Economic indicators are analysed on the basis of benefit described above. These are EIRR of 0.5%, B/C of 0.491 and NPV of US$-11,456, all of the values are far below feasibility, reflecting the nature of the project for the scenario earthquake employed with the returen period of about 500 years.

When the return period is assumed to be 200 or 100 years for the purpose of analysis, EIRR increases to 6.67% or 14.57% respectively. In this case, B/C obtained will be 1.138 or 2.457 respectively. These figures are in the feasible range.

11.2 Technical Evaluation

Most of the activities can be done with the local technology. Some technology shall be imported from other countries but they can be maintained with local skills. Therefore, the proposed project can be considered as technically sound. Basic effects of the earthquake resistant project are:

- great decrease of initial water supply interrupted population from 4 million to 1.7 million after the project, and
- great reduction of restoration period of damaged water supply facilities form 82 days to 30 days after the project.

As for emergency water, drinking water of one week after an earthquake is secured at distribution reservoirs, emergency tanks or deep wells. The required quantity of water is estimated as 89 lpcd. Well water of TWWC and parks are planned to be disinfected at water tanks before supply. Treated surface water of good quality is supplied through emergency water tanks to southern part of the city where concentration of nitrate and nitrite in groundwater is rather high and not suitable for drinking especially for infants.

Some deteriorated distribution reservoirs are refurbished and some CIP distribution pipelines will be replaced with DIP with earthquake proof joints. These activities contribute to increased stability of the water supply system, which includes reduction of water leaks and decrease of pipe breakage by high water pressure or water hammer, etc.

11.3 Financial Evaluation

Since investment would not generate an increase of water sales, it is difficult for an earthquake resistant project to be financially feasible. Moreover, the present financial status of TWWC is not always sustainable as shown in *Table 11.1.1*. In case when the earthquake resistant project is implemented by the TWWC expenditure only, the water tariff should undergo an average increase of 5.5% which would not be easy to be agreed by the citizens. When the return period is assumed to be 200 or 100 as mentioned in previous section of Socio-economic Evaluation, the water tariff increase will become less. However even with this level of the tariff increase, it is considered not easy to be agreed by the citizens. In Japan, central government subsidy of 1/4 to 1/3 of the project cost is given to non profit program such as the earthquake resistant project. It is expected that a governmental subsidy should be given to the project for successful implementation. If so the rate of increase of tariff will be lower than the above.

Table 11.1.1 Sustainability Indicator of TWWC

Sustainability Indicators	Description	Current Status	Minimum Requirement	Desirable Level
Staff per 1000 Connections	Total Staff / Number of Connections / 1,000	5.93	5.0 persons	
Working Ratio (WR)	Operational Cost (excluding Depreciation) / Tariff Revenue	125.70	Not Exceeding 100%	70% or Less
Operating Ratio (OR)	Total Operational Cost (including Depreciation) / Tariff Revenue	129.20	Not Exceeding 120%	100% or Less
Collection Ratio (CR)	Amount of Money Collected / Total Value of Billing	90.0	90%	100%

Note: Current status is based on FY 2005 Statement

11.4 Environmental Evaluation

The earthquake resistant project is to reinforce or retrofit the existing water supply system and does not include a new facility construction or expansion of the existing facilities. This is why the project would not require acquisition of a new water source or an additional land area. In addition, reinforcement or retrofitting works for facility structures and equipment are executed within buildings or premises of the facility and the outgoing noise and vibration would be the minimum.

According to the Iranian local regulation, the proposed project would not require full scale EIA. However, there are several items which are better to meet JICA's Social & Environmental Guidelines such as; a) Traffic jam during construction stage, and 2) Noise, dust and vibration during construction stage. The above negative impacts predicted are not prolonged but limited in construction stage therefore they can be avoided or mitigated as long as proper consideration is given and incorporated in design and construction stage. Recommendation of mitigation measures for possible negative impacts by the implementation of the project are given as *Table 11.1.2*.

Table 11.1.2 Proposed Mitigation Measures

Possible Negative Impacts	*Evaluation*	*Proposed Mitigating / Optimizing Measures*
Impacts on traffic	Negative but temporary and can be minimized	✓ Submission of transport plan for the work by the contractor of civil work ✓ Mutual agreement and coordination with relevant competent department responsible for traffic. ✓ Arrangement of adequate precaution and safety measures ✓ Appropriate repair and reinstatement work
Noise, dust and vibration	Negative but temporary and can be minimized	✓ Sprinkling of water to avoid generation of dust ✓ Observance of work hours

On the other hand, the project naturally has various positive impacts on environmental aspects such as:

- aquisition of no additional water source or land area, and
- reduction of secondary disasters including chlorine gas leakage and fire by oil leaking,

in addition to the impacts described in the above socio-economic and technical evaluations.

11.5 Comprehensive Evaluation

The project formulated by this study can be judged as adequate for execution because of following: Big benefits can be obtained by decrease of water supply interrupted population and restoration period. Effects on environment are small. Since the total project cost is not huge, economic and financial feasibility can satisfy thee cut-off level when the return period is considered as 200 years, even though the project does not increase water sales.

It is of vital importance to protect the citizens from an earthquake disaster although the probability of its occurrence would be very low. In case of Teheran and its vicinity, 150 years period, which is thought as a return period of large scale earthquakes as described in "Seismic Microzonation Study" report, has already passed after the earthquake with second largest acceleration occurred in 1830.

It is expected for TWWC to be given a considerable portion of governmental subsidy in order to implement the earthquake resistant project satisfactorily.

11.6 Recommendation

Recommendation on the earthquake resistant plan including the plan of emergency countermeasures is summarized as in the followings.

11.6.1 Recommendation on Earthquake Resistant Plan

(1) General

1) Succeeding Work

In order to implement the earthquake resistant project, it is urgently needed to review, study in detail if necessary and design the project. It is expected to give a contract to local consultants for executing work very soon.

The earthquake resistant plan and plan of emergency countermeasures are based on available existing data and/or on-site visual check. Therefore they should be reviewed and examined using further data in detailed design stage.

2) Acquisition of Data

There are several data of facilities and pipelines not in hands of JICA study team. Such data should be obtained or, if no data are available, measurements need to be made at the site in the detailed design stage. These data includes:

- Reinforcement steel bar arrangement of facility structures or buildings,
- Drawings and design data of connecting points between pipelines and facility structures for identification of their reinforcement means,
- Sizes and locations of old "Qanat" or other structures.

3) Preparation of Master Plan of Water Supply System

Such large scale measures as to install big connecting transmission mains, sodium hypochlorite disinfection system, etc. will be studied and implemented in the future for further aseismicity of the water supply system. A master plan of the water supply system to meet future water demand should be prepared. It is expected for the aforementioned measures to be incorporated in the master plan for sound operation of Tehran water supply management.

4) Hydraulic Isolation of Reservoir Zones

Served area of Tehran water supply system is divided into numerous reservoir zones for even distribution of water. Some reservoir zones are hydraulically isolated but others are not yet isolated for flexibility water distribution. The new telemetry system, which is designed for flow and pressure measurements in every zone, is about to be put into operation. Water distribution in each reservoir zone is to be monitored for effective operation. Hydraulic isolation of each reservoir zone should be made to realize the advanced monitored operation of water distribution.

(2) Seismic Data

1) Fault location

Finding the existing fault locations and probabilities of movement including secondary faults are necessary. It must be specified by the upper depth of fault whether the fault surface is exposed or not. Exposed fault affects directly the above ground structures. Mosha and North Tehran faults are examples of this type. Other faults such as North Ray, South Ray, Parchin and Kahrizak are not the exposed ones. By obtaining the exact fault locations, countermeasures for strengthening the facilities or pipelines should be further studied.

2) Land Slide / Land collapse Caused by Shaking

Possibility of such hazard as land slide or land collapse should be studied. If these hazards occur, there is no alternative other than rerouting of pipelines. Land slide or collapse might occur in northern area.

(3) Pipe Material requirement

Robust Pipe shall be used. This means pipes with strong joints. Use of weld steel pipes for large diameter line, ductile iron pipe with detach-resistant joints for medium size pipes and polyethylene pipe with electro fusion bond joint for small diameter pipes are recommended. Even in hazardous conditions, serious damages can be avoided using these pipes.

(4) Construction procedures

Quality control is quite important for satisfying quake-resistant pipelines. This means good joining procedures should be prepared. Corrosion control and installation procedures are also important.

11.6.2 Emergency Countermeasures

(1) Locations for Emergency Water Supply Basis

TWWC plans to construct 17 distribution reservoirs in the future. According to the progress of construction, the amount of water secured in earthquake disaster increases, and the increase will affect the installation of the other emergency water basis. It is desirable to formulate future stepwise construction plan of distribution reservoirs and to fix implementation plan for emergency water supply basis.

(2) Groundwater

1) Deep Well in Parks

With respect to the use of deep wells in parks for emergency water supply, RTWO, which is competent organization for licensing and exploitation of deep well, has an opinion that there would be no constrain in using deep well in park for emergency supply purpose. Nevertheless, TWWC side should have opportunities to explain the concept of emergency supply to the owner of deep wells in parks (i.e., municipality), in order to agree with the use of wells for emergency purpose.

2) Monitoring of Groundwater Quality

TWWC should regularly monitor water quality of every deep well, which is used as emergency supply bases. TWWC conducts regular monitoring for its wells but wells in park to be used for emergency purpose should be also monitored. At least toxic items (such as heavy metals, toxic organic substances, nitrate & nitrite) should be listed up for regular monitoring program.

11.6.3 Emergency Water Supply and Restoration Activity

(1) Cooperation with Other Organization

1) TDMO

TWWC should ask TDMO for arrangement of emergency water supply assistance with the municipality or citizens in periodical meetings.

2) Other water Company

Previous discussion and mutual arrangement with other water companies in other provinces on emergency assistance should be made. It is important to confirm availability of manpower and materials with other water companies. The requirements for receiving assistance from other water companies should also be provided.

3) Private Company

Preparation of list of private companies who have heavy vehicles or water tanker should be made. It is also necessary to coordinate for emergency assistance with private sector who has required material and equipment. Training shall be given to private companies on pipe restoration and use of them in ordinary time.

(2) Role and Duty

1) Role and Duty of TWWC Organization

Decision on the detailed roles / duties of each division in crisis management organization of TWWC is necessary. The basic idea is recommended in the report. After the decision of duties is made, it is important to make all the staff understood. The decision should be revised and improved after several discussion and maneuver / training.

2) Rules for Emergency Gathering

Preparation of rules for emergency gathering of staff as recommended in Chapter 8 shall be made in early stage.

3) Training on Emergency Supply Base

Training on usage of emergency water supply bases should be made periodically. It is important for TWWC staff to be accustomed to checking water quality, chlorination, and cooperating with assistants from other organizations or residents.

CHAPTER 12 TECHNICAL ASSISTANCE FOR REDUCTION OF NON REVENUE WATER (NRW)

12.1 Definition of NRW and Related Technical Terms

It is observed that TWWC does not necessarily have clear definitions of the terms relevant to NRW at the moment. However different usage or understanding of the terminology will lead to misunderstanding of the current situation and failure in finding tactics for reduction of NRW. It is essential that the relevant terms are clearly defined and all of the staffs use common terminology for the same meaning.

This section will discuss the definitions of NRW applicable to the Tehran water supply system considering internationally recommended definitions.

12.1.1 NRW by TWWC

NRW has lowered from 46.8% to 27.5% in the past ten tears according to information from TWWC. This "NRW" ratio was defined as follows:

(1 – Billed water / Raw water taken for water supply) x 100%

This figure of NRW includes water losses from raw water transmission and water treatment facilities, in addition to clear water transmission and distribution facilities. This definition of NRW is different from what NRW refers to in other countries. Therefore it becomes difficult to compare the figure and situation with the other countries.

Treatment loss of surface water is generally 3 to 10% of the water production while losses of groundwater are negligible in many cases. When water losses before and after water treatment are considered separately, it will become easier to find the causes/components of water losses.

It is also observed that NRW of TWWC sometimes excludes raw water treatment loss and water treatment loss. As for Unaccounted-for water (UFW), the word is used in several ways.

12.1.2 NRW Internationally Accepted

Table 12.1.1 shows the definition of NRW components prepared by International Water Association (IWA), which is internationally accepted. NRW ratio is defined as follow:

(1- Billed water / System Input Volume*) x 100%

*: Production or clear water transmission / distribution Volume

In this case, water losses in raw water transmission system and water treatment facilities should be

considered independently.

Table 12.1.1 Definition of Non Revenue Water Components by IWA

<table>
<tr><td rowspan="8">System Input Volume (Production/ Distribution Volume)</td><td rowspan="3">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Non-metered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption (water used for fire fighting, etc)</td><td rowspan="6">Non-Revenue Water （NRW）</td></tr>
<tr><td>Unbilled Non-metered Consumption (free water distributed at standpipes)</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Losses (Non-technical or Commercial Losses)</td><td>Unauthorized Consumption (illegal use and connections)</td></tr>
<tr><td>Metering Inaccuracies
- No meters
- Meters not working
- Meters not recording accurately
- Meters misread</td></tr>
<tr><td rowspan="3">Real Losses (Technical Losses)</td><td>Leakage from Transmission and/or Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility’s Storage Tanks</td></tr>
<tr><td>Leakagefrom Service Connecting pipes up to Customers’ Meters</td></tr>
</table>

Source: IWA (International Water Association)

NRW is composed of unbilled authorized consumption, unauthorized consumption, metering inaccuracy and leakage.

12.1.3 Recommended Definition of Terminology

If TWWC has common understanding on the term of NRW, it will not be necessary to change the terminology since changing will cause confusion. However it is not the case in TWWC at present.

It is recommended to define the terminology clearly and make it understood by all the staff. The terminology defined by IWA will be recommended for TWWC to use because it is internationally accepted and it becomes easier to compare the figures/conditions with other various cities in the world.

When the above definition is applied, the NWW can be said to be lowered from 44.5% to 23.7% in the past ten tears.

As for the losses other than NRW, i.e. the losses which occur at the upstream of water treatment plant, the following terminology is recommended:

- Raw Water Transmission Loss: The water losses, which happen between the intakes and the water treatment plants (or chlorination basins in the case of groundwater).
- Water Treatment Loss: The water losses during water treatment process, which should be calculated by the difference of water inflow and outflow of the water treatment plants.

There are several definitions on "Unaccounted for Water" (UFW) and it is better not to use the term to avoid confusion.

12.2 Composition of Water Losses and Their Measurement

12.2.1 Raw Water Transmission Loss

At present raw water transmission loss is assumed but not measured.

In order to know the raw water transmission loss, water flow should be measured at raw water intake and groundwater pumping and then they should be compared by the measurement of the raw water flow at inlet of water treatment plant and chlorine contact tank or reservoirs. However groundwater is not measured at present.

The current situation and requirement for raw water transmission loss is summarized as in the following:

(1) Unbilled Authorized Withdrawal

Water volume of unbilled authorized withdrawal of raw water is estimated to be 73,349 m^3/day, which is about 3% of total raw water in 2004 while it is not measured at present. Water should be measured by installing flow meters and efforts should be made to change it to billed consumption since TWWC is paying for raw water. Even if it is not billed, still it is important to measure the actual amount of loss to know losses of water and money and to encourage water conservation.

(2) Unauthorized Withdrawal

The amount is not considered at the moment. If unauthorized withdrawal of raw water is found, penalty should be imposed and the withdrawal should be legalized. Previous announcement / warning are required for applying the penalty.

(3) Meter Inaccuracies

Parshalll flume flow-meters are used at the inlet of raw water transmission and inlet of water treatment plants. However meters are not installed at groundwater pumping points and reservoirs and the amount of groundwater usage is only estimated. The actual loss of raw water should be measured and monitored after introduction of SCADA system.

(3) Leakage in the pipes

Leakage volume in raw water transmission line should be measured and monitored. If any abnormality is found by the monitoring, the reason should be investigated since it might be the sign of accidents

occurrence. When it is due to accidents, quick response is required to find the type/location and repair them. If the water loss in pipes is not negligible, reinforcement of patrol and leak detection or pipe replacement should be implemented.

12.2.2 Water Treatment Loss

Water treatment loss is also estimated but not measured at present beacuse meters are insufficient at the outlet of treatment plants. Water loss in each water treatment plant is estimated as follow:

Table 12.2.1 Water Treatment Loss

Year	WTP No.1	WTP No.2	WTP No.3&4	WTP No.5	Total
1998	0.12%	0.11%	0.02%		0.07%
1999	0.05%	0.06%	0.04%	0.00%	0.05%
2000	0.06%	0.07%	0.07%	0.00%	0.06%
2001	0.07%	0.05%	0.10%	0.00%	0.07%
2002	0.06%	0.10%	0.33%	0.00%	0.19%
2003	0.08%	0.69%	1.43%	0.00%	0.94%
2004	0.14%	2.77%	3.58%	10.69%	3.48%

Data source: TWWC

The average estimated figures are ranging from 0.05% to 3.5% in these 7 years and they seem to be very small. The figures needs to be confirmed by measurement and comparison of raw water inflow to each treatment plant and distributed water from the plant. By knowing the actual loss from each water treatment plant, required actions should be studied.

If treatment loss is large, required actions to be considered will include following:

- Revision of filter backwash frequency/method
- Revision of drainage of pre-sedimentation basin and clarifiers (timing, method)
- Return of waste water to inlet canal (after treatment)

12.2.3 Non Revenue Water (NRW)

NRW cannot be measured at present because of insufficient installation of meters for treated water and ground water. The current situation of each component of NRW is summarized below.

(1) Unbilled Authorized Consumption:

Unbilled authorized consumption will be water for pipe flushing for removal of debris after accidents, fire fighting, and water supply to special facilities such as parks, schools and army.

It is essential to know the water volume of unbilled authorized consumption to find its impact, in order to control it or ask water conservation. However TWWC does not have reliable figures for the consumption at present and it is difficult to take actions on this component.

Consumer meters are expected to be installed for measuring consumption of unbilled authorized consumers after listing up the major consumers. Water volume for pipe flushing and other works should be estimated if it is difficult to measure by flow meters.

It is noted as reference that water usage at parks and other public / government places are generally measured and charged in Japan Therefore unbilled authorized consumption in recent years is 3.0 to 3.3% in average.

(2) Unauthorized consumption:

Number of illegal connections found in recent years is summarized below:

Table 12.2.2 Number of Illegal Connections

Year	FY 2002	FY 2003	FY 2004	FY 2005 (up to July)
Identified	1620	972	877	1,067
Disconnected	940	306	291	138
Legalized	950	193	154	94

Data source : TWWC

Unauthorized connections have been identified through public reports, meter readers as well as repeated auditing of consumers' properties.

It is very important to continue the effort for finding illegal connections and for legalizing them and to keep records to estimate lost volume as unauthorized consumption, even though it is negligible comparing with total number of house connection, which is 899,725 as of January 2006.

(3) Metering inaccuracy:

Inaccuracy of consumer meters and errors of meter reading will increase NRW. Regular replacement of meters and education / supervision of meter readers are required. The amount of meter inaccuracy cannot be measured directly but it can be estimated by comparison of NRW before and after replacement of meters in some area, or other methods.

By understanding the importance of this issue TWWC has started periodical replacement of consumer

meters of Class C and 673,000 meters were replaced between 2000 and 2004. Since useful life expectancy of meters is considered to be ranging from 5 to 7 years in Tehran, TWWC has a plan to replace all the consumer meters every 6 to 7 years for decreasing NRW.

(4) Leakage:

Table 12.2.3 summarizes the number of accidents in distribution network attended by each district office in fiscal year 2004 and fringe information. It is found that such a large number as 433 accidents were attended by TWWC every day in 2004.

Table 12.2.3 Accidents in distribution network attended by TWWC (FY 2004)

	Water District 1	Water District 2	Water District 3	Water District 4	Water District 5	Water District 6	Total
Number of connections	105,279	160,829	92,000	180,000	160,000	184,000	882,108
Length of distribution(km)	1,674	1,450	1,100	1,224	1,125	1,330	7,903
Average Daily accident	69.0	84.0	42.0	78.0	81.7	78.0	432.7
Branches	–	–	19.0	63.0	78.5	72.0	232.5
Network	–	–	1.0	6.0	1.2	2.2	10.4
valves,Fittings	–	–	1.4	9.0	2.0	3.6	16.0
Accuident per unit (nos/km/yr)	15.0	21.1	13.9	23.3	26.5	21.4	20.0
Branches (nos/1000nos/yr)	–	–	75	128	179	143	138
Network (nos/km/yr)	–	–	0.3	1.8	0.4	0.6	0.8
Valves,Fittings (nos/km/yr)	–	–	0.5	2.7	0.6	1.0	1.2

Data source: TWWC

Location of accidents are calculated from available data and presented in *Figure 12.2.1*, while such data for water district 1 and 2 are not available.

Majority of leakages (about 89.8%) were found in House Connections. The volume of water leakage is neither measured nor estimated at the sites and reliable figures for leakage volume are not available at present. In order to understand the seriousness of problem clearly, leakage volume should be measured or estimated when leaks are found and recorded after repair.

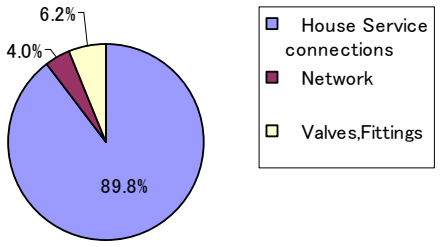


Figure 12.2.1

Location of Accidents in FY 2004

Accidents in Transmission Mains are shown in *Table 12.2.4*.

Table 12.2.4 Accidents in Transmission Main

Fiscal Year	Leak Cases	Fiscal Year	Leak Cases
1996	5	2001	4
1997	5	2002	7
1998	3	2003	8
1999	4	2004	10
2000	5		

12.3 Activities of TWWC for NRW Reduction

12.3.1 Organization

Operation & maintenance of raw water and clear water transmission mains are the responsibilities of head office and three repair teams in Department of Production & Distribution of Water Affairs at TWWC are working on them.

Neither the monitoring of water flow rate, checking of pipe conditions nor leak detection works is executed by any plans for the transmission mains at present. Division of Consumption and NRW affairs Management handles NRW in distribution networks and physical daily operation while maintenance on distribution system is executed by six of O/M district offices. The above two divisions are under Operation Department, and six O/M district offices are directly under Managing Director as shown in the figure of the organization chart of TWWC in Chapter 2. Location of six district offices is shown in *Figure 12.3.1*. Division of Consumption and NRW affairs Management is the section to collect data regarding to non revenue water and give directions to six district offices when it is necessary. Even though the divisions pay great efforts, it is not easy to obtain sufficient and concrete data smoothly.

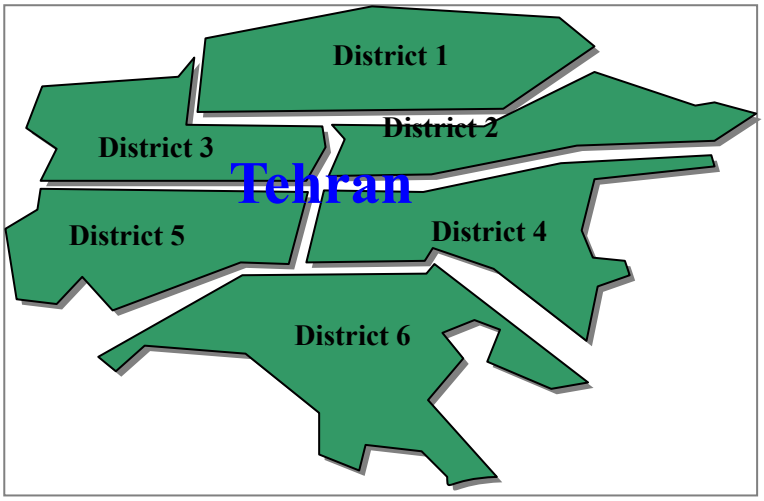


Figure 12.3.1 Location of District Office

Each district office has two to four emergency posts, which collect information of accidents, execute leakage survey and repair. The Organization Chart of Emergency Posts is shown in the figure in Section 7.1.

There are totally eighteen emergency posts in Teheran. Three emergency repair groups in average execute 24 hour service in shifts in each emergency post. Each group forms 2 to 4 teams for leak repair with 2 operators, who receive information of accidents by radio or telephone. In addition, information of accidents also comes from “Call 122” in public communication center.

It should be noted that the activities, which require for additional cost, are decided in the head office but not at the district offices and it sometimes takes a long time to realize the improving methods of operation and maintenance including reduction of none revenue water.

A Regular discussion among the head office and district offices has started recently for the improvement of operation and maintenance. The effort to hold discussions should be continued and expanded to exchange the information and ideas for improvement of operation and maintenance works, which would also include NRW reduction.

12.3.2 Leak Detection and Repair Works

As far as JICA study team concerns, the equipments are manipulated appropriately and leak detection works are executed in a proper way while the staffs at site face difficulties for finding leakage in PVC and polyethylene pipes.

Leakage teams are executing leakage detection by using leakage corelators and other tools as shown in *Table 12.3.1*.

Table 12.3.1 List of Leak Detection Equipment in Each O/M District

Item	District 1	District 2	District 3	District 4	District 5	District 6	total
Leak Noise Logger	1	1	1	1	1	1	6
Globe Geophone	2	2	2	2	2	2	12
Leakage Detector	1	1	1	1	1	1	6
Correlator	2	2	2	2	2	2	12
Metal Detector	5	1	4	4	6	4	24
Pipe Locator	2		1	1			4
Pressure Gauge	3		2				5

It is generally said that staff has sufficient number of equipment and materials at the present.

However serious problem is that it takes time to calibrate or repair tools & equipment and there are requests for introduction of new tools. Introduction of cars equipped with leak repair tools such as pipe cutter is worth consideration for expediting repair works

Leak repair works are generally executed in good ways. There might be no problem in technical skills, while it was noticed that the sites were sometimes not cleaned properly for the repair works. In such cases, screws and other parts to be installed got dirty and disturbed appropriate repair works. Continuous steady work attitude will be requested from the staffs at sites.

In addition, operation and maintenance staffs pointed out that quality of materials and tools are not always appropriate due to insufficient quality control for procurement. It will be required to review procurement procedure together with specification and standard periodically.

12.3.3 NRW Reduction Efforts

Non Revenue Water (NRW) has been significantly decreased in these 10 years in Tehran water supply

system. The approach of NRW reduction taken by TWWC is considered as appropriate and should be appreciated, while reliability of the data might not be so high. The major efforts taken by TWWC for the reduction of water losses are summarized below.

(1) Replacement of Consumer meters

As described in the previous section, TWWC has replaced about 80 % of the total consumer meters in Tehran and is executing periodical replacement.

(2) Control of Water Pressure

By acknowledging the importance, TWWC put great efforts on controlling water supply pressure. The major activities are installation of pressure reducing valves. Plans for zoning are also prepared to isolate each water supply zone with sluice valve. Number of pressure reducing valves installed at each district is reported as shown in the table below.

Table 12.3.2 Number of Pressure Reduce Valves in each District

District 1	District 2	District 3	District 4	District 5	District 6	Total
257	74	61	60	27	43	522

(3) Replacement of old pipes

TWWC is replacing old pipes and problematic pipes. About 505 km of pipes are replaced in the last 9 years.

(4) Leak Detection and Quick repair

Table 12.3.3 Leakage Detection in each District

(FY 2004)

Item / District	Distance of Leak Detection (km)	Number of Detected Leakage		
		connection	netwrok	total
District 1	292.0	20	35	55
District 2	812.0	240	256	496
District 3	501.0	73	75	148
District 4	579.2	188	117	305
District 5	323.1	55	89	144
District 6	695.8	166	139	305
Total	3,203.1	742	711	1453
		51.1%	48.9%	100.0%

About 3.2 km of distribution pipes were detected in fiscal year 2004. In the recent five years (from FY 1999 to FY 2004), leakage detection has bee conducted along 1,2809.7 meters of distribution pipeline, which is more than 1.5 times of the total distribution length.

Repair teams in each emergency post are in service for 24 hours a day and attend repair without delay.

12.4 Recommendation on Methods for Further Reduction of NRW and Other Losses

NRW and other water losses have been drastically decreased. It will become difficult to reduce NRW further at the same pace with the same efforts. After achievement of this low level of water losses, it will require much more efforts and costs for further reduction while benefit from leakage losses increased a little. The idea of relation between leakage volume and required cost for leakage reduction is shown in

Figure 12.4.1.

Recurrence of leaks also becomes a serious factor of NRW at this level. (Refer to *Figure 12.4.2*)

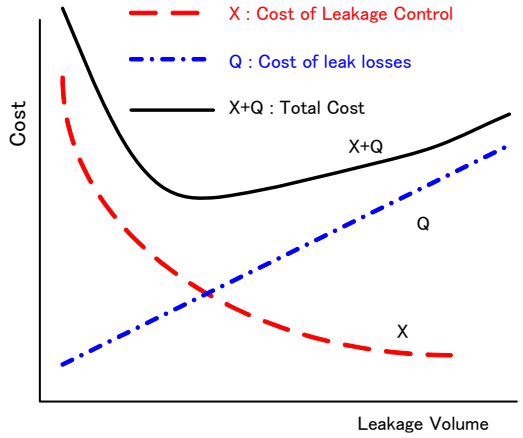


Figure 12.4.1 Cost of Leakage Losses and Leakage Control

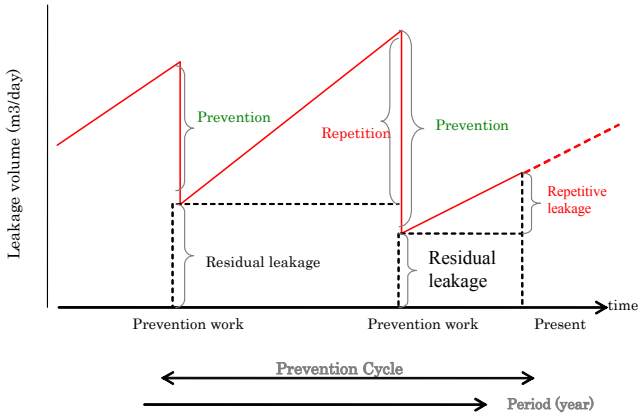


Figure 12.4.2 Recurrence of Leakage

For improvement of the works with limited budget and workforces, “Selection of Priority” becomes much important to reduce NRW in effective ways. “Selection of Priority” includes selection of priority activities, selection of priority area to be surveyed, and selection of priority pipes to be replaced.

After selection of priority area, leak detection should be done in systematic ways. An example of flow chart of systematic leak detection is shown in *Figure 12.4.3.*

Example of Allowable Level:
Paved Road 20 m3/day/km,
Unpaved Road 5 m3/day/km

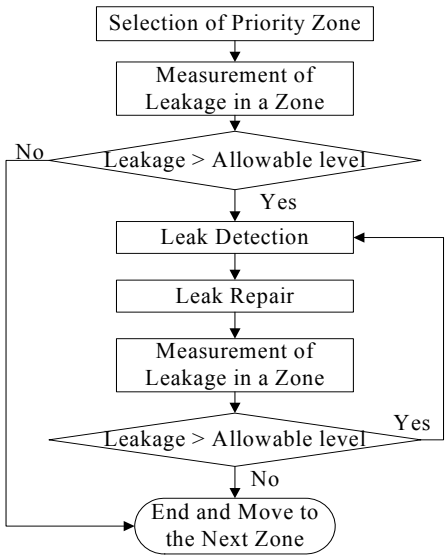


Figure 12.4.3 Example of Systematic Leak Survey

The table 12.4.1 summarizes the list of recommended methods for further reduction of NRW and other water losses and the explanation of the items follow.

Table 12.4 1 List of Recommended Methods for Further Reduction of NRW and Other Losses

1.	Measurement and Monitoring of Flow Rate
2.	Analysis of factor and causes of NRW and other losses
3.	Hydraulic Isolation of Each Zone
4.	Data Collection and Usage
5.	Discussions for improvement
6.	Improvement of Motivation
7.	Public Relation Activities
8.	Others

(1) Measurement and Monitoring of Flow Rate

Flow meters should be installed or repaired in several locations and monitoring of flow rates should start to know the water balance, problems like leakage, and priorities.

Table 12.4.2 Recommended Location for New Flow Meters to Be Installed

	Location	Inclusion in on-going projects for SCADA system
1	All of the outlet pipes of WTP	Included
2	All of the deep wells or group of deep wells or their chlorine tanks	Included
3	All of the Inlet and Outlet of Distribution Reservoirs	Included
4	All the branches from feeder main (Inlet to each zone)	Not included
5	All of the withdrawals of raw water (billed/unbilled)	Not included
6	All of the consumers including authorized unbilled consumers	Not included

After measurement by the above flow meters and monitoring of flow rate, TWWC can find the actual figures of water production volume together with the amount of water loss from raw water transmission, treatment plant, treated water transmission, reservoirs, and distribution pipes. It will contribute to finding the priority facilities to be repaired or improved.

Monitoring of each flow rate is very useful / important to find problems in each system and occurrence of accidents. Minimum night flow (refer to *Figure 12.4.4*) into each distribution zone will give an idea of leakage volume in each zone and its monitoring will show abnormality such as the accidents of pipes. The information is useful for selection of priority zones for leak detection.

Priority of locations for meter installation should be determined considering the amount of water losses.

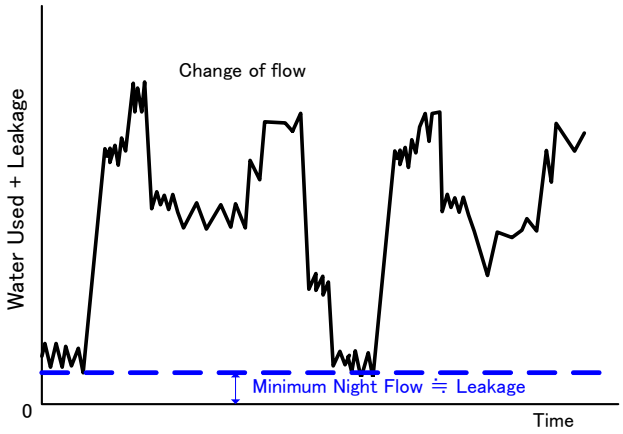


Figure 12.4.4 Minimum Night Flow (Monitoring)

(2) Analysis of factors / causes of NRW and Other Losses

The common understanding of the terminology is indispensable to avoid confusion and to consider the tactics concerned with reduction of water losses.

According to IWA category, NRW is composed of "Unbilled Authorized Consumption", "Illegal Connection", "Meter Error", "Leakage at transfer/distribution mains", "Leakage/overflow from storage tanks", and "Leakage from service connections".

It is required to find the water loss volume of each NRW factor by measuring water flow rate and by estimating leakage volume. The same procedure should be applied to find other water losses from raw water transmission mains and water treatment. The loss volume and analysis on the causes will contribute to finding the priority factors to be improved and priority measures to be taken. Even though the majority of leakages occur at service connections, its volume is not measured / estimated. The effectiveness of replacement of service connections for NRW reduction could be known by finding out the volume of relevant water losses.

Periodical analysis of the amount or ratio of each loss will also give ideas on the effectiveness of efforts.

(3) Hydraulic Isolation of each Zone

TWWC is preparing a plan to divide distribution area into several supply zones and to isolate them in order to control water pressure. However they are not hydraulically isolated in a proper manner at present. Pressure control valves are installed to control water pressure and they do not always satisfy the target of pressure control. Sufficient water pressure will not be reduced by pressure reducing valves when pressure is high due to less water consumption, especially at night. Auto-valves are good instruments to keep water pressure at a target level while maintenance is not easy due to clogging of debris.

Considering the above, hydraulic isolation of each zone is the most appropriate method to control water pressure in distribution area. It is strongly recommended to isolate all the zones hydraulically.

The zoning of distribution area will not only contribute to pressure control but also to

- monitoring flow rate to find priority zones (minimum night flow or comparison of inflow data and billed data),

as well as

- limitation of damage and quick recovery after earthquake disaster.

It is also important to set targets of minimum pressure and maximum pressure since they are not widely understood.

(4) Data Collection and Usage

It is useful to report accidents and compile data for the study of problems. By analyzing the complied data, causes of NRW and its reduction methods can be found.

The required data for reduction of water losses, collection methods, and data usage are discussed below.

1) Introduction of uniform data base system

Building of database for issues of leakage, accident and repair has started by each District Office. However each District Office has different data base and it is difficult to integrate them into one system. Uniform data system is recommended to be prepared taking into account the purpose of data collection and the methods of usage.

Department of Water Production & Distribution Affairs in the head office will be required to play a key role for the preparation after discussion with district offices.

2) Leakage data to be colleted /assumed

Information of leakage will be useful to find priority activities and then to prepare a reduction plan. Following data should be measured or assumed for each leakage.

- Time for attending after information and repair
- Detailed conditions of leakage
- Attribution of accidents (Natural or artificial)
- Assumption of leak volume

The other required data should be decided after discussion of data usage

3) Preparation of leakage maps

While TWWC has already acknowledged the importance of leakage maps, they have not been prepared yet. It is important to set up rules for preparation of leakage maps. The recommended method is that all the repair teams should mark the leakages on pipe network drawings (Scale 1/2,000) whenever they are repaired. Leakage on pipe networks and service connections should be identified by using color pencil. The results of leakage survey should be marked in the same way.

The leakage maps will become useful to find priorities such as problematic pipelines and areas.

4) Updating of distribution pipe network drawings

It is difficult and requires huge expenditure to update all the information of distribution pipe network at one time. The most simple and effective way to start is to collect information from current / previous operation staffs, and then to update the information at site whenever the difference in drawings is noticed through daily activities such as operation and repair works.

Pipe network drawings must show the location, pipe material, diameter, and installation year. The location of pipe appurtenances such as sluice valves and air valves should also be marked. While it sometimes becomes difficult to find the location of these valves after re-pavement, usage of pipeline drawings and metal detectors will be helpful to find them.

5) Data compiling

Data should be monitored and used at each emergency post and district office. After collection, each district office should transfer the data to the head office periodically and then the head office should compile them for the purposes of analysis and finding priorities. The results of analysis should be announced at least every 3 months for understanding the problems and prompt actions to be taken.

6) Utilization of Data

After collection and compiling, data should be used in several ways. The usage of data, in other words the purpose of data collection, should be discussed and understood by all the staff to be aware of its importance.

The major usage of data or data collection will be as follows:

- Finding or confirmation of problems, such as inaccurate meters, weak service connections, poor work quality of contractors and plumbers.
- Understanding of problematic routes and areas.
- Selection of priority route/area for leakage survey
- Selection of priority route/area for countermeasures, such as pressure control and
- Replacement of distribution pipes/service connections.
- Selection of appropriate pipe materials
- Selection of preventative countermeasures

Announcement of compiled data and the results of data analysis will also contribute to improvement of motivation for proper construction and repair works.

(5) Discussion for Improvement

It is generally said that tactics, prepared based on the idea of the sites, will be executed smoothly at sites. For further reduction of NRW and other losses, discussions among the head office and the district offices will be helpful to set realizable target and to find adequate methods for the achievement of the target. It should be noted that this study has found several problems and obstacles together with improvement methods for reduction of NRW and other losses through discussion with TWWC's officials. (Refer to Meeting Memo in Appendix-7.)

Operation and maintenance staffs in the district offices are working hard and doing good jobs. It is required to collect their knowledge on the problems in operation & maintenance, reduction of water losses, and the improvement methods through discussion.

It will be useful to include the following in the discussion items:

- Problems in operation and maintenance for reduction of NRW and other losses
- Settling strategies for the above problems
- Improvement of the water losses reduction methods
- List of useful data for further reduction of NRW and other losses.
- Difficulties in data collection and methods for improvement
- Data usage methods
- Methods of motivation improvement.

It is strongly recommended to collect ideas of operation staffs and then realize the adapted methods as soon as possible.

Procurement and utilization of motorbikes is recommended for avoiding heavy traffic and providing quick response to site. Motorbikes are useful for simple repairs, such as leakage around consumer flow meters, which comprises half of the leakages found. The request for these methods has come from district offices. It will indeed contribute to reduction of water losses if this kind of ideas would be realized in a short period.

(6) Improvement of Motivation

The NRW reduction activities are very tough jobs. This is why the attitude and daily activities of the staff are very important. It will necessitate seeking the methods for keeping the staffs highly motivated no matter the operation staffs are already highly skilled.

Following methods are recommended to consider for improvement of motivation:

- Competition of NRW reduction works
- Training
- Reward and/or punishment after the competition
  (Reward may include commendation, announcement in TWWC through papers, prize, or special holidays.)
- Special allowance (bonuses)
- Promotion
- Implementation of applied ideas from site without delay.

It is really required to consider and find the methods to expedite realizing the ideas.

(7) Public Relation

Consumers understand the importance of water and are willing to inform when they found a leakage.

Figure 12.4.5 shows the method of accident finding. About 99.1% of accidents were attended based on information from consumer and the remaining 0.9 % was found by leak detection in fiscal year 2004.

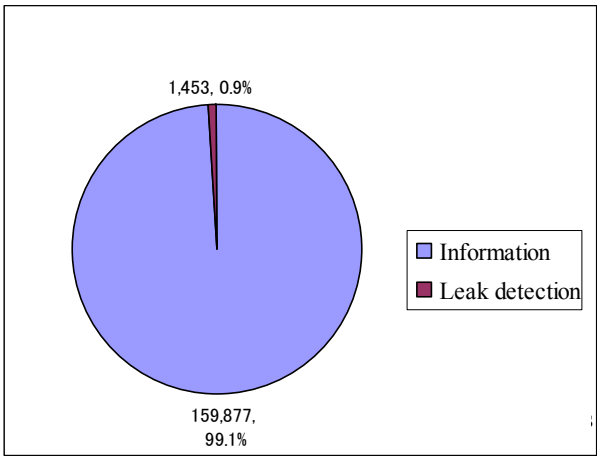


Figure 12.4.5 Method of Accident Finding

Since TWWC is relying on information from the consumers to a certain extent, it is important to encourage consumers' information through public relation activities. At the same time, water conservation should be encouraged through the activities.

Public relation activities are one of the most cost-effective methods for water conservation and water loss reduction, which include water distribution control, leakage prevention, replacing distribution pipes, wastewater reuse, and widespread usage of water conservation equipment.

Just like in Tehran, several public relation activities have been done to raise water-saving mind and to reduce water losses in Japan. These activities are introduced below, which will be worth consideration for reduction of losses and water conservation even in Tehran:

Campaign

- Setting of "Water-saving day"
- Preparation of an example for water saving such as:
- To construct a "People's Dam" by saving water!
- Conducting a poll on citizens who have water-saving minds for information and encouragement of water-saving

Publication (Pamphlet, leaflet, etc.)

- Preparation of leaflet to explain "How to save water"
- Preparation of articles of school textbook

Field trip

- Organization of field trip to water treatment plants
- Preparation of bulletin board about treatment process, water supply system, cost of water and other explanations.
- Presenting samples of filters, pumps, pipes and other devices by making use of the abandoned equipment If possible preparation of scale model is also useful.
- Organization of water schooling for parents and children
- Visiting schools to educate about "water" including water conservation.

Visual aids

- Preparation and presenting posters concerning water saving and others
- Preparation and presenting educational video for schools

Advertisement

- Newspaper, radio, TV, and the Internet
- Advertisement in the water bills

Stakeholder, Community leader and others

- Stakeholder/customer meetings or workshops
- Involvement of community leaders by giving incentives
- Demonstration at community
- Art competition such as drawings and essays by school children

Others

- Citizen's participation programs for volunteers to work for water recharge such as cultivation. By attending the activities, the citizens' knowledge and motivation for water conservation will improve.
- Distribution of water saving plugs among consumers

Since PR activities can be started without waiting for large allocation of budget, discussion and trial introduction of some the above activities are recommended to commence soon.

(8) Other Recommended Items

1) Improved Relation with Meter Readers

Communication with revenue section should be improved since cooperation of meter readers is indispensable for NRW reduction. Meter readers can find important information, such as leakage, illegal connections, problematic material, and poor installation. The strategies for encouragement of prompt reporting from meter readers are also required to be discussed and tried.

2) Quality Control of Material

Periodical review of specification and standard of materials will be required with consideration of the ideas from the operation staffs. It is also useful to review procedure of procurement in order to improve quality control of the material.

3) Continuation of Good Repair Works

It is always necessary to keep clean the repair the sites and prevent both poor quality repair and quick reoccurrence of leaks.

4) Allocation of Budget to District Offices

It is important to consider the rearrangement of budget allocation for smooth execution of improvement methods.

If some additional budget is allocated to district offices and its usage can be decided at district offices, improvement of NRW reduction works will be drastically expedited. The improvement

methods will include “quick repair of tools” and “introduction of motorcycle for quick attendance of simple leakage”.

Discussion among top levels of TWWC head office is recommended because it will be useful for further reduction of NRW and other losses.

CHAPTER 13 ADVISORY SERVICE FOR PUBLIC RELATIONS

13.1 Evaluation on Current State of Public Relations

13.1.1 Organization

In 1970, Tehran Water and Waste Water Authority was moved to a company (TWWC) by total government investment along a flow of deregulation. This means that the superior management, combined with ingenuities and the efficiency of private company, will be expected, in addition to administrative reliability and certainty of business execution. A municipal authority having such a management form like TWWC is widely seen in the world today.

TWWC is positioned as one unit of taking most important administration in municipal government. The municipal government is a regulator and TWWC is a water supply operator.

(1) Joint PR Unit by TPWWC & TWWC and its Separation

The Public Relations & International Department was placed within the TWWC's main office. As to public relations activities, they had been carried out jointly by TPWWC and TWWC.

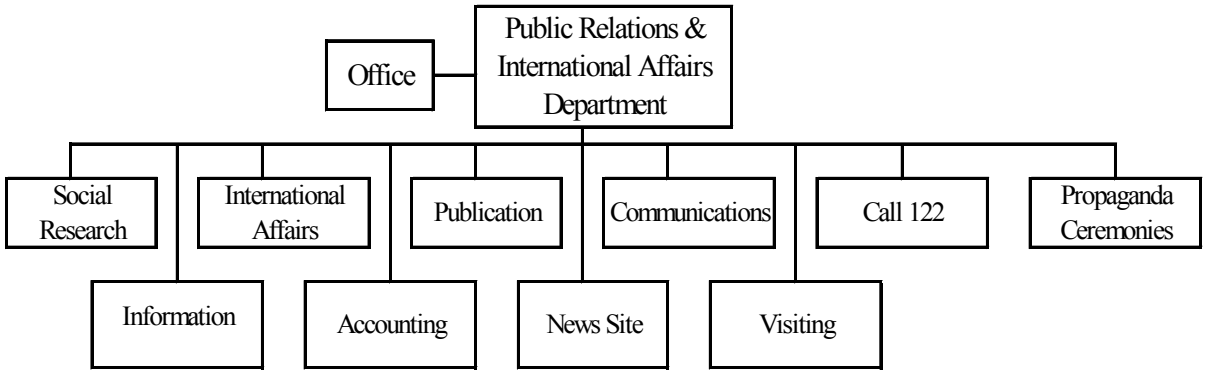


Figure 13.1.1 Organization Chart of PR & International Affairs Department (TWWC)

On July 1, 2004, TWWC was separated from TPWWC as an organization. The individual business that TWWC had processed was transferred one by one. On September 2005, the public relations activities were transferred to TWWC.

(2) TPWWC's PR Activities after Separation

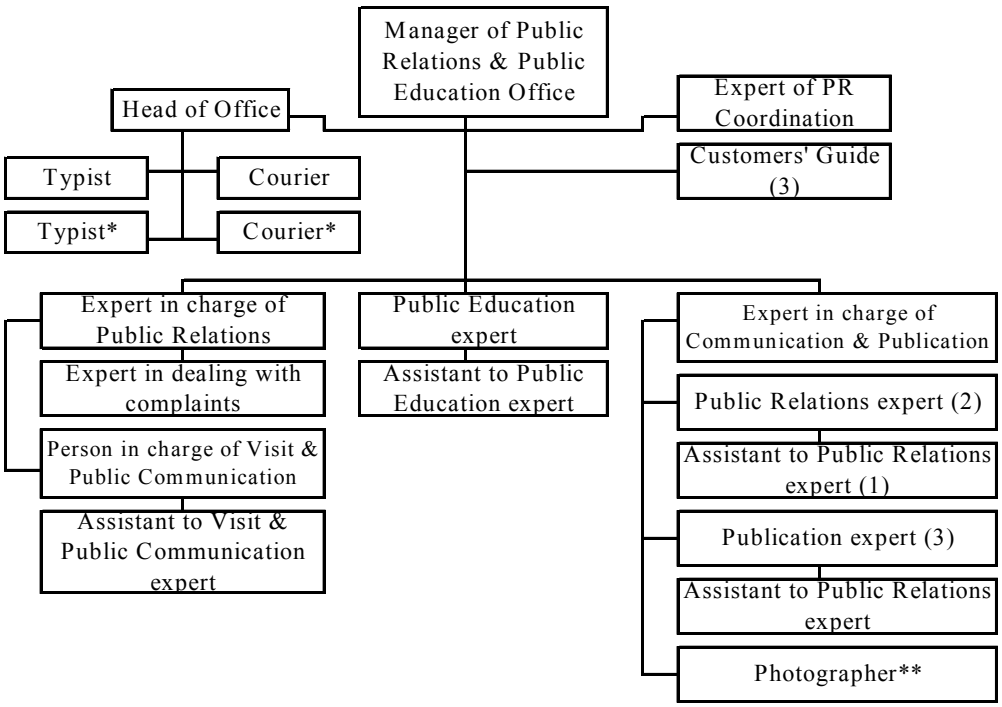
After the separation of PR activities of TPWWC and that of TWWC, the following understanding exists. As headquarters, TPWWC is holding responsibilities such as showing the guidelines and programming and supervision were taken by public relations of TPWWC and execution activities such as activities of propagators of consumption efficiency, visit of facilities and execution of enacted yearly programs etc, were assigned to public relations of TWWC.

At the moment, PR of TPWWC is active in the following sections as required by the headquarters and also takes the responsibility of supervising and programming for the extension public relations. It is necessary to mention that international affairs are only dealt with in headquarters.

1. Mass media relations
2. Survey and polls taking
3. Relations with organizations at large scale
4. Publications
5. Advertising and informing
6. Audio & visual service
7. Electronic relations
8. Exhibitions affairs (at large scale it is upon the headquarters and in the extension companies it is performed under supervision of headquarters)

(3) TWWC's PR Activities

As some of TWWC's public relations activities were separated on September 2005, the organization chart of newly established PR office is as follows. The organization of Call 122 with the staff of 39 went to customer service section and the general staff of 12 were moved from PR & International Affairs Department to TWWC. The total staff of the PR & Public Education Office consists of a manager and 16 staff.



Note:

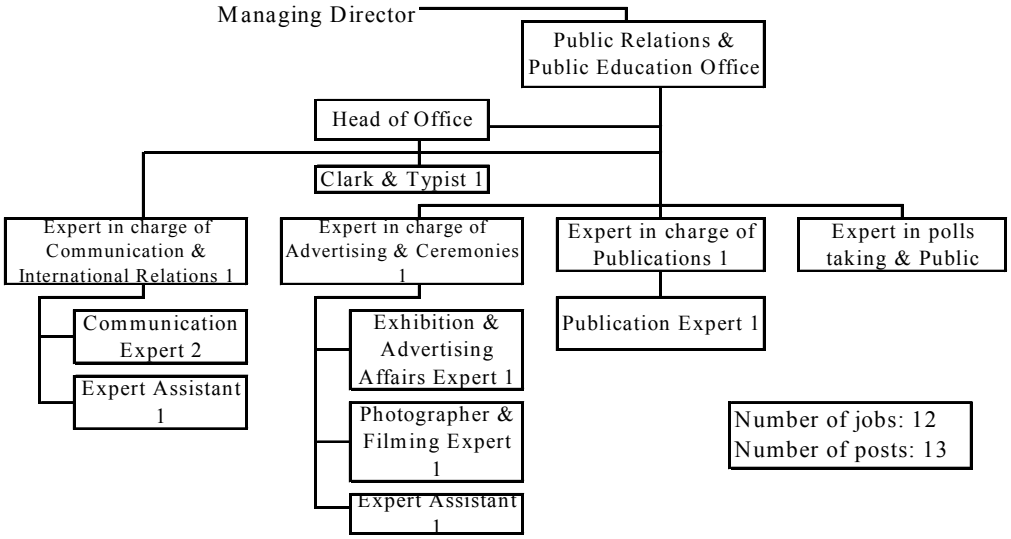
** By the end of the employment of the employees in posts which are marked with one star, these posts will be eliminated.*

*** If an appropriate job field is not determined on the basis of the criteria for payment by the mentioned posts classification, the mentioned jobs will be eliminated.*

Figure 13.1.2 Organization Chart of PR & Public Education Office (TWWC)

(4) Proposed Organization Chart of PR & Public Education Office (TWWC)

Newly started PR & Public Education Office proposed to change the organization chart as follows.



Note:

**Prepared by Institute of Research & Management Training*

Figure 13.1.3 Proposed organization chart of PR & Public Education Office (TWWC)

(5) Proposed Organization Chart of PR & International Affairs Department (TPWWC)

TPWWC's PR & Public Education department proposed to change the organization chart as follows.

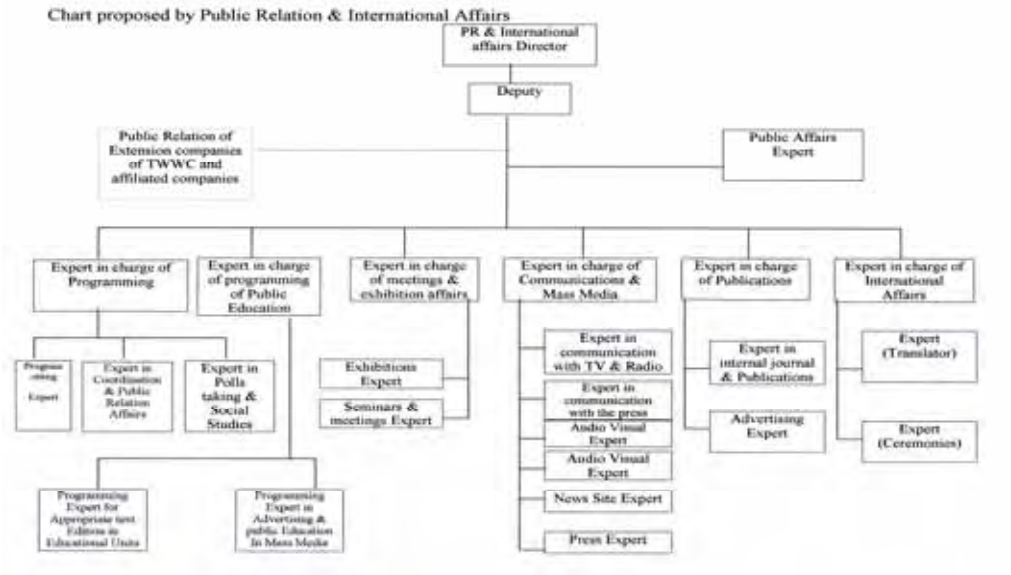


Figure 13.1.4 Proposed Organization Chart of PR & Public Education (TPWWC)

Before 1992, the PR unit was called 'Public Relations & Public Education'. But 1992, the MD of the time changed the name to 'Public relations & International Affairs'. In 2005, the name was changed to 'Public Relations & Public Education' again. With respect to the international activities performance in the public

relation of the province, term ‘international’ must be used in the name of this unit.

One of the eye-catching services of PR activities, Call 122 was transferred to TWWC’s customer service section. There is a pros and cons attitude of the decision, TWWC’s idea is agreeable, because hearing from public is most effective when number of customers complaints will be treated quickly, promptly and utilized to improve the customer related services directly.

The new PR organization's actual performance are few, description of the study on the current situation cannot mainly be referred to but the old organization.

13.1.2 Objectives

It is necessary for water utility to secure full trust and cooperation of the citizens or customers in order to manage water supply which is indispensable for citizen's lives, urban activities and industrial activities adequately. For that purpose, it is necessary to conduct and develop wider publicity works which involve both releasing utility's public information and hearing from the public. In other words, the publicity work plays important roles such as releasing the utility's information, conducting antenna, sight and communication function. The name “international affairs” was first introduced to reflect the recent increase of information exchange and interchange with foreign countries in this field.

13.1.3 Activities

TWWC’s new Public Relations section has shown a few results or performances, therefore the former PR & International Affairs department’s activities are mainly referred hereinafter.

(1) Evaluation of Public Opinion

The department conducts investigation by providing questionnaires for the customers so as to grasp customers’ needs / complaints / general demands of water services run by TWWC. The gathered results will be analyzed, evaluated and delivered to the related sections. The department grasps what is necessary for TWWC to gain customers' satisfaction and to know what is the customers’ demand.

(2) Publication

The department publishes,

- Weekly Journal for employees named 'Colleagues'. The Journal reports TWWC's daily business movement, statistics of the water supply and relevant events to be made known to all staff. The staff share these information and use them for the business.
- Monthly technology Journal named 'The kind aspect of water'
- Water supply related books, pamphlets, chronicles and etc.
- Pishgam Newsletter for school children as a side reader.

The department distributes PR materials, such as printed matters, visuals and etc. to news agencies.

(3) Communication

The department conducts daily and continuous communication with various sections and companies concerned in TWWC, and other organizations outside.

- Inside TWWC:
  Communications within TWWC.
- Outside TWWC:
  mass-medias, Public section, Other groups, Culture center of NGO's, Students and pupils, Ministry of Education, Others

(4) Publicity Ceremony

Various ceremonies to be connected with advertising of TWWC (events) are carried out and promoted positively.

- Exhibition: training, workshop, seminars.
- Exhibition of eminent photographers: Children and young adult art exhibitions on water conservation and water & environment
- Exhibition of skilled calligraphers: 2005/3rd international and 13th domestic art exhibitions

(5) International Affairs

The department handles and supports the increasing information exchange and technology interchanges with foreign countries adequately.

- Journals, overseas books, various investigations
- Support for application and receipt of visa and passport as for personnel interchange.
- Interchange with a foreign country's embassy.
- Interchange with various foreign countries.

Table 13.1.1 Table of Reported & Explored Events 5/2005 Call 122

Event	*Reported*	*Explored*
Cracking of pipe in the street	645	420
Cracking of pipe in the main	617	494
Cracking of meter	278	278
Leakage from meter	437	437
Failure of meter control valve	439	439
Cracking of meter box	126	126
Leakage from meter box	79	20
Cracking of pipe between meter & box	1,281	1,281
Water leakage from line valve	24	17
Leakage from fire hydrant valve	31	23
Municipality water pipe cracking	41	41
Water flow interruption	510	510
Occasional pressure loss	256	256
Water contamination	2	2
Waste water	296	296
Volume meter	0	0
Local water	0	0
Other cases	747	747
Total	*5,809*	*5,387*

(6) Call 122

The public communication center, shortly Call 122, responds a telephone inquiries from the citizens immediately based on the customers' information on-line for 24 hours in 3 shifts. The role of this center is not to send information from TWWC in advance, but to respond to an inquiry or complaint from the citizens immediately to meet citizens' demands and questions and resolve their dissatisfactions.

In 2005, TWWC allocates 40% of the PR department staff to "Call 122". It seems that TWWC takes it for granted that the positive absorption of citizens' voices and demands will be most essential for maintaining a sound management of TWWC.

(7) Information

The section covers all the office's activities related to cultural products.

(8) Accounting

The section conducts the processing of all the financial activities and auditing.

(9) News Site

Because of vast progress in IT, making use of information technology is a must and therefore it is one of the most potential parts of duties.

(10) Visiting

This is one of the most active parts in the office; Annually more than one hundred thousand people who be categorized in groups of students, experts and managers visit the TWWC.

13.2 Suggestion for Better Activities of Public Relations

13.2.1 General Remarks

TWWC's various PR activities seem satisfactory and deserve evaluation compared with those of other overseas water utilities. The public relations basically consist of sending information and hearing from public in both directions called two way communications. Many examples show that the function of public hearing seems insufficient compared with public information, but in case of TWWC, both the activities are well balanced. Rather public hearing is more stressed than sending information, some certain points have gone ahead, and seem to form a positive predisposition of TWWC.

The organization, activities and function of the department are combined together; it is no inferior compared with several examples of the big cities such as Lisbon, Buenos Aires and Tokyo, etc where the JICA expert concerned studied. An expert having good experience and knowledge about public relations was appointed as a manager and various new and innovative ideas were examined and introduced and practiced. This was a superior point for TWWC.

13.2.2 Individual Problem

(1) Positioning of the Public Relations Department

In recent years, there has been a trend which has placed PR department connected to the customer service department by specializing as the customer information department, in spite of the PR department being traditionally placed within a general affairs department of the head office (such as Tokyo water bureau and Tokyo gas co. ltd). It is widely called 'Customer Center'. It is an outcome of water utility's

intention placing emphasis on customer relations more and shifting to public hearing. In other words, it is not relations with public generally, but customers to be emphasized.

These two options have some advantages and disadvantages respectively. The PR department deals with many issues related to not only public sectors but international issues today. If the customer relations is placed aside of traditional PR department, there remains another function.

In addition, the respective emergency posts in 6 districts offices deal with urgent measures for leakage control works for 24 hours with 3 shifts.

It is not necessary to assign telephone operators in each district office. All of the water leakage reports by citizens could be accepted through Call122 and the repair works will be done by the district office through report from Call122. Say that it is limited to the leakage control, several stand-by sections are on duty to meet customers' telephone calls for a whole day. This may be duplication of resources.

(2) Full follow-up for Telephone response

As to telephone responses at Call 122, the contents are classified into events and customer complaints. These data are analyzed and evaluated in detail, and delivered to every section concerned within TWWC on a monthly basis to make the most of them for the improvement of the customer services

Table 13.2.1 Number of Reported & Explored Affairs of Customers

Items	Reported	Explored
Not sending water bill	115	58
Not reading the meter	18	13
failure of meter	106	66
Construction	5	1
Regional pressure loss	91	56
Illegal water	20	5
Illegal charge	1	0
Filling the pool	1	0
Green environment irrigation	5	0
Consumption Customers	53	0
Total	415	199

It is important for a water utility to reply the complaints and inquiries of customers by making phone calls as soon as possible, but they must not be satisfied by this. Hearing from customer's complaints means only a first step of improvement of customer services. A water utility should grasp a common cause and tendency from various complaints and inquiries of customers. By solving the central cause, the outbreak of various complaints and inquiries will be prevented. A water utility should not consider dealing with customers' grievances to be the matter of trouble, rather, it is necessary for a water utility to find important problems hidden to be solved. A water utility should welcome a customer who offers complaints.[1]

[1] In 1966, Tokyo Water Bureau established an organization for an emergency accident corresponding to 24 hours/day called 'Emergency Squad'. At that time, the Emergency Squad was very busy and 20 vehicles with 130 staff in three shifts equipped with water tank, machines & engineering and PR were mobilized everyday and night. Today, however, the staff has decreased to 75 and the organization and staff have reduced with respect to expense/effect. This result shows that Tokyo water has made a continuous effort to expand, reinforce and well maintain the water supply facilities corresponding to various accidents mainly brought by active urban activities ready as a lesson as for water supply, and the emergency accidents decreased and they have to correspond with only unavoidable accident and patrolling today.

13.2.3 Suggestion Comments

(1) The Measurement of Public Relations Effects

It is pointed out that in the most publicity works which are carried out by public organizations, there is a big difference between the effects an addressor's expects and the addressees findouts. It is a task of water utility to know how they can achieve more effective publicity works with limited resources. It is necessary for a public relations department to measure whether the planned effect is achieved by using various resources (such as manpower, money and intellectual resources). It is important for the department to reexamine the activity if the planned effect cannot be achieved. Therefore, for the effective measurement, an appointment of several numbers of monitors is recommended. The department is advised to send questionnaires to the monitors by asking 'Do you know or understand the contents of publicity by the PR department?' In case of a monitor system, a water utility does not wait for complaints and inquiries to come from customers, but it is a technique to ask customers about the problems that a water utility has from the water utility side positively.

(2) Public Relations of Water Supply for Citizens in an Earthquake Disaster

As TWWC has not experienced any big earthquake in Tehran for a long time, a big earthquake may not yet occur for a while. However, the possibility of an earthquake occurrence on tomorrow cannot be denied at all. How does TWWC manage a big earthquake disaster if it occurs today? Does TWWC have enough preparation for it, especially for PR activities? Is there any manual for it? Has TWWC trained the staff how to deal with customers in a disaster?

What are the roles and responsibilities of the central government, provinces and municipal authorities? The local governments such as province and municipal authorities usually have a central role of taking earthquake disaster prevention measures for a community. Among comprehensive measures of a municipal authority, the water utility's measures (emergency water supply and facility restoration) are included. It is important for a water utility that an accentuated PR activity for the community be conducted, and in concert with it PR in an emergency is also needed. The emergency measures by water utility should be released and the contents of measures by water utility itself and citizens are to be made clearly public.

Tehran City has a Master Plan as follows. Based on the report, TWWC is required to have PR activities plan in preparation for earthquake disaster.

(3) The Publicity Work is Done by All the Staff

The member of every section in water utility has the chance to come in contact with citizens and customers in various occasions. It is essential for the staff to inform citizens and customers of their

activities information and the importance of water supply through these contacts. The number and the activities of public relations department staff are limited and the capacity is restricted. The number of whole water utility's staff is more than that.

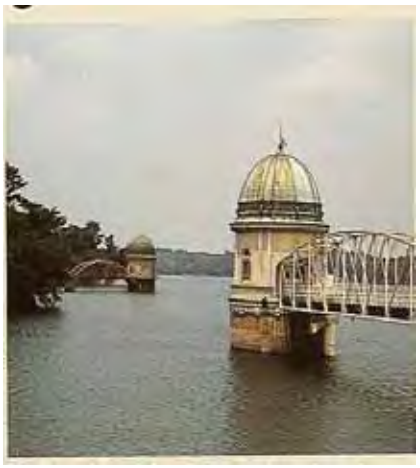
If each individual of the water utility's staff serves as a PR person, he/she will have abundant opportunities as much as the actual public relations department staff have. For example, a meter reader usually visits 120-150 customer residences a day for 20 days a month, when he exchanges a few words (the total number of meter readers are around 120). The on-site technical staff is also in the same situation. If all the staff are as well informed as a public relations person of TWWC, the quantity and power of public relations of a water utility will increase greatly.

Water Organization Building

(4) Image Enhancement of Water Supply Facilities

TWWC runs a lot of water supply facilities and most of them are hard to be seen by citizens, because their locations are underground or in the suburbs. However, in some areas, where the community inhabitants have been accustomed to look at the water treatment plants, pump stations, water towers and the headquarters buildings, they play an important role, and their good images are vivid in their memories for a long time.

Whenever they look at these important facilities, their affection for and trust in water supply will be strengthened. Together with making a good utilization of water supply facilities themselves as resources of public relations, new designs should be encouraged to be adopted which raise a good image of water utility in harmony with community landscape. From this aspect, the front of the main building of the 5th water treatment plant and one of the headquarter buildings of TWWC (Picture in the previous page) seem most attractive.



Intake Tower, Tokyo

It is desirable for a water utility to plant trees, to construct parks, sports grounds and soccer grounds on the upper parts of distribution reservoirs and to open them up to citizens.

It is reported that some of the European countries have a system which provides young artists with 1% of

Water Tower, Tokyo

subsidy out of construction fee for public architectures by encouraging and developing good design. When a water utility tries to design some important water supply facilities, these facilities will last so long that they should be designed in a fashion to keep better harmony and images with community's landscape. It is advisable for a water utility to investigate an introduction of illumination by electricity on distinguished facilities in urban area and painting the reservoirs and water towers with colors and pictures. The photos (above) are a view of the intake tower, Tokyo and, (left) the water tower, Tokyo.

(5) Practical Use of IT

When a technological innovation goes on, more practical use of Information Technology is to be investigated. TWWC has already been using IT to manage internet and internet services in company.

(6) Visit of Water Supply Facilities

It is preferable for a water utility to open the treatment plants and reservoirs for citizens and to encourage them to visit positively. When these facilities are made parks and trees are planted, citizens will visit there as a place of rest in holiday or evening stroll. In case of observation of water treatment plant, the course that visitors walk is decided in advance and guidance by staff is necessary.

(7) A Water Museum

If a water museum is established, the citizens can watch and understand the water utility's various activities and its current situation in one fixed place. The water museum provides the citizens, especially the students with the information and data by exhibiting and distributing models, panels and photos etc. In addition, visual projection and demonstration will be provided. When a citizen visits there, he can easily obtain some knowledge of water supply which is indispensable for a community by studying and experiencing general and scientific features of water. As a part of public relations, the establishment of a water museum should be positively examined.

13.2.4 Disaster Prevention Measures and PR

(1) Earthquake Disaster Prevention Measures of Tehran City and Earthquake Disaster Prevention Measures of TWWC

Many people believe that there will be no breakout of a big earthquake in Tehran City for a while because their memory do not have it. When a big earthquake and its subsequent damages occur in Tehran, TWWC is ready to cope with the situation perfectly It isimportant for a water supplier to have a general PR for citizen, but in addition to that it is more important to publicize measures in preparation for a disaster. The PR activity aiming at earthquake measures is to inform what citizen should prepare in an emergency occurrence and what sort of actions they are advised to take in an emergency. The damage of an

earthquake takes a life base of citizens and citizens suffer damage in all such as a house including water service, food, an injury or a disease. Measures of water supply are publicized as a part of general measures of municipal government, and it must be made known to every citizen.

(2) Earthquake Disaster Prevention Measures of Tehran City (Master Plan)

According to the 'Comprehensive Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area in the Islamic Republic of Iran (JICA 2004)', the following items are described by planning period of 2015 (long term).

1) Goal

To establish a safe and secure urban environment against a potential earthquake

2) Objectives

- to secure lives and properties of the citizens of Tehran,
- to protect citizen's life after the event and
- to prepare rehabilitation and reconstruction.

3) Strategy

- Strengthening the existing buildings
- Improvement of the existing urban structure
- Identification of the safety evacuation square
- Strengthening the existing infrastructure and lifeline
- Provision of earthquake information and education
- Establishment of disaster mitigation policy
- Establishment of community level disaster management organization
- Improvement of disaster management system
- Formulation of emergency response plan
- Establishment of rehabilitation and reconstruction procedure

4) Strengthening of the Lifeline Structure (Water):

The previous micro zoning study showed the pipeline damage points. The damage analysis on other water supply facility has not been done. It is required to assess the vulnerability of the water supply facility and improve it according to the analysis results. As for emergency response plan, evacuation plan (evacuation places, evacuation route and evacuation operation) and security of lifeline were described.

5) Emergency Response Plan for Tehran Municipality

The main objectives of emergency response for water supply are:

- to maintain water supply at emergency phase,
- to make a quick response to recover damaged facilities,
- to minimize spreading of damage by quick recovery,

6) Several Points

- Quick recovery of water supply area,
- Minimizing water failure area by controlling distribution of water,

- Prioritizing recovery work

7) Preparation for Emergency Response Activities

- Establishment and operation of water supply countermeasures headquarters
- Establishment of mobilization system : ・Mobilization, ・Request for assistance made to relevant organizations and constructors
- Information and communication activities : ・Means of information gathering on damage condition, ・Other means of information gathering, ・Communication timing and contents

8) Temporary Measures

- Preparation of materials and equipment for emergency operation
- Facility inspection
- Temporary repair: Intakes, raw water transmissions, treatment plants and reservoirs, Water supply and distribution pipes

9) Recovery Measures

- Intakes, raw water transmissions, treatment plants, pipelines, water supply service pipes

10) Measures for the Future

- Establishment of water tankers dispatching plan
- Construction of new water reservoir
- Construction of emergency water supply points.

(3) Some Concrete PR materials for Citizen

An earthquake disaster prevention plan by Tehran municipal authority was already shown and TWWC has been tackling at both sides of hard and soft measures. It is important to make known to citizens by distributing a simple pamphlet that shows what kind of action to take, when he/she faces a disaster. The contents of pamphlet (Some examples of Tokyo) are shown next.

13.2.5 Action to Be Taken in Case of Emergency

(1) 10 Rules to Remember in an Earthquake

Pamphlet of these 10 rules was translated into Persian and submitted to TWWC.

Rule 1: Protect yourself and your family!
Rule 2: Turn off gas, oil heaters, etc. the second you feel the earthquake., and should a fire break out. Put it out quickly!
Rule 3: Avoid rushing out of your house!
Rule 4: Open the door to secure an exit!
Rule 5: When outside, protect your head and keep away from dangerous objects!
Rule 6: If you are in a department store, theater, or the like, follow the instructions of the staff!
Rule 7: Park your car on the left side of the street. Driving is prohibited in restricted area!
Rule 8: Watch out for falling rocks, landslides, and tsunami(tidal waves)!
Rule 9: Evacuate on foot rather than car, and carry only what you need!
Rule 10: Avoid being misled by false rumors and try to obtain and act on correct information!

(2) What to Do Immediately after an Earthquake

a) 0-2 minutes: Protect yourself:
・Get yourself under a table or desk; get away from other furniture, such as cabinet or wardrobes.
・Open a door.
b) 2-5 minutes: Handling fires

・you have 3 chances to extinguish a fire.
・Stay calm
・ Before you evacuate , turn off your gas main and electrical breakers.
c) 5-10minutes: Make sure your family is safe
d) 10minutes-Half day: Check to see that your neighbors or others nearby are OK and help each other.
・Secure the safety of elderly and handicapped.
・Work with others to rescue those in need.
・Beware of aftershocks.
e) 1st half day-3rd day: Take care of yourself and work with others to take care of your area.
・Use what water and food you have on hand.
・Do not enter collapsed houses
・Observe the rules of emergency shelters
f) 3rd day on-: Help rebuild your community
・Residents, companies and the government will work together to rebuild the community.

(3) Citizen Should Know the Seismic Intensity Scale

Table 13.2.2 Seismic Intensity Scale

Scale	Effects on people	Condition indoors	Condition outdoors
3	Most people indoors feel the tremor Some people become afraid.	Tableware in the cupboard may rattle.	Electric wires sway slightly.
4	People feel quite afraid. Some people try to take protective action. If asleep, most people wake up.	Hanging objects sway considerably as well as tableware in the cupboard. Unstable objects may fall over.	Electric wires sway considerably. People walking outside feel the shock. Some drivers also notice the earthquake.
5 Lower	Most people take protective actions. Some people have difficulty controlling their movements.	Hanging objects sway violently. Tableware may fall off shelf. Most unstable objects fall over and furniture may move.	Windowpanes may break and fall out. A few telegraph poles may fall over Un-reinforced concrete block walls may collapse. Roads may be damaged..
5 Upper	People feel very frightened. Most people have difficulty controlling their movements.	Most tableware fall off cupboard and books off the shelves. TV may fall off its stand. Heavy furniture such as chests of drawers may topple over. Doors may become jammed and not open. Some doors come off their hinges.	Most unreinforced concrete block walls collapse. Inadequately anchored automatic vending machines may fall over. Many tombstones fall over. Driving becomes difficult and many cars stop.
6 Lower	It is difficult to stand.	Most heavy furniture that is not anchored moves or falls over. In many cases doors will not open.	Wall tiles of many buildings break and fall off and windowpanes crack and fall out.

6 Upper	It is impossible to stand and movement is only possible by crawling difficult to stand.	Almost all heavy furniture that is not anchored moves or falls over. Some doors fly off their hinges.	Wall tiles of most buildings break and fall off and windowpanes crack and fallout. Almost all unreinforced concrete block walls collapse.
7	People are tossed about by the shaking and it is impossible to move by own will.	Most furniture moves about considerably and may fly about.	Wall tiles of nearby all buildings break and fall off and windowpanes crack and fall out. Reinforced concrete block wall may be damaged..

13.2.6 Some Useful Advices for the Staff in Charge of PR Activities from PR Experts or Researchers

(1) Organization

1. Organization will be restructured nearly continuously at different levels based on the demands of the markets, stakeholders, and society.
2. Greater amounts of managed information will be used for public relations and management decision making from syndicated and proprietary data bases built from integrated communication programs.
3. Organization will use more ‘zero-based’ thinking and planning to move away from incremental budgeting and implementation.
4. Organization will track external trends and events with greater rigor and precision to anticipate changes relevant to their products, services, and stakeholders.
5. Greater organizations will be managed increasingly from the outside-in rather than inside-out with the benefit of management issues and other PR practices.
6. Organizations will be managed by modern ‘renaissance man and women’ with both qualitative and quantitative skills and hearts minds to use the skills.
7. Corporate and organizational values and will alien more precise and fiscally measurable methods to evaluate with ethical and judge the result of integrated management and communications programs.
8. The growth of new and more effective media will increase the value of public relations as a communication-based field.
9. Global relationship building will contribute to a more significant role for public relations using advanced communications technologies and knowledge.
10. Public relations thinking and practice will permeate all levels of organizations with both the ability to contribute to the long- and the short run objectives.
11. Career opportunities will increase for public relations and PR-related area of professional practices.
12. Organizations will rely increasingly on stronger alliances with customers, suppliers, and other stakeholders. In some cases, organization will work more closely with their historical competition.

Source:
Clarke L. Caywood, Ph.d. (Northwestern University)

(2) Creativity in Public Relations

1. Big ideas—A strategic approach
2. Mission—What makes an idea creative? a: Risk, b: Relevance, c: Impact, d: originality
3. Tactics and procedures
4. Visual/Verbal synergy
5. Getting Ideas
6. Creative thinking
7. The ideation process
8. Creative personality
9. Forward thinking: The future

Source:
Sandra E. Moriarty, Ph.D. (University of Colorado-Boulder)

(3) Clear Writing for PR Practitioners

1) 4 barriers to clear writing

a) Industrial tribalism
b) Speed
c) More choices
d) Team

2) 15 Sins of Businesses

a) Ignoring the audience
b) Oxymoron
c) Euphemism
d) Inflated labels and titles
e) Redundancies
f) Pomposity
g) Slang
h) Verbs from nouns, and vice versa
i) Misused or mixed metaphors
j) Overcapitalization
k) Convoluted grammar
l) Reliance on passive voice
m) Dead constructions
n) Unconventional punctuation
o) Piling on adjectives
p) False warmth

Source:
Clarke L. Caywood, Ph.d. (Northwestern University)

(4) What the Best Have Said about Writing

- Be careful that you write accurately rather than much (Erasumus).
- Thanks to words, we have been able to rise above the brutes; and thank to words, we have often sank to the levels of demons (Aldus Huxley).
- Education doesn't change life much. It just lift trouble to a higher plane of regard (Robert Frost).
- Writing is something that you can never do as well as it can be done. It is a perpetual change and it is more difficult than anything else that I have ever done…so I do it. And It makes me happy when I do it well (Ernst Hemmingway)

(5) Tactics for Clear Writing

1. Editing yourself
2. Spelling of proper names.
3. Start at the bottom and work upward, looking at words with capital letters.
4. Clarify. Make sure that the identifications are correct for each difficult term.
5. Message. Does the piece stick to a single unifying point?
6. Sound. Find a corner to yourself and then read the piece aloud.
7. Spell check., 19 century version. Read sentences back to front. Or run your cursor from bottom to

top. This will cause you to examine each word.

8. Fat. Find out how to use the word count function on your computer's word-processing program. Measure the piece, then cut 10 percent. If you cannot, give it to your colleague to cut.
9. Directness. Search for the passive voice and remove it.
10. Distance. Remove yourself from ownership. Walk away from the piece for a while. When you come back to it, try to look at it as a reader would.
11. Is the first sentence intriguing, interesting, and appropriate?
12. Have I put the facts in logical and readable order?
13. Do my transitions eliminate jolts as the story shifts from one topic to another?
14. Do any paragraphs need separating ? Combining?
15. Do the sound of the sentences vary? Is the voice of the writer consistent?
16. Have I slipped unnecessarily into jargon or cliché?
17. Can I trim any fat?
18. What's the headline?

Source:
Clarke L. Caywood, Ph.d. (Northwestern University)

(6) The Powerlessness of Businesses—6 Tips to Remember

1. Watch out for piling adjectives before the noun, because the readers have to slow down in order to avoid losing the noun.
2. Avoid using the same words twice in a sentence or a paragraph.
3. Look for new action verbs for the beginning sentence. Having your company's press releases 'announce' this and 'announce' that makes it seem almost as if the company doesn't do anything but proclaim.
4. Try to cut down on the passive voice. 'The products engineering department has also been restructured' could be 'the product engineering department also has a new structure'.
5. Police the jargon. 'Growing' sales and 'market share are jargon that ought to stay inside a company.
6. Avoid acronyms, overcapitalization and all-cap headlines. Many corporations are setting arguments over trivial matters by adopting the Associated Press stylebook. Their rationale: It is logical and it is widely accepted.

(7) For Public Relations Director or Assistant Secretary

1. Acting as the senior public relations advisor. This means the public relations advisor sees secretary daily and attends most senior staff meetings, where policy and actions are decided upon.
2. Serving as the public spokesman for the department. This means the daily care and feeding of the news media is handled by the public affairs director or staff members.
3. Coordinating public relations policy and programs within the department. This includes the planning and execution of public relations strategies and central themes.
4. Functioning as the senior public relations advisor for crisis management. This crisis role may involve public relations coordination with other government departments or agencies, as directed by secretary or higher authority.
5. Seeking to coordinate public relations activities, as deemed appropriate, with the office of legislative relations.
6. Releasing information of special interest concerning the department in coordination with the secretary or designated higher authority. (All government public relations staff personnel must be familiar with the provisions of all laws pertaining to the release of information that may affect their units)
7. Supervising the coordination of community relations, internal information, and audio-visual programs with the department.

Source:
Clarke L. Caywood, Ph.d. (Northwestern University)

13.3 Suggestions for Exhibition of Water Museum Establishment

13.3.1 Review of PR Activities for Water Museum Establishment

(1) High-ranking Water Officers of Iran Visited Kobe Water Science Museum

On 13th-14th, May 2002, the five prominent officers related to water & wastewater services of Iran visited the Kobe Municipal Waterworks Bureau. After they heard the explanation of current technology and countermeasures of earthquake disasters of 1995 in Kobe, they visited the various water supply facilities at the sites. Among the group, Director-general of Water & Wastewater Bureau of Ministry of Energy, DG of Water & Wastewater Company of Tehran Province, two members of National Congress and a senior officer of Electricity & Water Technology Research Institute of Iran were included. On that occasion, they visited the Kobe Water Science Museum and it was reported that they were impressed with the distinguished exhibition and importance of sustainable public relations between water supplier and citizens.

(2) TWWC Has a Plan to Construct a Water Museum

TWWC has originally an idea to construct a water museum in a control house of the 5th Tehran Water treatment plant. However, the planned space of the 5th water treatment plant was found too narrow. The other couple of candidates have been studied. One is the telemetry control center building of TWWC's main office yard and the other is under construction in the premises of distribution reservoir No.3.

Old Telemetry Control Center. TWWC

The TWWC plan shows that the function of the conventional telemetry control center will be moved to a newly constructed control center in the same yard, and the vacant space will be used as a museum. However, TWWC thinks that a part of telemetry appliances in the old control center will be stored in preparation for a crisis. So, the space of about 350m2 on the 1st floor and about 100m2 on the ground floor is available for use as museum exhibition. The lavatory and the break space for visitors can be found around the stairs of ground floor to 1st floor and in particular, nearby, there is a Hellenic cultured atmosphere. At first, it is one idea to start in a compact form and expand checking the demand and reaction of the visitors in the future. However, the present available space is too narrow that the rebuild and expansion of ground floor will be necessary without damaging the scenery of the current building, and at least the space of 1000m2 should be secured in total.

The latter is situated near the Laleh Park and the carpet museum, therefore the museum location is geographically of most convenience for the visitors who want to visit some museums in a short time.

13.3.2 Policy for the Establishment of Water Museum

(1) Necessity of Construction of a Museum

When a plan is examined, it is necessary for TWWC to clarify the necessity of museum from the view point of roles and significance in PR activities of water utility.

1) Good Public Relations of Water Utility

A water utility provides the requisite and continuous public services in a community and it has a local monopoly feature. Due to lack of competition, a customer of the community cannot look for another water utility that provides better water services. Therefore, a water utility needs to make a continuous effort to obtain customers satisfaction by reducing the difference between water service level and complaints or demand of customers, and establishes and maintains good customer relations.

2) Importance of the Roles of Water Utility's PR

A water utility should take an advantage of every opportunity to improve water services by releasing the content of management (publicity activities) and hearing customers' demand and complaints (public hearing), and engaging in various kinds of communication.

3) Kinds of Publicity Work

The water utility's publicity works are as follows,

- Distribution of printed material / media for public information : pamphlets, brochures, posters, photographs, videos, pictures, stickers, water supply news, annual reports, financial documents, etc.
- Events: water week event, street consultation, lectures, UN world water day, visit of water facilities and various demonstrations
- Practical use of news and media: TV programs, various event introductions by newspapers, saving water campaign
- Practical use of fixed PR facilities: water museums, water monuments, water towers, customer center
- Public hearing: Street consultation, water monitors, complaints reception, customer (telephone) center
- Internet: Establishment of HP, indication of email addresses
- Others

4) Significance and Roles of Fixed Facility for Publicity

As for TWWC's publicity, they have already carried out almost all of the public relation activities as mentioned in the three kinds of PR activities, but unfortunately they have not any water museum yet which plays an important role for PR. A museum is defined as "a place which collects, classifies, stores and exhibits the cultural, historical, scientific, academic and archeological data systematically for visitors, while research and studies are conducted at the same time." Judging from this definition, as for a water museum, it may be said that it is "an open institution in which the data of the above mentioned fields in a water utility concerned are collected, classified and stored and they are distributed, exhibited and utilized organizationally, systematically and in a way which is easy to understand by visitors.

When a visitor wants to study something related to water utility, he must visit usually various institutions one by one. But a visitor can visit and study almost everything at a place like museum comprehensively and intensively. Further, he can get valuable help and advices from curators. The museum is not only a very convenient facility for the citizens, but also its public relations effect seems very big. As for the PR activities, TWWC's PR activities will be further enhanced by the establishment of a museum.

5) The Features of Museum

As a water museum is a fixed PR facility for a water utility, it has not only the above mentioned objectives, but also it has a role of social educational institution for the commoners as a supplement of school education for the young people. Social education means the education which is conducted at a place outside of school system principally intending for adults. Therefore, the range of visitors will be extended to include all of the citizens from young people to adults. A museum will be opened to all citizens, such as researchers, scholars and foreigners as well.

(2) The Name and Objectives of a Museum

1) Objectives

To provide citizens with an open institution, in which various data of the above mentioned fields in a water utility concerned are collected, classified and stored and then are distributed, exhibited and utilized organizationally, systematically and in an easy way for visitors to understand.

2) Name

Tehran Water Museum or Tehran Water Science Museum

3) Construction Policy of a Museum

a) Museum Construction Committee

In TWWC, a committee is advisable to be established to survey, prepare and implement the plan to construct a museum. At first, there are three groups working under the committee which handle mainly the operation, construction and exhibition. The committee discusses and studies the construction of a museum taking outside voices into account, and submits a report to the managing director (MD) of TWWC

The MD will respect the reports submitted by the committee. The proceedings of a committee will be carried out according to majority decision.

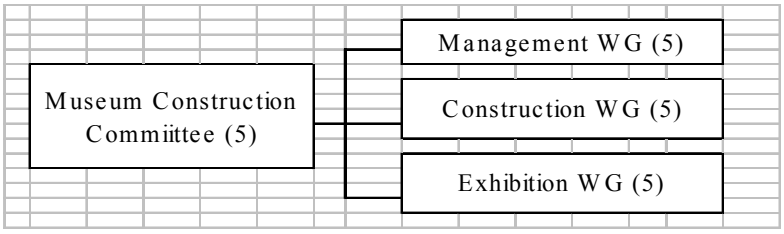


Figure 13.3.1
Organization Chart of Museum Construction Committee

- Nomination of the committee members: The MD nominates 5 committee members, from inside of TWWC (3 persons) and outside (2 persons). A chairman will be elected by the committee members. A chairman presides the proceedings of committee and represents the committee.
- Establishment of working groups: Under the museum construction committee, 3 working groups named operation, construction and exhibition will be established. The number of members of each group is about 5 persons and the members of the groups will be

nominated by the chairperson.

- Period of deliberation / studies by the committee: Approximately 1 year since the day of the committee establishment.
- Record of the deliberation of the committee: will be open.

b) Locations, floor space and construction time

- Location: Old building of Telemetry Control Center in TWWC's yard
- Floor space: about 1,000m2 (total GF-1F)
- Construction time: approximately 3 years includes investigation and designing
- Budget: opened

c) Inauguration

- Beginning of 2009

(3) Exhibition Objects and Methods to Be Referred

The exhibition working group under the Construction Committee will be expected to discuss and make a draft of exhibition objects and exhibition methods. The various illustrations of water museums in Tokyo, Yokohama and Kobe are displayed as models in the Appendix of the report. The illustrations of them will be useful to be referred to as models for the TWWC's museum. TWWC will be able to select the most suitable ones or combination from the models.

13.3.3 Examples of Exhibition Objects (Materials) and Methods in Japan

(1) Exhibition Objects (Materials)

The exhibition objects of 5 museums of 3 advanced water utilities, such as Tokyo Historical Water Museum and Tokyo Science Museum, Yokohama Water Memorial Museum, Museum for Water Supply Engineering of Yokohama and Kobe Water Science Museum are introduced as follows. These museums are famous for their superior characteristics. However, their ways of thinking and intensive points about objects to exhibit are different and unique, and it is natural for the difference of history and various conditions individual water utilities have.

(2) Exhibition Methods

1) Difference between a Traditional Exhibition Type and a Participation Type

a) Traditional Exhibition Type

The features of an exhibition method of Tokyo Water Historical Museum are traditional ones in which the history of water supply and some events are displayed and exhibited chronologically, so visitors observe individual exhibition along the regular route by reading and hearing the explanation. Visitors often stop for a while and try to compare explanation and exhibition, and then confirm the meanings.

The illustration below shows a layout of Tokyo Water Historical Museum (GF).

Visitors take a memo as needed and proceed to the next. Because visitors are not required to participate in exhibition in case of Tokyo, the visitors' movements are made smoothly.

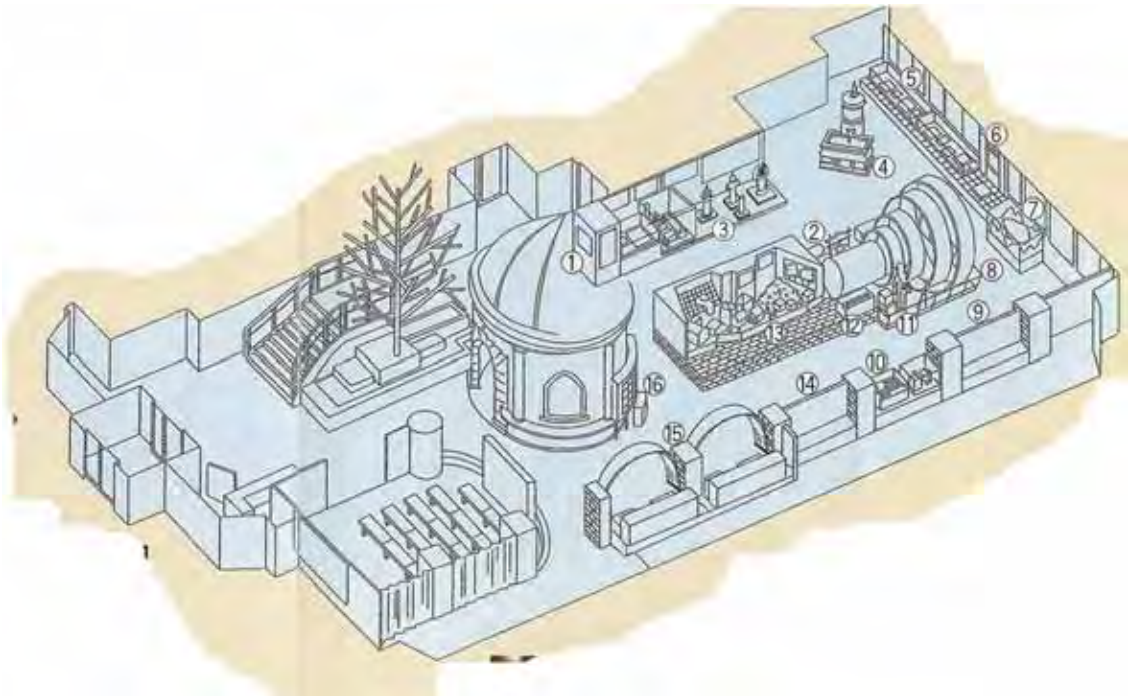


Figure 13.3.2 Layout of Tokyo Water Historical Museum

b) Participation Exhibition Type

On the other hand, Kobe city takes the exhibition method of participation type, so visitors stop at a place for a while to touch and operate the exhibition according to instruction. Through this participation, visitors can grasp what the museum intends to appeal without difficulty. Without participation motivation, an effect of exhibition will not be put forth. Because visitors active participation is a premise, visitors cannot understand what the exhibition tries to appeal. The difference has to be told to visitors in advance.

Today, most visitors are not satisfied with the ordinary exhibition methods in which visitors are required to walk along by reading and listening to the explanation or commentary (a passive involvement of information which a museum intends to release). Visitors would like to obtain various messages and information released by exhibition through their own participation such as touching, operating the exhibitions and getting to the results intentionally.

It is necessary for a museum to try to look for better ideas and devices which attract the interest of visitors. It requires a lot of wisdom to gather and satisfy as many visitors as possible, when so many entertainments and amusements of the society are attracting people today.

2) Exhibition by Group and Exhibition Order in Layout

As for the exhibition method, grouping and order are important.

a) Grouping

The group done by arranging the items chronologically is from upper stream to lower stream

(water sources, water transmission, water treatment, water distribution and water supply by service pipes, etc.), improvement of technology, functions / facilities / materials & devices, experiences of various disasters, and management system (legal frameworks, water tariff, business handling).

b) Exhibition Order

From simple to complex, individual cases to comprehensive outlook, old to new, small to bigger, manual to machines (includes automation), advanced technology, etc.

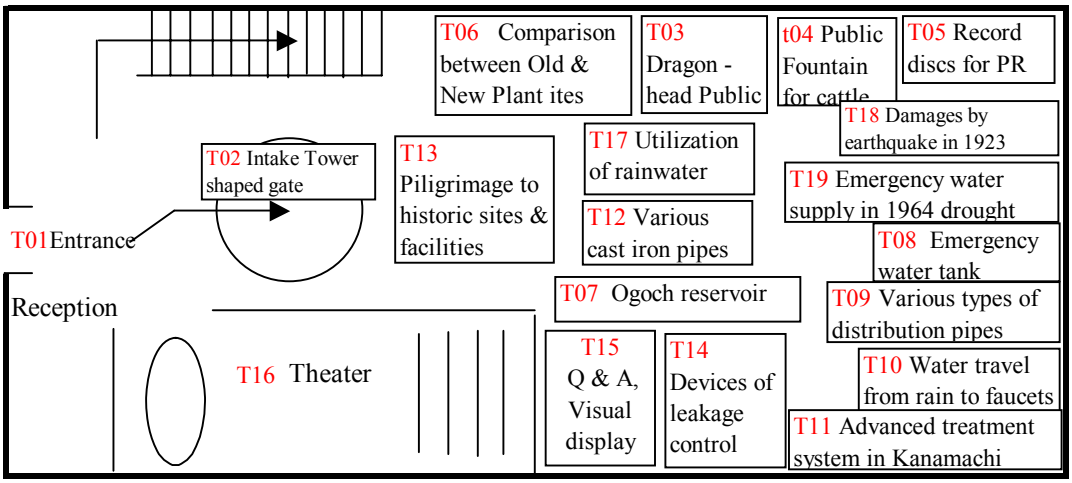
c) Exhibition Change and Renewal

It is necessary for a museum to change and update the exhibition by hearing the visitors voices and demands (questionnaire is available-such as, which exhibition do you like best, which exhibition method is appropriate?).

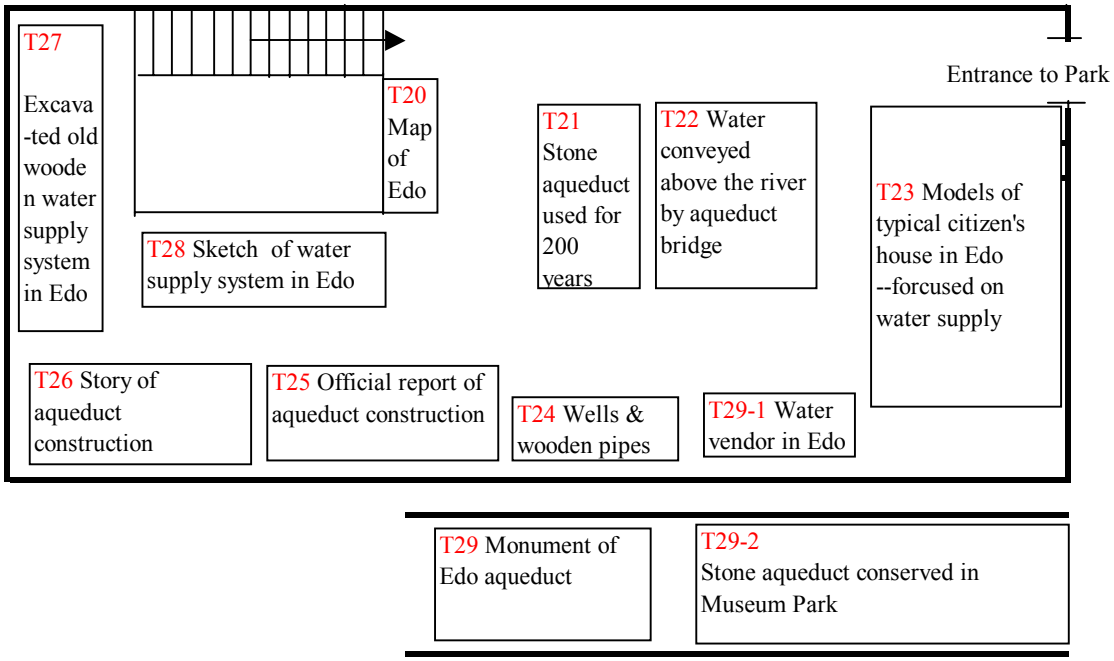
(3) The Models of Layout of Exhibition Objects

The several layouts (exhibition method) of exhibition objects of water museums in Tokyo, Yokohama and Kobe are shown as follows. The numbers of exhibition correspond to the photo No of objects, therefore one can easily understand the place where the objects displayed in these museums. In Tokyo 36 pieces of photographs, in Yokohama 20 pieces and in Kobe 11 pieces are displayed. There are a lot more of exhibition objects, but several main important objects are collected. One can understand what sorts of objects are selected and how they are displayed in museum. This report will give some valuable ideas for TWWC, when they examine how water museum of Tehran should be to select exhibition objects and how to exhibit them.

・Ground Floor： Modern Water Supply Section (After 1868)



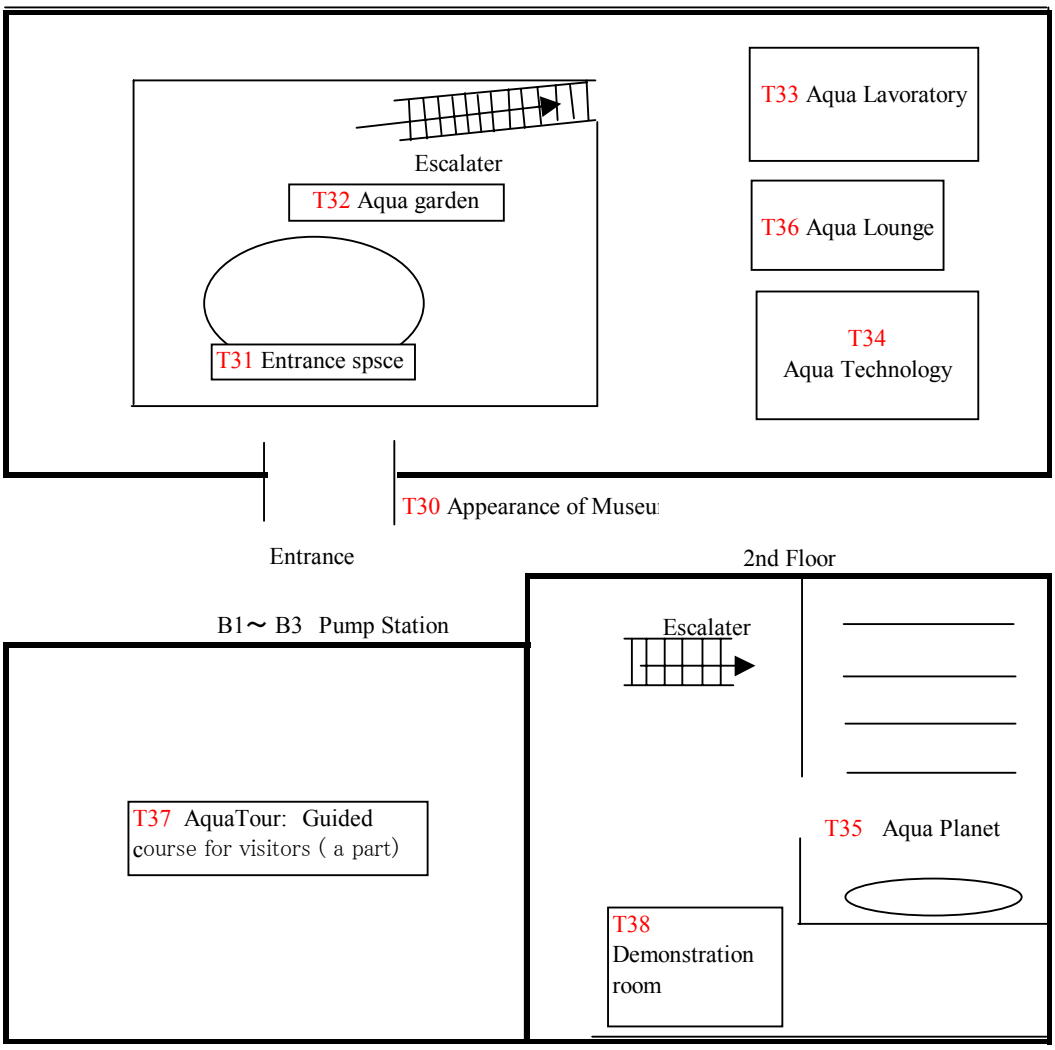
・1st Floor & Park : Premodern Water Supply Section (Before 1868)



〒113-0033 1-7, Hongo 2-Chome, Bunkyo-ku, Tokyo
℡03-5802-9040 Fax03-5802-9041

Figure 13.3.3 Tokyo Historical Water Museum

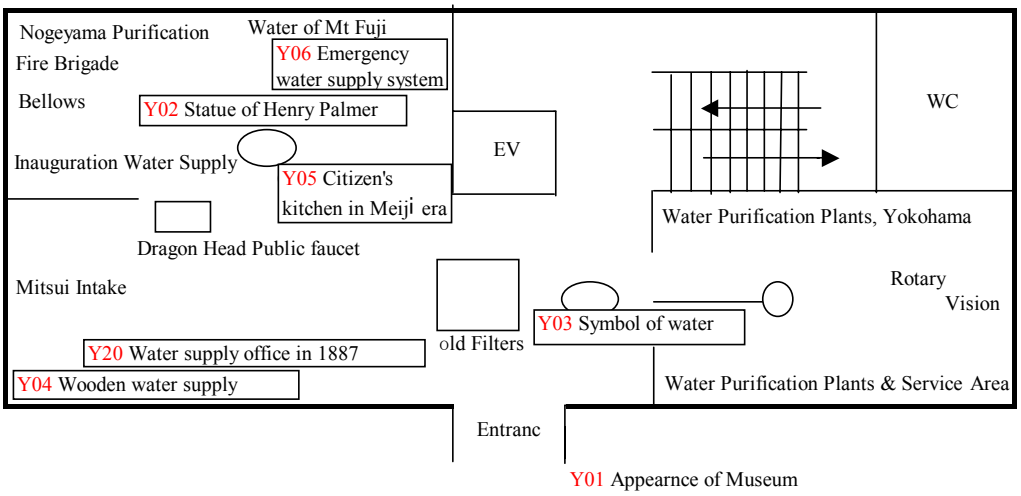
・Ground Floor-1st-2nd F, BF1-BF3



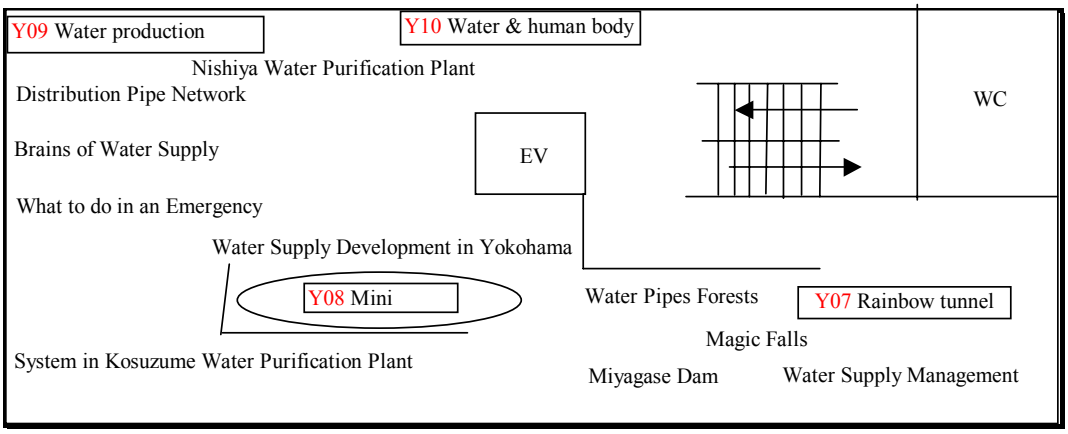
〒135-0063 1-4,Ariake-2Chome,Koto-ku,Tokyo
℡03-3528-2366, Fax03-3528-2380

Figure 13.3.4 Tokyo Water Science Museum

・Ground Floor: Water History in Yokohama



・1st Floor : Seeking for safety water



522 Kawashimacho, Hodogaya-ku、Yokohama City ℡045-371-1621

Figure 13.3.5 Yokohama Water Memorial Museum

・Ground Floor: Display of Water Supply Engineering

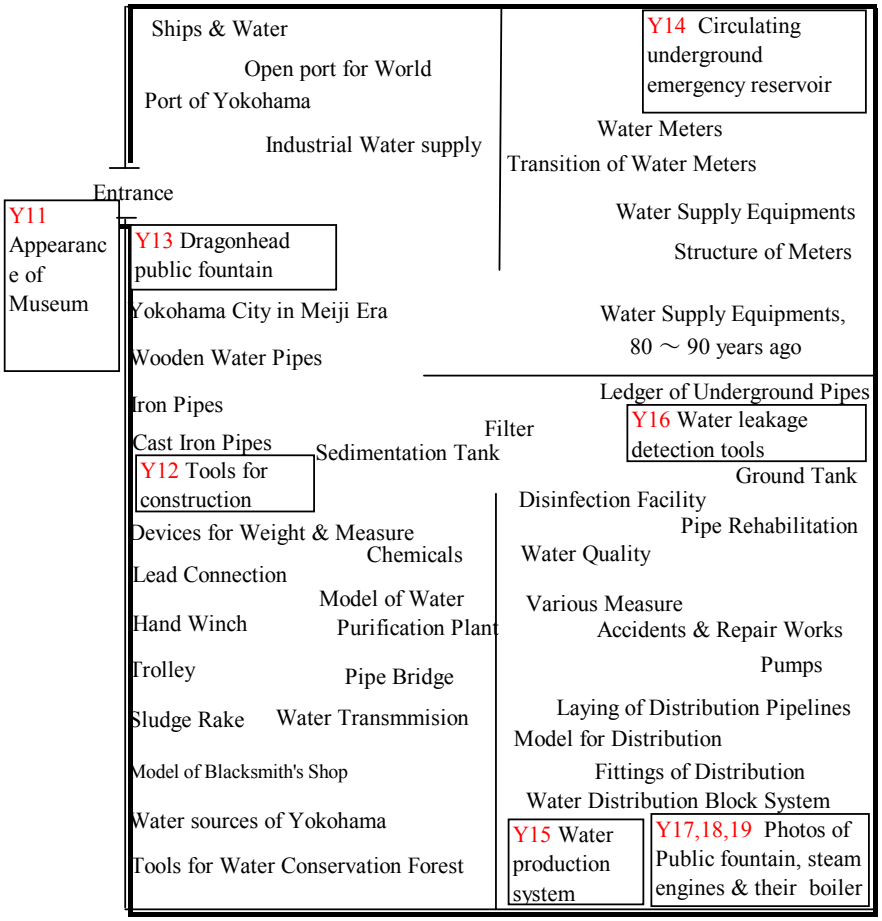
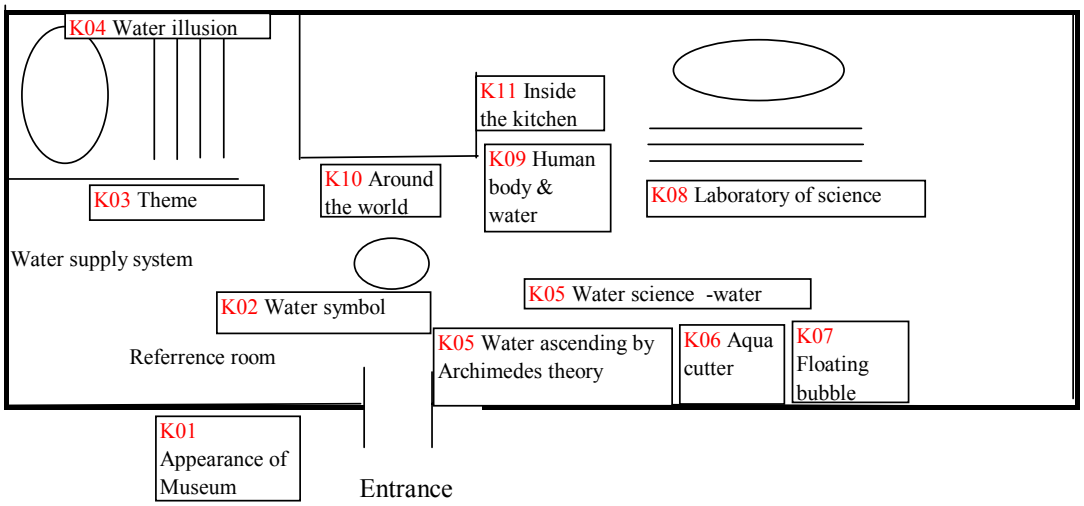


Figure 13.3.6　Museum for Water Supply Engineering, Yokohama

Ground Floor:



Kusutanicho Hyougo-ku, Kobe City, TEL351-4488

Figure 13.3.7　Water Science Museum of Kobe

13.3.4 Suggestions for Sustainable Management of Water Museum

(1) The operation system of a museum

- Entity of operation: TWWC
- Burden of expenditure : the operation and maintenance expenses will be disbursed by Tehran City at least
- Trustee of contract: a company who has experience and competent capability to run museum.
- Contract: bidding competition
- Contract period**:** 5 years
- Opening hours: 9:00 a.m. to 5:00 p.m. closed on Friday
- Entrance charges: 1,000 Rial

(2) Some Remarks for the Operation of Sustainable Management of the Museum

1) Several necessary considerations

The following items are necessary to be taken into consideration:

- At first, a campaign to have a large number of citizens learn about the existence of a water museum is necessary. Ask the city, mass media to take up the museum on their media, and print it on the back side of water bills.
- To rank it as one of the important PR activities of TWWC.
- To make an effort to increase the number of visitors.
- To develop ingenuities of exhibition / plan and make exhibition contents an attractive and up to date one. If contents are not attractive, visitors will not come, even if spending money for advertising.
- To cooperate with various groups in community, schools, and environmental organizations.
- To let a water museum for rent for events and as meeting places.

Save Water Campaign by Kindergarten Children

- To fill up a reference room by increasing water-related books, study papers, newspaper, documents in country and overseas.
- To make the environment around the water museum ready by making a park, and green land, and making the visitor's access convenient.
- Not to ask for an excessive burden on TWWC in finance respect.
- To hear voices of citizen.
- To promote a composition contest related to water and give prizes to excellent works.
- To exchange information and cooperate with overseas water museums.

2) Trial and error

A museum will not be expected to be idealistic from the beginning. By changing exhibition objects often and improving exhibition methods and changing the location according to some case, and hearing visitors frank voices and after trial and error, the museum may approach to be a better institution. Sometime, it takes a long time.