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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

WATER AND SEWAGE COMPANY OF KERMAN (WSCK)

THE STUDY ON RECONSTRUCTION PLAN

FOR

BAM WATER SUPPLY SYSTEM

FINAL REPORT

December 2004

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PREFACE

In response to a request from the Government of the Islamic Republic of Iran, the Government of Japan decided to conduct the study on Reconstruction Plan for Bam Water Supply System and entrusted to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched the Study Team headed by Mr. Itaru Mae of Pacific Consultants International consisted of Pacific Consultants International and OYO International Corporation, to the Islamic Republic of Iran from January 2004 to March 2005. JICA set up an Advisory Committee chaired by Dr. Kimiro Meguro of the University of Tokyo, which examined the study from the specialist and technical points of view.

The Study Team held discussions with the officials concerned of the Government of the Islamic Republic of Iran and conducted the Study in collaboration with the Iranian counterparts. Upon returning to Japan, the Study Team accordingly finalized and delivered this final report.

I hope that this report will contribute to the promotion of the reconstruction and development of water supply system in the Bam area, and to the enhancement of friendly relationship between the two countries.

Finally, I wish to express my sincere appreciation to all the officials concerned of the Government of the Islamic Republic of Iran for their close cooperation extended to the Study.

December 2004

Estuo KITAHARA
Vice President
Japan International Cooperation Agency

Mr. Estuo KITAHARA
Vice President
Japan International Cooperation Agency
Tokyo, Japan

December 2004

Letter of Transmittal

Dear Mr. KITAHARA,

We are pleased to formally submit herewith the study report entitled “The Study on Reconstruction Plan for Bam Water Supply System” included in the final report entitled “The Comprehensive Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area in the Islamic Republic of Iran”.

This report compiles the final fruits of the Study which was undertaken in Bam city, the Islamic Republic of Iran, by the Study Team that was formulated shortly after the Bam earthquake on December 26, 2003, by Pacific Consultants International and OYO International Corporation under the contract with the JICA.

The study report is prepared as the constitutive part of the final report entitled “The Comprehensive Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area in the Islamic Republic of Iran”. It compiles the results of the Study, including the rehabilitation plan, facility design and reconstruction of water supply system. To feedback the experience of the Bam earthquake greatly contributes to promoting the formulation of the master plan for the Greater Tehran Area, the Islamic Republic of Iran.

Finally, we would like to express our sincere gratitude and appreciation to all the officials of your agency, the JICA advisory Committee, the Embassy of Japan in the Islamic Republic of Iran, and Ministry of Foreign Affairs. We also would like to send our great appreciation to all those who have extended their kind assistance and cooperation to the Study Team, in particular, relevant officials of Tehran Disaster Mitigation and Management Center (TDMMC) and Water and Sewage Company of Kerman.

Very truly yours,

Itaru Mae
Team Leader, JICA Study Team
The Comprehensive Master Plan Study on
Urban Seismic Disaster Prevention and Management for the Greater Tehran Area in the Islamic Republic of Iran

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Abbreviation and Acronyms

BN-nit	Bam-Narmashir Watershed Unit
BrvtWSC	Baravat Water Supply Company
BWSC	Bam Water Supply Company
DP	Drilling Point
EMS	European Macroseismic Scale
gal	cm/s^2
IIEES	International Institute of Earthquake Engineering and Seismology
K	Coefficient of Permeability
Mb	Body wave magnitude
MCM	million cubic meters
microS	Micro-siemens
MMI	Modified Mercali Intensity
Ms	Surface wave magnitude
msl	mean sea level
Mw	Moment wave magnitude
NGO	Non Government Organization
PGA	Peak Ground Acceleration
RWRCK	Regional Water Resources Company of Kerman
T	Transmissivity
UNICEF	United Nations Children's Fund
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
USGS	US Geological Survey
WHO	World Health Organization
WSCK	Water and Sewage Company of Kerman

1. Overview

General

This is the third report prepared by the JICA Study Team for "The Study on Reconstruction Plan for Bam Water Supply System." The Study Team was initially formulated shortly after the earthquake on December 26, 2003, which hit the southern Iranian city of Bam in Kerman province and left devastating physical damage and distress, not only to the people of Bam, but also to the nation.

Scope of the Study

The scope of the study is set to introduce a water supply system which is seismic resistant and feasible to maintain, and the work items should cover 1) water supply network reconstruction plan and the formulation of long-term reconstruction plan and 2) evaluation of water source potential, which includes digging of two test boreholes.

The first primary component, formulation of the long-term reconstruction plan consists of 1) designing of water supply system, 2) implementation plan, operation and maintenance plan, 3) preliminary design of monitoring and control system for the operations of well pumping stations, and 4) cost estimate of implementation of the reconstruction plan.

The second component is to implement the construction work of 1) water network facility, which is approximately 30 km of the priority route in Bam municipality, 2) a distribution reservoir (V=2,000m³) with a gate house and a chlorination house, including chlorination equipment in Baravat, and 3) the building structure of pump house (No.3) in Baravat

The ultimate objective of the rehabilitation work is to restore the damaged facilities to the pre-earthquake conditions in the course of the project.

Figure 1.1 shows the schedule of the study from the preparatory mission sent in January 2004 to a seminar which will be held in February 2005.

Progress of the Project

Overall reconstruction works on Bam water supply system is being implemented by WSCK. Two contractors were nominated for reconstruction works of the distribution system based on the detailed design by Jooyab-Nou Co.; consequently, the works started August 2004.

A part of reconstruction works is also being done in parallel by PCI procured by JICA in the form of ODA. These works are composed of construction of Baravat reservoir (2,000 m³) and distribution pipe network (approx.30 km). The construction work of Baravat reservoir started August 2004, and its progress is approximately 50 % as of the middle of October. The construction work of pine network has just started. These works are expected to be finished by the end of January 2005.

The groundwater resources study in Bam was carried out to evaluate the potential of groundwater resources in the well field for the sustainable use. The investigation on the site is finished except the installation of one water gage and one pumping test at existing well. The study including the residual site investigation is expected to be finished by the beginning of November 2004.

Outlook of Damage caused by the Earthquake

Table 1.1 shows the type of residential housing categorized by structure and material, which were built before 1996 in the Bam areas. As it shows, "steel frame" and "RC frame" consist only of 0.3% to the total, and the majority of buildings were built with "brick/stone and steel" and "adobe and mud" at 68.2% and 29.1%, respectively.

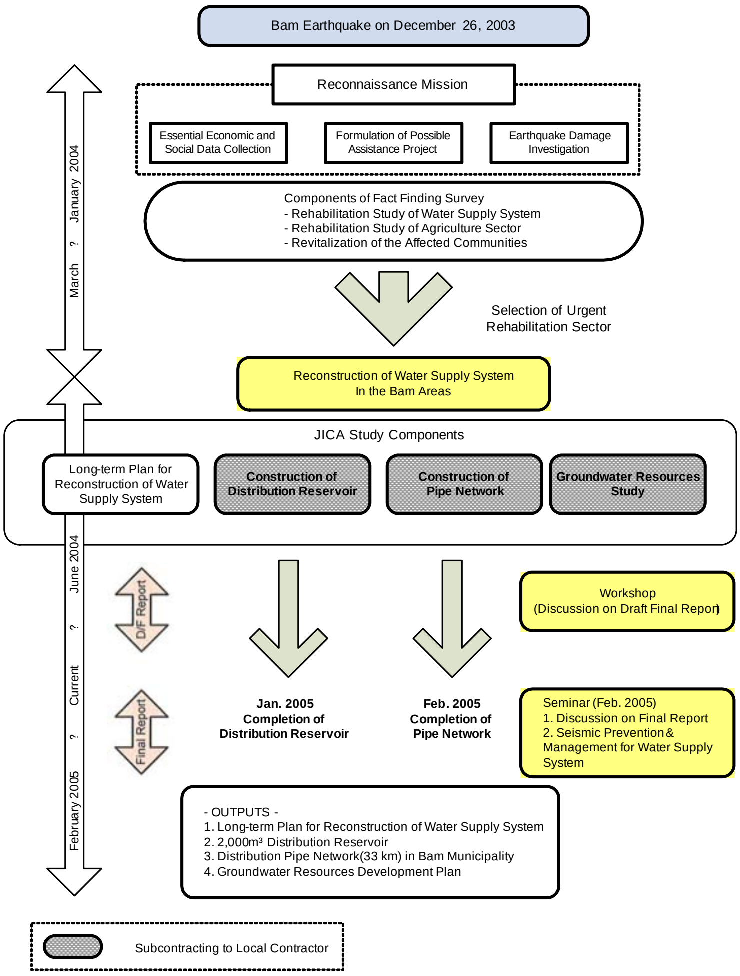


Figure 1.1 Schedule of the Project

Table1.1 Type of Residential Housing by Structure and Material

Structure	Numbers	Ratio (%)
Steel frame	20	0.2
RC frame	9	0.1
Brick/stone & steel	8,602	68.2
Brick or stone-brick	91	0.7
Adobe and mud	3,666	29.1
Others	43	0.3
Not specified	176	1.4
Total	12,607	100.0

Source: Statistic Data 1996. Central Statistical Survey of Iran

Table 1.2 Population Projection

	Zone	Before & After Disaster		Projected Population		
		Before	After	2004	2015	2023
Bam	1	10,000	5,896	2,603	3,920	7,700
	2	9,600	6,331	5,375	8,100	8,300
	3	12,000	5,737	26,424	39,820	12,700
	4	12,400	7,016	11,701	17,640	12,000
	5	12,400	6,031	11,255	16,960	13,300
	6	11,960	5,487	4,225	6,370	12,100
	7	15,200	4,566	2,937	4,430	7,800
	8	4,400	2,353	1,389	2,090	3,100
	9	12,000	4,325	2,680	4,040	5,700
	10	9,200	7,954	3,512	5,290	10,400
	11	4,800	5,300	2,340	3,530	9,000
	12	6,800	6,599	2,914	4,390	8,600
	14	1,800	1,600	706	1,060	3,500
Sub-total (Bam)		122,560	69,195	78,061	117,640	114,200
Baravat	13	20,800	15,875	7,009	10,570	45,400
Grand Total		143,360	85,070	85,070	128,210	159,600

Figure 1.2 shows the extent of damage estimated based on the destruction of building structure. As it shows, most areas were affected with more than 50% and north and east parts of Bam municipality were almost completely destroyed by the earthquake.

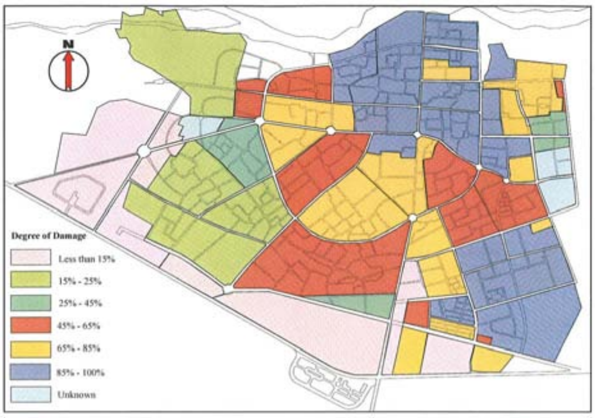


Figure 1.2 Estimated Damage Level based on the Destruction of Building Structure

Population

Several population projections were announced from various institutions, such as UN OCHA, SCI and Bam Reconstruction Committee, and their projections, as was expected, differed from one another. Yet, all institutions estimated the population in year 2015 will be around 120 thousand to 160 thousand and in year 2025, the projection is around 150 thousand to 220 thousand. The Study Team has decided to adopt the projection estimated by UN OCHA as the base to estimate water demand in the Bam areas and design mid- and long-term water supply master plan. The population projection below seems to be between moderate to conservatively high growth rate.

Water Supply System in the Bam Areas

Bam Water Supply Company (BWSC) provides service (tap) water to Bam city and its surrounding areas through distribution pipes from several distribution reservoirs owned by BWSC in Bam and Baravat. The main facilities supplying service water to the eastern area of Bam city were built around 20 to 25 years ago. Since then, BWSC has expanded and improved its services, and it provided approximately 28,000 m^3 per day covering about 130,000 people in the urban area of Bam, Baravat and the surrounding areas before the earthquake.

BWSC relies solely on its water source to groundwater, and owns seventeen operational production wells, fifteen wells for Bam and two wells for Baravat. The groundwater from eight wells in Bam is conveyed to three reservoirs, which have a combined capacity of 30,000 m^3. The groundwater pumped up from four wells in Bam is conveyed to a reservoir, which has a capacity of 5,000 m^3, and two wells in Baravat is conveyed to a reservoir with a capacity of 1,600 m^3 for the users in Baravat.

The earthquake inevitably damaged the water supply facilities and infrastructure in both Bam and Baravat, and their major damaged facilities are:

- distribution pipes,
- pump houses and control panels of production wells (No.1 and No.2 wells in Bam and No.1 and No.2 wells in Baravat), and
- reservoir with the capacity of 1,600 m^3, disinfection house and gatehouse in Baravat.

2. Existing Water Supply System

Outline of the Water Supply System before the Earthquake

Water Source

Groundwater is used as the water source for the water supply system. All the water sources are deep wells and there were originally 16 wells: 12 around the warehouse of BWSC and four in the city. However, since one of the wells (Well No.3) had already been out of service, 15 wells were found operational. The water source for Baravat is also groundwater and there are two wells from which water is distributed to the area. In addition, about 30 l/s of water is transmitted to the area from Bam water supply system.

All the water sources have good water quality except for No.1 and No.2 wells in Baravat and Bam that have relatively high concentration of EC, Sodium and Chloride.

Pumps, Wells and Reservoirs

The No.1 reservoir (R1), which is located to the north of BWSC warehouse, is composed of three reservoirs with a total capacity of 30,000 m³ (V=10,000 m³ x 3). The No.2 reservoir (R2) with a capacity of 5,000 m³ is located 1,900 m away to the west of R1 reservoir. R2reservoir was newly constructed and operated in 2003.

Population Served and Supplied Amount

The following Table 2.1 summarizes the conditions of water supply before the earthquake.

Table 2.1 Condition of Water Supply before the Earthquake

Item	Bam City	Baravat
Population served	104,000	20,800
Service ratio	100%	100%
Supply amount	23,391 m³/day *	4,980 m³/day
Number of house connections	21,812	3,678

Source: BWSC

* including surrounding villages

The service ratio of Bam city and Baravat is almost 100%. The Bam water supply system delivers water to the surrounding areas (rural area) as well.

Distribution Pipeline Network

The distribution pipeline network of Bam city is divided into two blocks. One is the East Block (eastern lower area of the city and surrounding rural areas) that is supplied with water from R1 by gravity. The other one is the Western Block (high elevation area of the western part of the city) that is supplied with water from the R2 by gravity. The diameters of distribution mains are 450 mm, 600 mm and 700 mm and 70% of the pipe materials including distribution pipes are asbestos and others are cast iron and polyethylene.

Baravat is a small, urbanized area with a house connection of 3,678 that constitutes a single water supply block. The transmission pipeline has a diameter of 300 mm and that of distribution pipe is 200 mm or less. Pipe materials are same as those of Bam city.

Outline of the Water Supply System after the Earthquake

Pumps, Wells, and Reservoirs

After the earthquake, water consumption amount has been increasing. Therefore, WSCK exploited two wells (one for Bam and one for Baravat) newly to increase the water drawn quantity. Hence, 16 wells for Bam and three wells for Baravat are operating in total as of June 2004. The water quantity of each additional well is estimated at approximately 30 l/sec.

The water drawn from the additional two wells in Bam is discharged into Bam distribution network directly. Also, the water drawn from one new well (No.3 well) in Baravat is discharged into Baravat distribution network directly.

After one compartment of Baravat reservoir was damaged, the water drawn from only one well (No.2 well) is transmitted to the reservoir. Therefore, discharge pipes of two wells (No.1 & No.3) are connected to Bam distribution network.

Two reservoirs in Bam are still working under their original conditions. However, the capacity of Baravat reservoir decreased from 1,600 m³ to 600 m³ due to cracks on its wall.

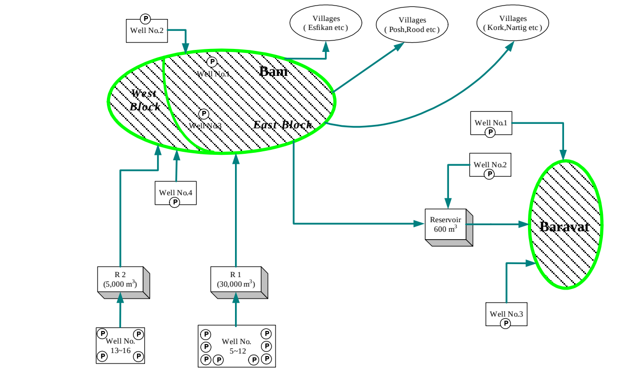


Figure 2.2.1 Existing Water Supply System After the Earthquake

Figure 2.1 Existing Water Supply System after the Earthquake

Management of Water Supply System

Operation and maintenance in Bam municipality, it is not expected to introduce a vast number of additional monitoring items or to install complicated operational devices; thus, there is no need to significantly increase staff number, but it is suggested to fill in vacant posts, and to fulfill the required total number of personnel by the target year in 2023.

With regard to Baravat Water Supply Company, since the projected population will be 32,381 in year 2023 from the current population of 15,875, i.e. the population increases as twice as current population, it is suggested to increase the number of staff to 20 – 24 staff members from 12 persons at present. It is strongly recommended, in particular, that a staff who has knowledge of water quality control should be placed at the agency.

"Revenue and Customer Services" section is responsible for dealing with water users; yet, it does not place much emphasis on the improvement of customer satisfaction. The main functions of the section are to check water-meter reader and to calculate water charge. According to the BWSC organizational chart, 11 staff including the head of the section should be allocated; however, only seven staff are currently assigned to this section. Although the users of water supply service had decreased dramatically after the earthquake, the usage of water in quantity has increased; therefore, BWSC has been operating all well pumps to supply water supply to the users. There are 21,812 house connections in year 2003. Once the water supply service goes back to normal conditions after the efforts made to rehabilitate the water supply facility, the works for not only checking water-meter, maintenance and replacing spare parts, but also educating and disseminating the proper manner of usage of water and controlling illegal usage of water, will increase and take the most part of their duties

Unaccounted Water in the Bam Areas

It is foreseen that there would be vast amount of unaccounted for water in year 2004 because the confusion derived from the earthquake has been seen even after the end of fiscal year, March 2004.

With regard to the data in 2002, it is premature to reach to a conclusion because of a lack of breakdown data, but 19 % of unaccounted for water ratio is not much significant.

Table 2.2 Unaccounted Water in Bam City

Year	Production	Distribution (m^3)	UFW (m^3)	Ratio (%)
2002	8,538,538	6,909,226	1,629,132	19.1%
2003	9,763,961	4,972,447	4,791,514	49.1%

Source: WSCK

3. Groundwater Resources Study

Background of the Groundwater Resources Study

Water source for existing water supply network in Bam is depending on groundwater. According to the projection of future water demand in the target year of 2023, however, it was concluded that the actual production amount cannot meet the demand. Since the wells were constructed in the existing well field in Bam, the investigation of groundwater potential has not been carried out. The aquifer in the area has been constantly recharged by the precipitation in Jebalbarez mountain range so that for a long time extraction amount has not affected the water balance in the area. However, it is reported that groundwater level has been decreased. Severe drought that has continued 6 years may cause the phenomenon. In addition, increase of water consumption for agriculture purpose caused by economic growth might be one of the reasons. Considering the situation mentioned above, the groundwater resources study in Bam was carried out to evaluate the potential of groundwater in the well field for the sustainable use.

Water Usage

As the precious resource, groundwater has been extracted by the qanats and wells, and has been utilized for irrigation, domestic and industrial purposes. The total discharge amount is estimated to be 256.3 MCM per year as minimum. The consumption of each water use is shown in Figure 3.1. Most of groundwater extracted, i.e. 94.4%, was consumed in irrigation purpose. For the irrigation purpose, the amount of 141 MCM of groundwater is extracted from qanats and the amount of 101 MCM of groundwater is extracted from wells. For the domestic and industrial use, the groundwater is extracted only from wells.

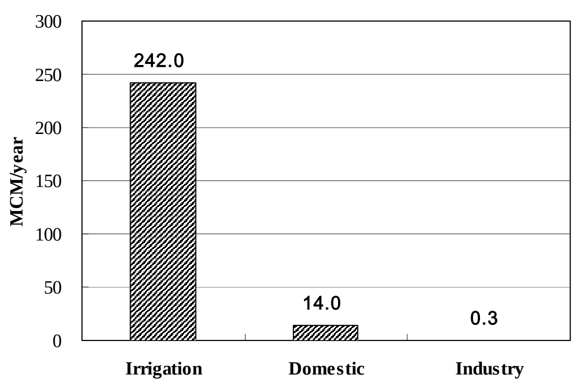


Figure 3.1 Water Consumption

Geotechnical Study

Site Investigation and the Result

In order to evaluate the groundwater potential in the well field of BWSC, test borehole construction and related data collection were carried out. Test borehole construction is composed of geo-electrical exploration, borehole drilling and pumping test. The location and test results of these items are summarized in Figure 3.2, Table 3.1 and 3.2. The obtained values of Coefficient of Permeability (K) are medium to high.

Figure 3.3 shows the distribution of Electrical Conductivity (E.C.). Modification of the existing map has been made based on the results of water quality analysis of existing wells. The figure suggests that water quality is much better in the southwestern part of Bam than in the northeastern part of Bam. This characteristic is considered to be in accordance with the recharge system in this area.

Hydrological Characteristics of Bam and Baravat Surrounding Area

The cities of Bam and Baravat are located in south-west region of a wide watershed including Loot Desert (see Figure 3.4), i.e., upper region of the whole watershed. There are two mountain ranges referred respectively to as “Kaboody” in the north and “Jebalbarez” in the south boundaries that are important sources of groundwater supply. An especially dissected valley has been developed in Upper part of Adori River so that the upper part is abundant in groundwater resource. Furthermore, there is a famous fault referred to as “Bam fault” between Bam and Baravat city. The fault has worked as a natural “Underground Dam” (see Figure 3.5). Bam city has been developed as water abundant area since historical times under this favorable condition.

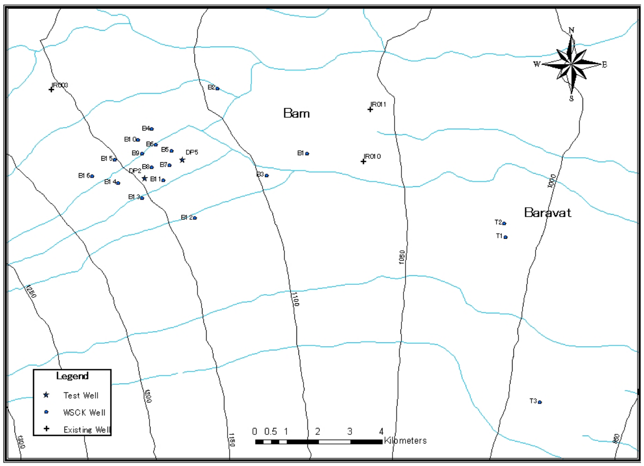


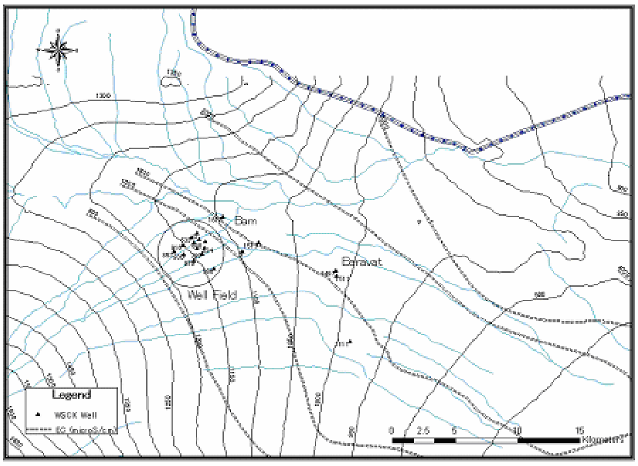
Figure 3.2 Location of Geotechnical Study

Table 3.1 Aquifer Property of Test Boreholes and Existing Wells

	Borehole	Location	Depth	Screen Length	Specific Capacity	Transmissivity	Coefficient of Permeability	
			(m)	(m)	Q/s (m^3/day/m)	T (m^3/day/m)	(m/day)	(cm/sec)
1	DP2 (WSCK No.17)	WSCK Premise	230	108.01	438	683	6.32	7.32.E-03
2	DP5 (WSCK No.18)	WSCK Premise	203	103.94	1530	1532	14.74	1.71.E-02
3	No.8 (WSCK No.8)	WSCK Premise	200	105	89	449	4.28	4.95.E-03
4	IR003	West Bam	120	90	547 (by step drawdown test)	1370	15.22	1.76.E-02

Table 3.2 Water Quality of the Test Boreholes and Existing Wells

Well No.	Unit	Iranian Driking Standard	IR003	IR010	IR011	No.8	DP2	DP5
Date of sampling		Maximum	6-Sep-04	6-Sep-04	6-Sep-04	6-Sep-04	14-Sep-04	4-Oct-04
Date of Analysis			7-Sep-04	7-Sep-04	7-Sep-04	7-Sep-04	15-Sep-04	5-Oct-04
Temporary hardness	mg/l	-	112	280	476	108	100	96
Permanent hardness	mg/l	-	-	-	16	0	0	0
pH	-	-	7.87	7.68	7.45	7.80	7.87	8.02
Turbidity	NTU	-	-	-	-	-	-	-
TDS	mg/l	1500	417	770	1649	445	508	411
Electric Conductivity	microS/cm	-	707	1346	2557	794	846	633
Calcium	mg/l	250	28.80	73.60	120.00	28.80	30.40	25.60
Magnesium	mg/l	50	9.60	23.04	42.24	8.64	5.76	7.68
Sodium	mg/l	200	113.18	209.52	439.55	130.03	140.56	117.40
Potassium	mg/l	-	1.90	5.10	9.90	4.80	4.80	3.60
Fluorine	mg/l	-	-	-	-	-	-	-
Bicarbonate	mg/l	-	200.80	409.92	561.20	219.60	239.12	200.08
Carbonate	mg/l	-	0	0	0	0	0	0
Nitrite	mg/l	3	0	0	0	0	0	0
Nitrate	mg/l	50	4.54	20.93	39.22	7.70	7.09	7.60
Chloride	mg/l	400	76.00	172.00	408.00	94.00	100.00	66.00
Sulphate	mg/l	400	104.13	152.29	330.93	100.43	100.84	84.40



After Halibb Consulting Engineering (1998)

Figure 3.3 Electrical Conductivity (E.C.) Contour Map

Optimum Pumping Yield and Groundwater Resources Development

Optimum Pumping Yield of Existing Wells

In order to evaluate the groundwater potential in the existing well field, optimum pumping yield of all existing wells are estimated based on the result of pumping test and existing data as described in Table 3.3. Drawdown at the end of radius of influence is set at 0.001 m. As a result, the optimum pumping yield of existing wells is estimated at 456 l/sec with the conditions such as radius of influence of each well, duration of pumping (20 hours) and Coefficient of Permeability (5.44 m/day).

Optimum Pumping Yield of Test Wells

The optimum pumping yield of the total of two test wells is 40 l/sec as described in Table 3.4. The optimum pumping yield is calculated considering the radius of influence, since these two test wells are located in the existing well field. The radius of influence of DP5 is further extended due to high transmissivity so that it is set at 250m in maximum with the yield of 10 l/sec.

Groundwater Resources Development

As a result, total amount of 496 l/sec can be supplied to the water supply network. The projected future water demand in the year of 2023 is 680 l/sec. Remaining amount of 184 l/sec should be developed to meet the demand of the year 2023.

Potential Area for Groundwater Development

The promising area for the future groundwater development is selected based on the result of hydro-geological analysis of the data obtained during the study. For the selection of the promising area, water quality, depth to the water level, and the coefficient of permeability were taken into consideration. Considering these conditions, the Adori River and its flood plain is deemed to be a preferable water source for future groundwater resources development (see Figure 3.6).

Water Balance

No matter the groundwater-rich condition Bam and Baravat surrounding area, a tendency of lowering groundwater level has been observed during recent drought. This means water balance of the study area is a minus value. For example, Figure 3.7 shows a deviation of monthly average groundwater level at the beginning of each hydrological year. The lowering is not always clear from each datum, but the tendency can be read despite the observation period of the data being before recent drought. There are a lot of qanats for irrigation in Bam and Baravat surrounding area, and their amount of discharge is significantly affected by groundwater level. Therefore, the groundwater use under strict watershed management is essential to regional sustainable development.

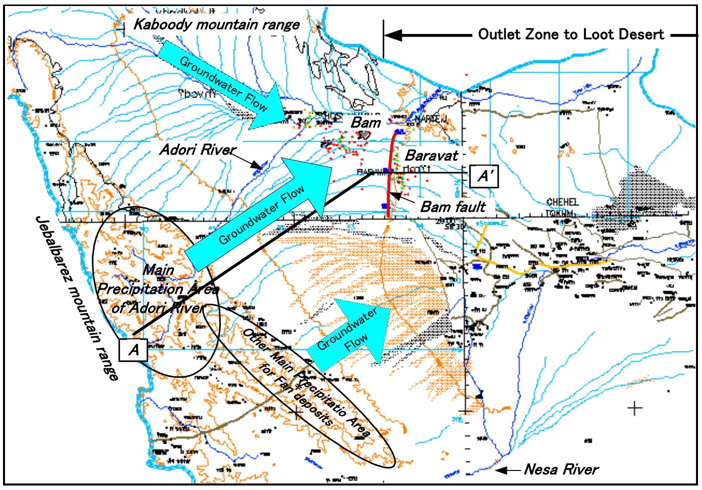


Figure 3.4 Hydrological Condition of Bam and Baravat Areas

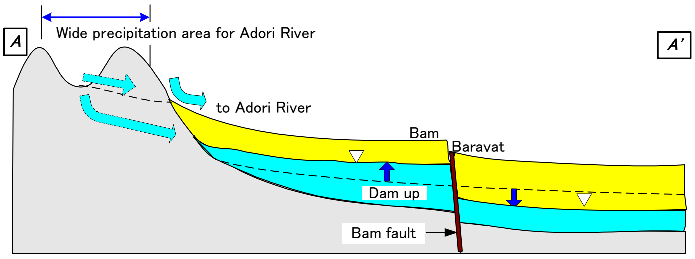


Figure 3.5 Schematic Cross Section of Adori River and Baravat Areas

Table 3.3 Optimum Pumping Yield of Existing Wells

Well No.	Depth	Dynamic W.L.	Static W.L.	Estimated Thickness of Aquifer	Coefficient of Permeability		Estimated Transmissivity	Optimum Pumping Yield	Radius of Influence
	(m)	(mBGL)	(m)	(m)	(m/day)	(cm/sec)	(m^2/day)	(litter/sec)	(m)
4	185	98	86	99	5.44	6.30E-03	539	35	200
5	179	135	90	89	5.44	6.30E-03	484	55	199
6	185	100	75	110	5.44	6.30E-03	598	28	203
7	(200)	200	90	110	5.44	6.30E-03	598	28	203
8	200	140	75	125	5.44	6.30E-03	680	20	207
9	185	110	100	85	5.44	6.30E-03	462	55	195
10	185	125	100	85	5.44	6.30E-03	462	55	195
11	185	140	105	80	5.44	6.30E-03	435	55	190
12	250	150	(120)	130	5.44	6.30E-03	707	25	215
13	(250)	(190)	(120)	130	5.44	6.30E-03	707	25	215
14	250	190	120	130	5.44	6.30E-03	707	25	215
15	250	190	120	130	5.44	6.30E-03	707	25	215
16	(250)	(190)	(120)	130	5.44	6.30E-03	707	25	215
								456	

( ) data estimated based on various sources

Table 3.4 Optimum Pumping Yield of Test Wells

Well No.	Depth	Dynamic W.L.	Static W.L.	Estimated Thickness of Aquifer	Coefficient of Permeability		Estimated Transmissivity	Optimum Pumping Yield	Radius of Influence
	(m)	(mBGL)	(m)	(m)	(m/day)	(cm/sec)	(m2/day)	(litter/sec)	(m)
DP2	230	98	117.18	112.82	6.32	7.21E-03	683	30	208
DP5	203	135	93.2	99.06	14.74	1.71E-02	1532	10	257
								40	

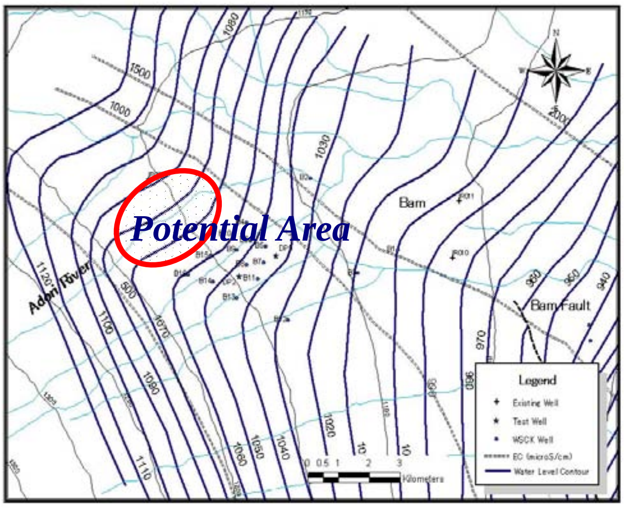


Figure 3.6 Potential Area for Groundwater Development

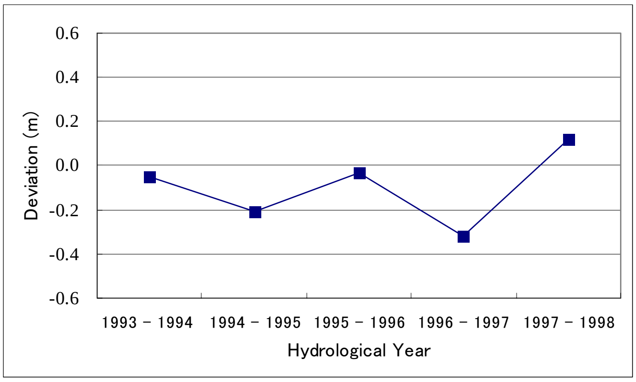


Figure 3.7 Groundwater Level Deviation of Each Hydrological Year

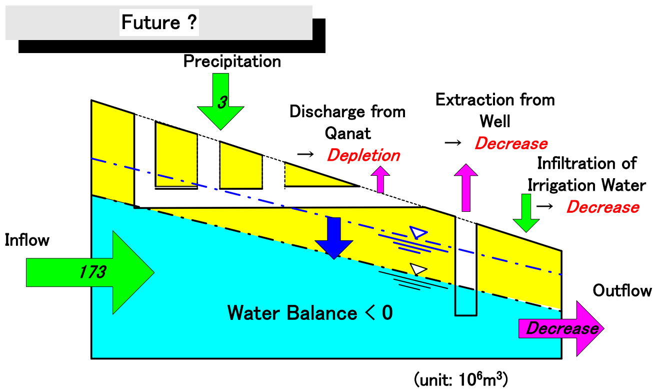


Figure 3.8 Possible State of Water Balance in Case of Non-Watershed Management

Recommendation

For the evaluation of the groundwater development plan, water balance should be considered in detail from the view point of sustainable water usage in the next step.

As it is mentioned in Chapter 3, most of extracted water was consumed for irrigation purpose. In Bam area, agriculture activity and its enlargement are an indispensable for the livelihood for people. There are a lot of qanats in the study area. The amount of discharge from qanats is significantly affected by the lowering of groundwater level. In fact, there is a report that mentions the shortage of water balance is 6MCM a year. Since the amount of 141MCM a year of groundwater is extracted from qanats for the irrigation purpose, some affect will be happened and will be critical issue for the regional sustainable economic development in future, unless the water consumption should be managed properly.

Therefore, considering the achievement of the sustainable economic development in Bam area after the earthquake, the water resources development and management plan should be formulated by the execution of study on comprehensive water resources in Bam desert.

1) To Implement Monitoring of Groundwater Resources in Bam-Narmashir Watershed Unit

Groundwater resources are distributed in the Watershed Unit continuously in whole bam desert. Therefore, in order to understand the situation of water resources, more systematic groundwater resources monitoring listed below is strongly recommended in Bam-Narmashir Watershed Unit as a part of the study on water resources development and management plan. Recommended locations of each monitoring points are shown in Figure 3.6.1.

- groundwater level monitoring
- surface discharge monitoring
- precipitation and other meteorological components monitoring

2) To Keep Hydro-geological Information

It is strongly recommended that the information related to the hydro-geological conditions be analyzed, kept and monitored in terms of stability of water supply condition and sustainable use of groundwater resources. Hydro-geological information to be kept is as follows.

- geological description of drilled well with the coordinates
- result of pumping test (step test, continuous discharge test, recovery test)
- well structure (depth, diameter of well and casing pipe, length and position of screen

- groundwater level (static water level, dynamic water level)

4. Long-term Plan on Reconstruction of Water Supply System

Introduction

A preliminary design of the distribution network was conducted by the JICA Study Team in February and March 2004. Then WSCK contracted with Jooyabu-nou Consulting Engineers to conduct detailed design of the distribution system. At present, the construction work on distribution system is on going based on the detailed design.

However, WSCK has no expansion plan of conveyance system because the location of new wells is uncertain. Moreover, WSCK has no plan of remote control system despite its necessity. Therefore, long-term development plan of water supply system including remote control system and conveyance system are studied in this chapter.

Planning Condition

Target Year and Population Served

Target year of 2023 for the water supply development plan was proposed by the JICA Study Team and Hengam, then this target year was adopted by WSCK.

Bam city and its surrounding area are divided into 14 zones. These zones are established by Task Force for handling of reconstruction activities sponsored by Provincial Housing Foundation.

Table 4.1 Future Service Population by Region

Category	Population after Disaster	Population served In 2031
Bam (Urban)	64,887	173,486
Bam (Rural)	4,307	11,514
Baravat	15,875	43,905
Grand Total	85,069	228,905

Water Demand

(1) Unit Water Demand

Table 4.2 Daily Average Unit Water Demand per Capita

(Unit: m³/person)

No.	Item	2003	2031
1	Domestic	151	164
2	Non-domestic	27	19
3	Losses	25	20
Total		203	203

(2) Water Demand

Maximum water demand for designing facilities (i.e. reservoir and pipe) is estimated based on the following conditions:

- Daily Peak factor for determining capacity of reservoir: 1.8
- Hourly peak factor for designing distribution network:
  1.4 for Bam network
  1.5 for Baravat network

Table 4.3 Future Water Demand in 2031

		Daily Ave.		Daily Max.		Peak Hourly	
Area	Population	Unit Water Demand	Water Demand	Unit Water Demand	Water Demand	Unit Water Demand	Water Demand
		(lpcd)	(m³/day)	(lpcd)	(m³/day)	(lpcd)	(l/s)
Bam	185,000	203	37,555	365	67,525	512	1,096
Baravat	43,905	203	8,913	365	16,025	548	279
Total	228,905	-	46,468	-	83,550	-	1,375

Planned Distribution System

Distribution Block

Bam service area has a slope evenly tilting toward the east. The altitude ranges from 1,130 m at the westernmost point to 1,020 m at the easternmost point of the service area. Existing distribution reservoirs are located in the southwest of the city to distribute water by gravity. The service area of Bam is divided into two blocks; West Block and East Block. The No. 1 reservoir (R1), located near the intersection of Amir Kabir Street and the main road (Kerman to Bam), distributes water to East Block. The No. 2 reservoir (R2), located 1.7 km away from the main road, distributes water to West Block. The water level of this reservoir is approximately 1,160 m above the sea level.

The altitude of east block ranges from 1,080 to 1,020 m, so excessive water pressure may be seen through the distribution network in eastern part of the block during the night. Due to the excessive water pressure during the night, the east block shall be divided into two areas, connected with two pipelines. The water to the east area is supplied through western pipe network, and two pressure reducing valves.

A planned service area of Baravat is approximately 17 km² and its altitude ranges from 960 to 1,010 m. The water is supplied from two reservoirs newly constructed at the middle of the service area of Bam and Baravat. The water level of these reservoirs is approximately 1,040 m above the sea level. The planned service area of Baravat is divided into two blocks, north and south.

Planned Distribution Pipe Network

Preliminary design with target year 2031 was carried out by Jooyabu-nou Consulting Engineers based on conditions aforementioned. The lengths of the pipes by diameter are shown in Table 4.4.

Table 4.4 Distribution Pipe Length by Diameter

(Unit: m)

Dia.(mm)	Bam East	Bam West	Baravat North	Baravat South	Total
110	64,950	43,220	20,140	30,420	158,730
150	35,490	7,430	8,810	15,310	67,040
200	23,660	2,330	1,250	8,660	35,900
250	4,840	2,210	360	2,570	9,980
300	3,150	1,560	-	840	5,550
350	-	3,320	-	-	3,320
400	8,670	-	-	160	8,830
500	390	-	-	-	390
Total	141,150	60,070	30,560	57,960	289,740

Planned Remote Control System for Well Pumps

Introduction

In order to improve the existing operation procedure for the existing water supply system, introducing a remote control system consisting of computer system, mechanical equipments, instruments, mimic panel and electrical facilities are proposed.

Remote Control System

- The central remote control unit conducts not only control but also monitor the status of equipments and instruments in each well pumping station and the reservoirs via wireless communication. Also, this unit provide with the alarming, tagging, reporting, historical trend recording and printing.
- Proposed instrument diagram is shown in Figure 4.4.1 (Chp.4).
- Each local remote control unit is installed in each house of the well pumping station and the reservoir and is connected with the instruments and mechanical equipment with cables to transmit and receive signals.
- The mechanical equipments are consists of the motor-operated valves and pump to conduct controls, and the instruments consists of the flowmeter, pressure transmitter, level transmitters, ammeters and voltmeters to measure operating conditions.
- The mimic panel indicates the status of pump running and is installed in the control room.
- The data transmission shall be conducted via wireless communication
- The control house shall be constructed not only control room for the installation of the central remote control unit but also stuff room.
- The room plan of proposed control house is shown in Figure 4.4.3 (Chp. 4).

Planned Electric Facilities

In connection with the proposed remote control system, it is necessary to provide with the distribution boards, cables, grounding systems and lightning protections

Cost Estimation for the Remote Control System

Introduction of proposed remote control system to 15 wells (No4~No.16, DP2 and DP5) is defined as phase1and future introduction targeting additional new 8 wells is defined as phase 2. Estimated construction cost of phase 1 and phase 2 is US$ 863,000 and US$ 324,500, respectively.

Proposed Conveyance Pipes

As mentioned in section 4.2.3, the water demand for Bam in 2023 is 53,140 m³/d. Of the 53,140 m³/d (=615 l/s), 83% is needed for east distribution block. This water amount will distributed from R1 to east distribution block. Moreover, needed water of 11,556 m³/d (134 l/s) for Baravat service area will be distributed from R1, because existing wells in Baravat will be disused.

Table 4.5 Required Water Quantity

Area	R1 System	R2 System	Total
Bam	510	105	615 l/s (53,140 m³/d)
Baravat	134	-	134 l/s (11,556 m³/d)
Total	644	105	746 l/s (64,496 m³/d)

According to WSCK's planning, some modifications on existing wells are to be made as follows:

- Water drawn from Well No.4 will be connected to R1
- Well No.1-No.3 within Bam city will be disused
- Well No.1-No.2 in Baravat will be disused

In that time total quantity of R2 conveyance system become 309 l/s as follows:

- Well No.5~No.12: 273 l/s (see Table 2.1.2; Chp.2)
- Well No.4: 36 l/s (see Table 2.1.2; Chp.2)

The R2 conveyance system is relatively new and its pipe diameters and pipe routes are appropriate for the most part. According to measured discharge flow of wells for R2 system, its total is 108 l/s. Hence, additional wells and modification of conveyance pipe for R2 system might not be necessary.

On the other hand, the conveyance pipe for R1 system should be expanded because additional wells are absolutely necessary to meet future demand of 644 l/s.

(1) Additional wells

The shortage amount of water drawn for R1 conveyance system is estimated at 335 l/s (=644 - 309). Assuming that 19 wells including additional 10 new wells for R1 conveyance system are required, the conveyance system is studied in this long term plan. Supposing that these locations are near the Adori River, R1 conveyance system is planned in this long term plan.

(2) Alignment of Proposed Conveyance Pipe

The existing conveyance pipes connect the eight wells and R1 as shown in Figure 4.5.1 (Chp.4); the connection is complicated. The water drawn from the eight wells are transmitted by pressure flow. However, in this system, on/off of each pump could exert negative effect to the other pumps. Therefore, gravity flow is recommended in main conveyance pipes.

Hydraulic calculation for R1 conveyance pipes is shown in Table 4.5.2 (Chp.4).

(3) Ventilation Pipe

Ventilation pipe is necessary in the discharging point to keep gravity flow. The ventilation pipe should be installed near pump house and fenced around to avoid accidents.

Implementation Schedule

The proposed water supply system is illustrated in Figure 4.6.1 (Chp.4).

The schedule of construction of remote control system, new conveyance pipes, additional wells and secondary distribution pipe network has not been fixed yet. The JICA Study Team proposed the implementation schedule for reference as shown in Table 4.6.1 (Chp.4).

Cost Estimation

Basis of Cost Estimates

The project costs are estimated under the following conditions:

All the costs are estimated under the economic conditions prevailing in October 2004.

- Exchange rate of currency is:
  USD 1.00= Rials 8,750,
  Euro 1.00= Rials 10,000
  Yen 1.00= Rials 78
- Engineering service cost, physical contingency and administration cost are assumed to be 8%, 10% and 2% of the total construction cost, respectively.
- Price inflation is not taken into account
- The project cost includes contributed portion by UNICEF, JICA and so on.

Project Cost

The project is composed of construction cost of:

Summary of project cost is shown below.

Table 4.6 Summary of Project Cost

Unit: '000 US$

A. Construction Cost		22,137
1) Main distribution pipe	13,232	
2) Secondary/tertiary distribution pipe	4,461	
3) Baravat distribution reservoirs	1,150	
4) New 10 wells	1,200	
5) New conveyance	906	
6) Remote control system	1,188	
B. Indirect Cost		4,477
1) Physical contingency (10% of A)	2,214	
2) Land acquisition	50	
3) Engineering service (8% of A)	1,771	
4) Administration costs (2% of A)	442	
C. Project Cost (A+B)		28,614

Operation and Maintenance Plan

Effective and sustainable upheld quality of daily and periodic operation and maintenance, as well as sufficient preparation for such incidents could lessen adverse impacts and provide prompt recovery of water supply to the affected people. Carefully designed daily and periodic operation and maintenance tasks, which should be carried out in proper manner following evidently written manuals and instructions, will ensure providing safe and uninterrupted water supply and will extend the life-long of machinery and facility used.

It is, thus, crucial for such company to set 1) operational and management tools for programming, performance evaluation and control of activities, 2) information control to formulate operation and maintenance plans and to identify training needs, 3) more thorough consideration on operation and maintenance requirements at the stage of project planning, design and construction, and 4) effective preventive maintenance procedures to minimize breakdown, and prolong the operational life of the service.

Redefining Organizational Structure of BWSC

It should be pointed out that current organizational structure is somehow a combination of functional structure and the structure based on facilities, i.e. there are functional sections of financial affairs, network operation and installation and technical services, and facility based structure of laboratory, warehouse and branch offices. The structure of company, therefore, should be redefine based on its planning function, business function, operational function and technical function. General affairs, such as administration, procurement, public relations, financial affairs and human resources are related to all functions and sections, so those functions shall be considered as a ground function of the institution.

The functional structure shall be divided into four divisions, and duty and responsibility of respective division shall be defined tangibly but not to be segregated as a vertical administrative system.

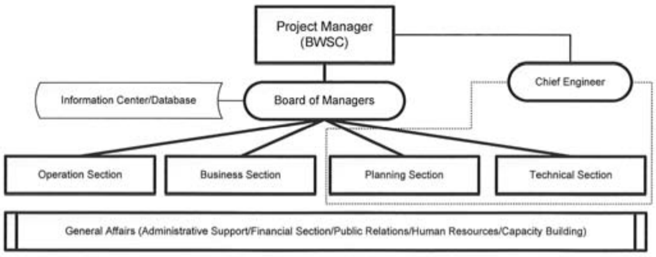


Figure 4.1 Proposed Organizational Structure

Operation and Maintenance for Water Loss Control

Water loss control activities consist of various measures, such as network survey, macro and micro metering control, leakage control, mapping and inventory management, improvement of housing connections and maintenance of distribution pipe network.

Mapping and inventory management is one of the vital components, among others, for BWSC to carry out without any delay, whereas new distribution pipe network is being installed and almost all network will be rebuild in the next few years in the Bam and Baravat areas. It is crucial for BWSC to take an initiative to up-to-date and ensure the accuracy of mapping and as-built drawing and inventory of distribution pipe network. It is also suggested to set up routine procedures for verifying and updating pipe route maps, drawing and inventory of pipes and fittings. It is also strongly recommended that GIS is used for base-map, mapping and drawing to ensure the accuracy the pipe network, and furthermore it is suggested to possibly exchange maps and as-built drawings in same plat-formed digital format with other public corporation and private utility services, such as electricity, telephone and cables.

Operation and Maintenance Costs in the Future

Financial estimate for future operation and maintenance in accordance with the water supply system development plan is scrutinized. The basic conditions are same as the cost estimates for the projects.

An average operation and maintenance cost per supplied water per m^3 and accounted water is 480 rials and 680 rials, respectively, which is not much significantly high considering the current revenue level. However, it should be noted that the amount will increase to some extent, if the depreciation of facilities and equipment is taken into account.

If BWSC will be able to resume the previous level of revenue from water charges, it is considered feasible to cover the operation and maintenance expenses.

5. Recommendations

Recommendation for Groundwater Resources Development

1) To implement Monitoring of Groundwater Resource in Bam-Narmashir Watershed Unit

More systematic groundwater resource monitoring listed below is strongly recommended in Bam-Narmashir Watershed Unit.

- groundwater level monitoring
- surface discharge monitoring
- precipitation and other meteorological components monitoring

2) To Keep Hydro-geological Information

It is strongly recommended that the information related to the hydro-geological conditions be analyzed, kept and monitored in terms of stability of water supply condition and sustainable use of groundwater resources. Hydro-geological information to be kept is as follows.

- geological description of drilled well with the coordinates
- result of pumping test (step test, continuous discharge test, recovery test)
- well structure (depth, diameter of well and casing pipe, length and position of screen
- groundwater level (static water level, dynamic water level)

Recommendations for Operation and Design of the Water Supply System

1) Review of Master Plan of Water Supply System

While the water distribution system is currently being constructed based on the master plan with the target year of 2031, it is recommended to review the master plan on water supply system in 2010 because the target year, 2031, is too far ahead and it is difficult to forecast recovery works after merely a year from the earthquake.

2) Non Revenue Water Control

Bam east block is divided into two service areas connected with two pipelines. Installation of flowmeter on the pipelines is recommended for effective distribution system operation because the comparison of measurement of actual water quantity supplied and revenue water quantity can be more easily identified by locating leakage point and inefficient water use in smaller service area.

3) Installation of Emergency Shutoff Valve

In the existing water distribution system, the most water is transmitted from reservoirs to the consumers by gravity Therefore, if a pipe of distribution network is broken, water runs off automatically. This running off continues until the reservoir become empty or all valves concerning to the broken point are closed. Especially when a main pipe is broken, a lot of water would run off. Therefore installation emergency shut off valves at outlet pipe of the reservoirs is recommended.

4) Installation of Drop Panel to Reservoir Design

According to the collective typical drawings on ground type water reservoir published by MPO, top slab is supported by columns directly. In this case big shear force acts on the top slab at columns. Flat slab with drop panel for water reservoir is recommended as shown below.

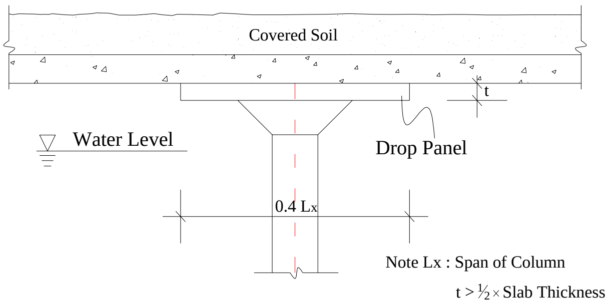


Figure 5.1 Flat Slab with Drop Panel for Water Reservoir

Introduction of Mapping System

Introduction of Mapping System is recommended for operation maintenance of water supply facilities. These mapping system concepts are described as follows:

a. Required computer device such as printer, software, digitizer and so on is installed in BWSC main office within Bam city
b. Preparation and collecting data
    - topographic map road, qanat, stream, pole, embedded facilities like cables and pipes
    - as built drawings regarding distribution and conveyance pipes
    - property data of distribution and conveyance pipes such as diameter, pipe material, time installed, contractor and so on
c. Inputting and updating the data and information regularly

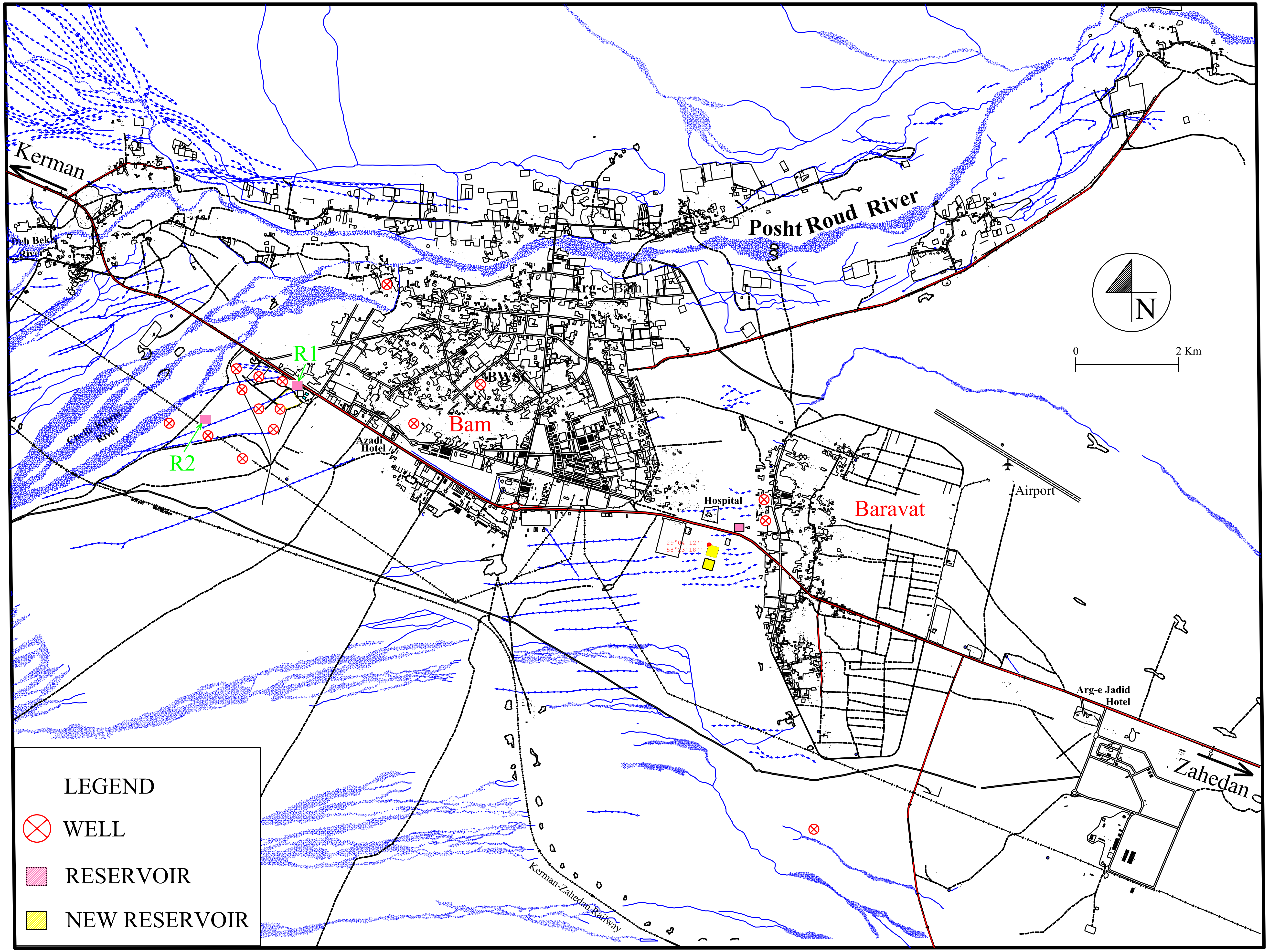
Recommendation on Environmental Aspects

Exiting daily average water demand of 21,109 m^3/d would reach 35,842 m^3/d in 2023. This is 1.7 times of existing water demand. Therefore wastewater amount also will increase automatically. This wastewater increasing might deteriorate present environment condition in Bam. In order to keep good living environmental condition, wastewater disposal system is expected to be employed in near future

Recommendation for Operation and Maintenance

It is recommended to redefine and demarcate the task, command line and responsibilities of respective sections in accordance with rational classification of objectives and activities. Capacity building shall be carried out with much emphasis, especially on technical skills, to empower the human resources.

When Bam city recovers from the earthquake disaster and the civil life becomes stable some years later, collecting tariff shall be resumed.



Project Area

CHAPTER 1 OVERVIEW

1.1 General

1) Introduction

This is the final report prepared by the JICA Study Team for “The Study on the Bam Earthquake and Reconstruction of Water Supply System in Bam and Baravat Areas” to formulate the long-term water supply plan in Bam and its surrounding areas, followed by the Bam reconstruction assistance study. The Study Team was formulated shortly after the earthquake on December 26, 2003, which hit the southern Iranian city of Bam in Kerman province and left devastating physical damage and distress, not only to the people of Bam, but also to the nation.

Japan International Cooperation Agency (JICA), accordingly, appointed the study team of the “Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area in the Islamic Republic of Iran” to carry out a primary survey to investigate the damage and consequence of the earthquake, considering that the study team has continually worked in Tehran on earthquake disaster management, as a JICA technical cooperation assistance, since 1999.

The government of Japan (GoJ), through JICA, sent a preparatory mission to the affected areas in January 2004 to investigate the extent of damage caused by the earthquake, and to formulate tangible disaster-relief measures for those who suffered, following the urgent medical assistance dispatched right after the earthquake. The first preparatory survey was conducted for two weeks from January 10, 2004, and the first report was formulated based on the observations and findings on the distressed Bam and surrounding areas.

2) Background of the Study

The preparatory mission sent by the GoJ had held intensive meetings with related governmental agencies and institutions concerned, and inspected various facilities with a view to grasping tangible needs for future assistance from Japan.

Among other primary social infrastructure in the Bam areas, water supply and irrigation facilities were severely damaged by the earthquake. Residential buildings were mostly collapsed and the people were forced to live in tents or temporary housing nearby their house. In a struggle to retain the key industry of the Bam areas, it was a matter of extreme urgency to restore the functions of lifeline facilities, such as water supply, i.e. distribution reservoir, piping network and its operation systems, and quanat irrigation, so as to accelerate the reconstruction progress of the local community.

As a consequence of the findings by the mission and corresponded to its urgency, the GoJ decided to proceed with the Bam earthquake study supplemented to the “Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area,” in collaboration with Tehran Disaster Mitigation and Management Center (TDMMC), covering the following three major sectors:

- Rehabilitation study of water supply system
- Rehabilitation study of agriculture sector
- Revitalization of the community

The study area was the earthquake-hit area of Bam municipality and its surrounding towns and villages, including Baravat. Counterpart agencies were set as 1) Water and Sewage Company of Kerman (WSCK) for the rehabilitation of water supply systems and 2) Management of Jihad and Agriculture in Bam Township for the rehabilitation of agriculture and community.

After the second reconnaissance mission in the Bam areas, the scope of the study was narrowed down to the rehabilitation of water supply systems as it is described in detail in the following section.

3) Scope and Schedule of the Study

The scope of the study is set to introduce a water supply system which is seismic resistant and feasible to maintain, and the work items should cover 1) water supply network reconstruction plan and the formulation of long-term reconstruction plan, and 2) evaluation of water source potential, which includes digging of two test boreholes.

The first primary component, the formulation of the long-term reconstruction plan consists of 1) designing of water supply system, 2) implementation plan, operation and maintenance plan, 3) preliminary design of monitoring and control system for the operations of well pumping stations, and 4) cost estimate of implementation of the reconstruction plan.

The second component is to implement the construction work of 1) water network facility, which is approximately 30 km of the priority route in Bam municipality, 2) a distribution reservoir ($V=2,000m^3$) with a gate house and a chlorination house, including chlorination equipment in Baravat, and 3) the building structure of pump house (No.3) in Baravat

The ultimate objective of the rehabilitation work is to restore the damaged facilities to the pre-earthquake conditions in the course of the project.

Figure 1.1.1 shows the schedule of the study from the preparatory mission sent in January 2004 to a seminar which will be held in February 2005.

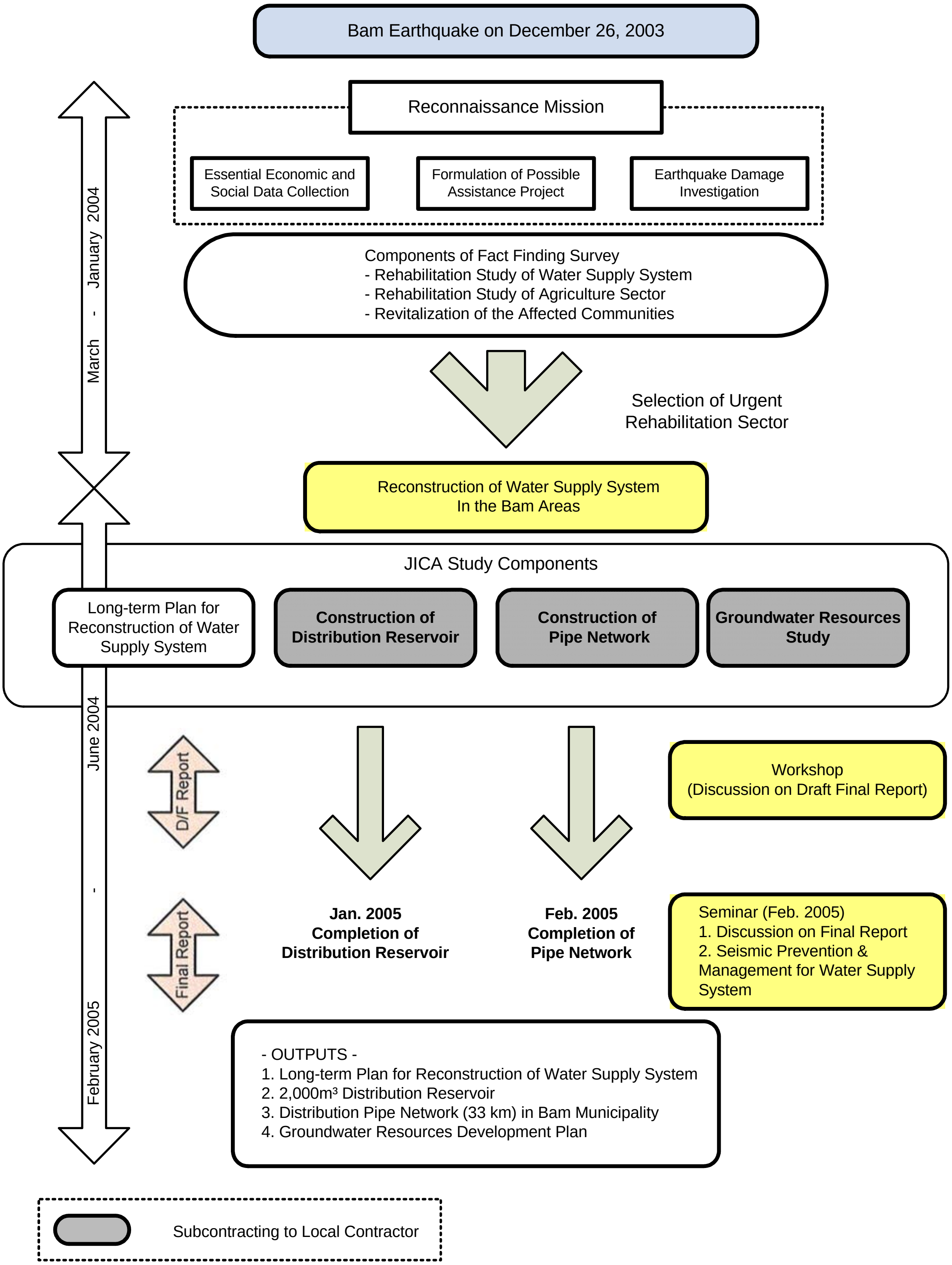


Figure 1.1.1 Schedule of the Project

Figure 1.1.2 shows the relationship of study organizations and the member lists of the study team, JICA advisory committee and counterpart are shown in Appendix.

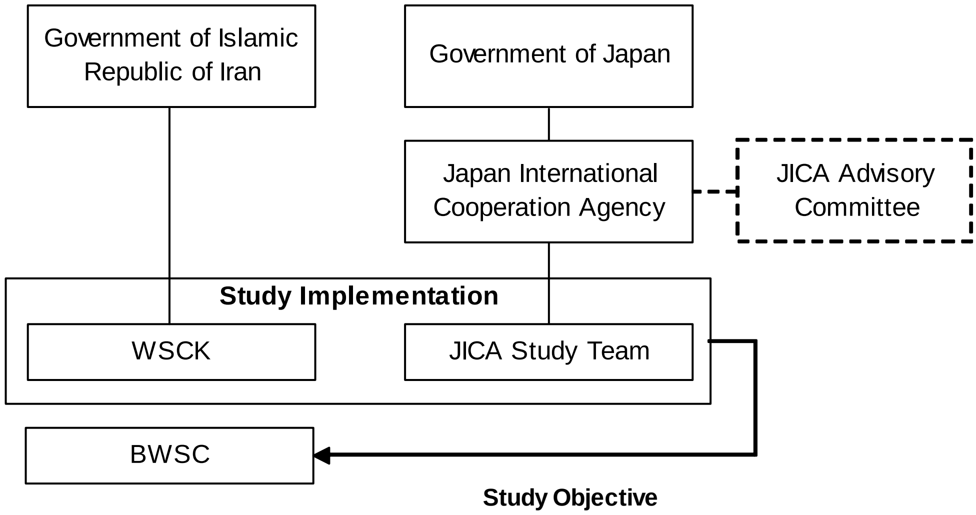


Figure 1.1.2 Study Organization

4) Outputs of the Project

Overall reconstruction works on Bam water supply system is being implemented by WSCK, while a part of the works are also being carried out in parallel by the study team funded by JICA. Those works are composed of two physical infrastructure construction works and two studies, which are 1) Baravat water distribution reservoir, 2,000 m³, 2) distribution pipe network, in the length of 33 km, 3) long-term plan for reconstruction of water supply system, and 4) the groundwater resources development study to evaluate the potential of groundwater resources in the well field for the sustainable use.

The 2,000 m³ distribution reservoir is one of two distribution reservoirs in the total volume of 5,000 m³ that were planned by WSCK in order to meet the water demand in the future targeting 2023. According to the Minutes of Meeting signed June 20, 2004, the 2,000 m³distribution reservoir is to be built in Baravat area next to the other distribution reservoir, 3,000 m³, constructed by WSCK.

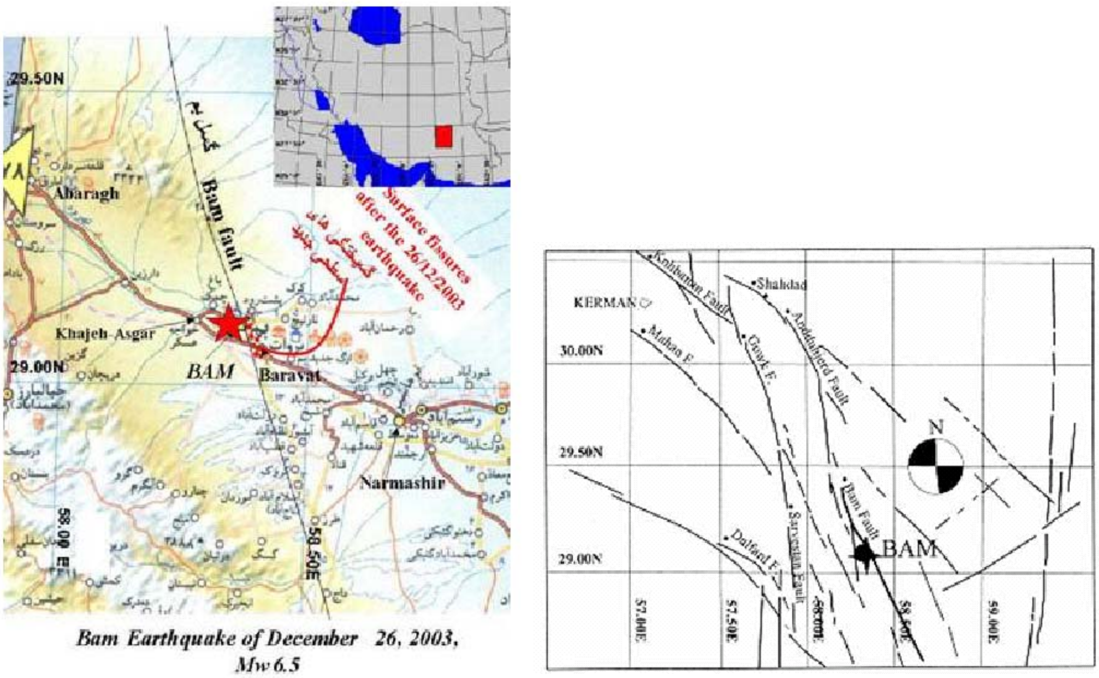
The distribution pipe network is laid in the Bam municipality areas, in its total length about 33 km as it planned. The network is a part of the reconstruction of water pipe network project initiated by WSCK and its expected total length is more than 420 km, carried out within three years term. JICA study team has implemented high propriety segments requested by BWSC.

The long-term plan for reconstruction of water supply system and groundwater resources development studies are carried out to analyze the balance of water demand and supply until year 2023, and the potential of groundwater resources development in the Bam and Baravat areas. The details of study analyses and recommendations are illustrated in the following chapters.

1.2 Intensity and Characteristics of the Bam Earthquake

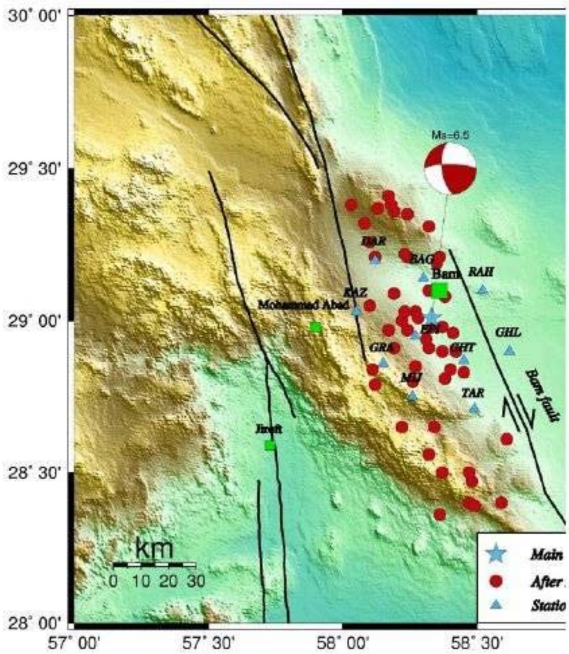
The earthquake hit Bam and the surrounding areas at 5:26 in the morning on December 26, 2003, measuring 6.5 on the Richter scale. According to seismologists, the earthquake was one of the shallowest recorded with a focal depth of only 10-12 km, and the epicenter was directly underneath Bam city where a main earthquake fault line can be found. The earthquake was the worst one to hit the country in more than a decade. USGS reported Ms=6.8, Mb=6.0 and Mw=6.5 as the extent of the earthquake in the Bam areas, and Harvard university reported Mw=6.6, Tokyo university at Mw=6.7 and Building Research Institute in Japan at Mw=6.5 respectively.[1]

The report of IIEES is shown in Figure 1.2.1 regarding the epicenter and focal mechanism of the earthquake, and that of USGS is shown in Figure 1.2.2. Figure 1.2.3 shows the distribution of fault-slip estimated using the inversion analysis by Yuji Yagi. The analysis of stress change on the fault plane due to fault slip done by Yagi is also shown in Figure 1.2.4.



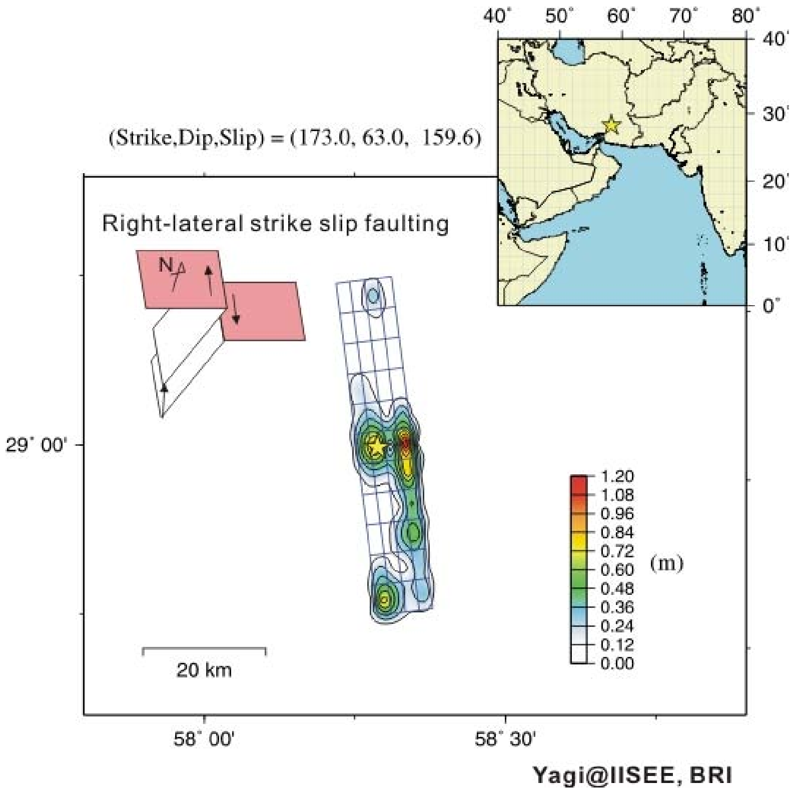
Source: International Institute of Seismology and Earthquake Engineering (IIEES)

Figure 1.2.1 Location Map of Bam Earthquake



Source: IIEES

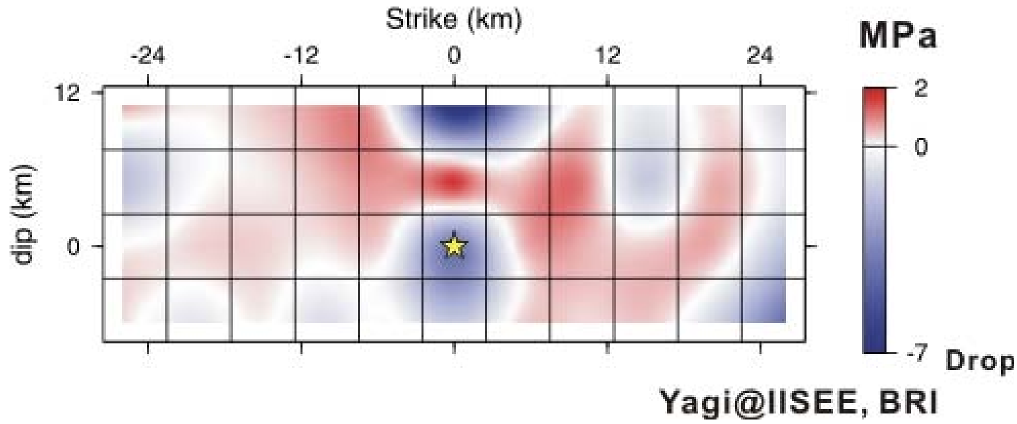
Figure 1.2.2 Bam Fault and Epicenter



Source: IIEES

Figure 1.2.3 Distribution of Fault-Slip (by Yagi)

[1] Mw is to express the magnitude of damage based on the physical condition of fault.



Source: IIEES

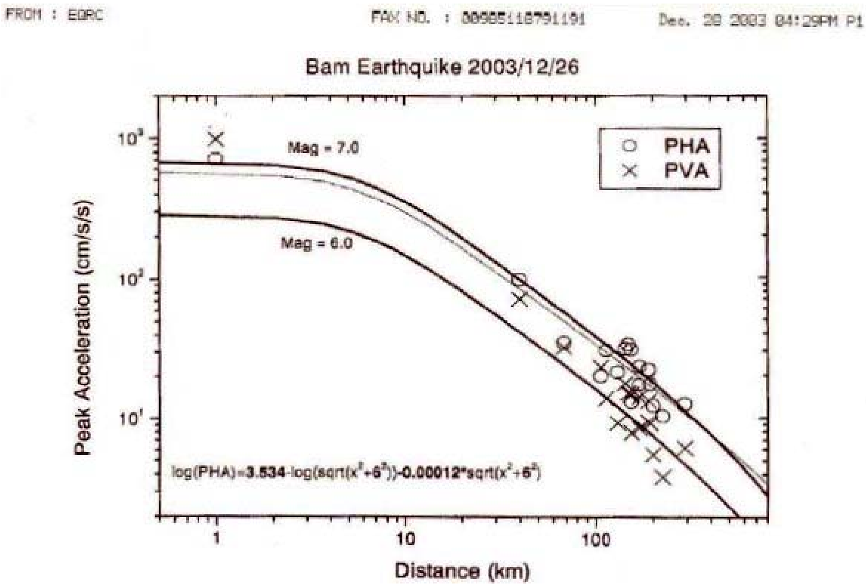
Figure 1.2.4 Stress Change on the Fault Location due to Fault-Slip (by Yagi)

Table 1.2.1 Specification of the Accelerograms of Main Shock recorded by Accelergraphs

Site Name	Record No.	Geographic Coordinates		Marcoscismic Center		Distance (km)	Reporter	Uncorrected PGA cm/s/s			Height from sca	Installation angle	
		E	N	E	N			L	V	T		L	T
Bam	3168/02	58.35	29.09	58.40	29.21	14	IGTU	799.06	988.50	636.37	1094	278	8
Mohamad abad Maskoon	3162/01	57.89	28.90	58.40	29.21	60	IGTU	123.52	70.74	71.40	1961	350	80
Jiroft	3170/02	57.74	28.67	58.40	29.21	88	IGTU	40.33	31.81	28.30	725	240	330
Jushan	3156	57.60	30.12	58.40	29.21	127	IGTU	24.99	17.52	36.64	1650	142	232
Anduhjerd	3164	57.75	30.23	58.40	29.21	130	IGTU	32.05	14.91	34.38	851	200	290
Sirj	3161	57.55	30.20	58.40	29.21	137	IGTU	31.13	14.64	29.71	1685	30	120
Golbaf	3155/02	57.72	29.88	58.40	29.21	99	IGTU	30.78	13.70	29.46	1698	150	240
Kerman	3157	57.04	30.29	58.40	29.21	178	IGTU	18.75	9.40	25.03	1767	175	265
Ghalchganj	3163	57.87	27.52	58.40	29.21	195	IGTU	21.04	13.99	24.99	439	210	300
Nosratabed	3160	59.97	29.85	58.40	29.21	168	IGTU	19.79	13.16	23.92	1115	284	14
Kahnuj	3166	57.70	27.94	58.40	29.21	157	IGTU	23.53	9.24	18.55	556	20	110
Cheshmesabz	3169	56.42	29.46	58.40	29.21	194	IGTU	23.39	9.15	11.09	2581	65	195
Rein	3167/02	57.44	29.59	58.40	29.21	102	IGTU	21.49	22.95	18.08	2195	334	64
Shahdad	3165	57.69	30.41	58.40	29.21	150	IGTU	20.50	8.49	13.55	515	78	168
Bardseer	3172	56.57	29.92	58.40	29.21	194	IGTU	13.97	5.50	10.43	2113	75	165
Mahan	3159	57.29	30.06	58.40	29.21	143	IGTU	12.70	7.88	13.26	1864	150	240
Ravar	3173	56.79	31.26	58.40	29.21	275	IGTU	12.47	6.15	12.62	1244	320	50
Bolvard	3154	56.05	29.42	58.40	29.21	229	IGTU	10.11	3.83	10.45	2088	145	235

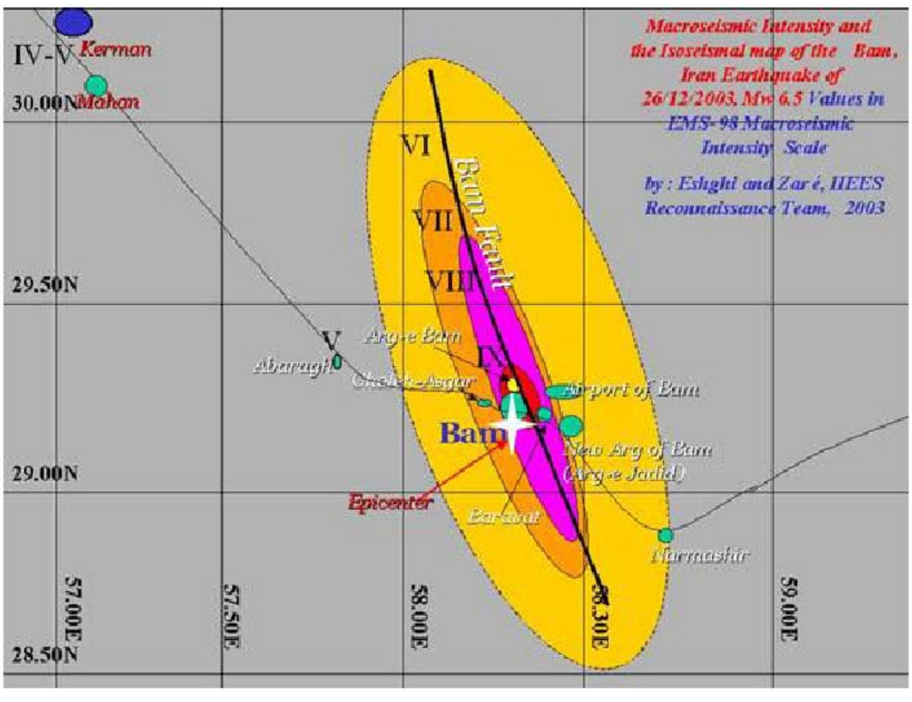
Source: BHRC

The largest value for horizontal peak ground acceleration is recorded at No.1 site, which is shown in Table 1.2.1. No.1 site is located at 14 km from the epicenter and it recorded 799.06gal. Attenuation curve is summarized in Figure 1.2.5. Figure 1.2.6 shows the distribution of the macro seismic intensity of the earthquake analyzed by IIEES.



Source: Ministry of Housing and Urban Development, Building and Housing Research Center.

Figure 1.2.5 Attenuation Curve



Source:IIEES

Figure 1.2.6 Distribution of the Macro Seismic Intensity of the Earthquake

As Figure 1.2.6 shows, macro seismic intensity of the earthquake for almost all of Bam urban area is lo=IX in the European Macroseismic scale.

If the PGA value for No.1 site, 799.06 gal, is applied to the equation below (by Trifunac and Brady, 1975), the figure of "modified Mercalli intensity scale" is corresponded to 9.6.

$\log (a) = 0.014 + 0.3 \times I$

The findings indicate that the intensity of the earthquake in almost all urban area of Bam shows same magnitude, yet Figure 1.2.3, Distribution of Fault-slip (by Yagi), implies that it could be some larger intensity area in the southern side of the epicenter, while the northern area of epicenter, where the center of Bam is located, shows the only slip. Thus, it can be said that the seismic intensity was probably high in the southern area of the epicenter, yet it is, at the same time, difficult to accurately identify the seismic intensity because no building structure can be found on these areas.

The findings, therefore, imply that the intensity of the earthquake motion in the central area of Bam city corresponds to MMI 9, and the intensity of the earthquake motion of the Baravat area, the Bam airport and the Arg-e-Jadid area corresponds to MMI 8 or less than that.

1) Outlook of Damage caused by the Bam Earthquake

More than 85% of buildings were completely destroyed and some 95% of the 2,500 years old historical archeological monument, internationally recognized Arg-e-Bam, was almost completely destroyed. Most of survivors have lived in tents or temporary housing on road side or close to their damaged house. They were reluctant to move to emergency camps because of various reasons, such as security, inconvenience and psychological reasons.

The extent and distribution of damage can be illustrated as follows:

- Damage level in Bam and Baravat shows some difference, even though the distance between those two areas is not far to each other from the fault line and epicenter.
- Many pancake-crushed buildings are found in the Bam areas.
- A significant correlation between the damage of buildings and intensity of earthquake motion was not found because the intensity of earthquake motions was very strong compared to the seismic resistance capacity of buildings.
- Earthquake resistance capacity of buildings is one of the dominant reasons for causing damages on building structures. Arg-e-Jadid area, especially, is different from the Bam and Baravat areas because the former have been developed recently targeting high-income residents, which implies higher quality and with better earthquake resistance.

(1) Damage on Building Structures

Building structures in Bam municipality are classified into three categories according to their construction year: 1) Arg-e-Bam, built about 2,000 years ago, 2) the buildings in old core city, built about 150 years ago, and 3) the buildings built in the vicinity of revolution era.

Old buildings were mostly built with masonry, some of which are called "adobe," which is made of sun-dried brick or burned brick. On the other hand, the buildings recently built have steel component to form frame.

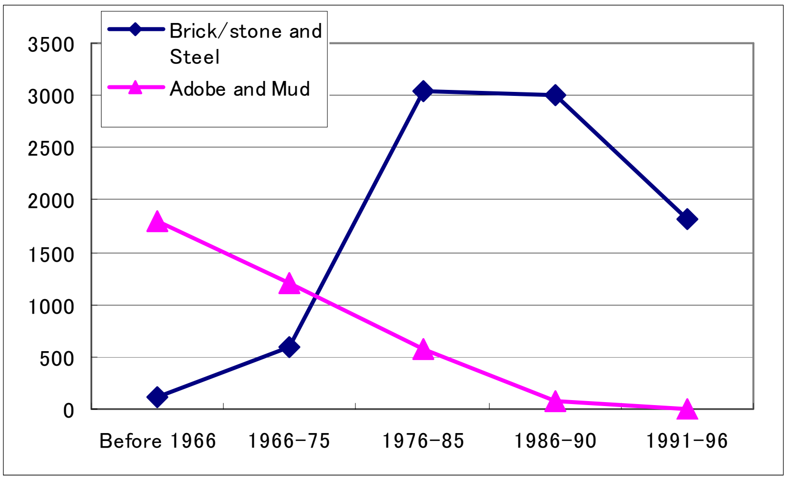
Table 1.2.2 shows the type of residential housing categorized by structure and material, built before 1996 in the Bam areas. As it shows, "steel frame" and "RC frame" consist only of 0.3% to the total, and the majority of buildings were built with "brick/stone and steel" and "adobe and mud" at 68.2% and 29.1%, respectively.

Table 1.2.2 Type of Residential Housing by Structure and Material

Structure & Material	Numbers	Ratio (%)
Steel frame	20	0.2
RC frame	9	0.1
Brick/stone and steel	8,602	68.2
Brick or stone-brick	91	0.7
Adobe and mud	3,666	29.1
Others	43	0.3
Not specified	176	1.4
Total	12,607	100.0

Source: Statistic Data 1996. Central Statistical Survey of Iran

Figure 1.2.7 shows the trend of typical structure and material of residential buildings over the decades. As it shows, the combination of adobe and mud used for residential buildings has decreased significantly over the years, and since 1986 it has not been used as much as before. Brick/stone and steel has taken the place of adobe and mud significantly since 1966 and has become the core structural material for building residential housings.



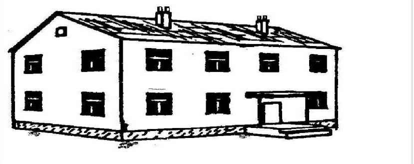
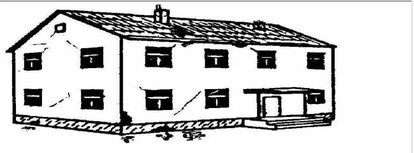
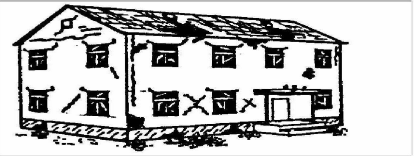
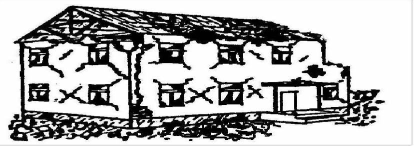
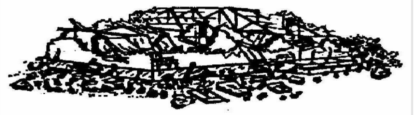
Source: Statistic Data 1996. Central Statistical Survey of Iran

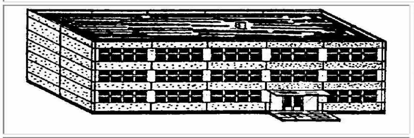
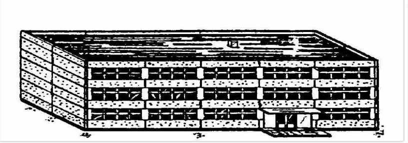
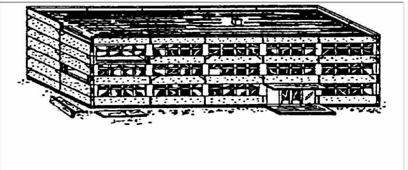
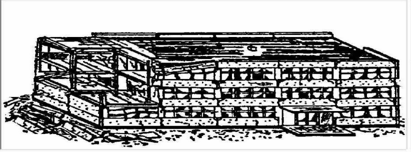
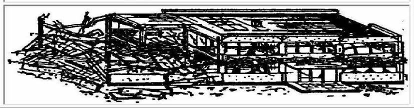
Figure 1.2.7 Residential Buildings Categorized by Year Build and Structure Type

Following are found from the reconnaissance right after the earthquake and primary observation:

- The damage of most buildings in Bam is seen as Grade 5 in EMS-98 scale.
- Satellite image shows that there is some disparity in the extent of damage between the eastern side, where commercial complexes are located, and the western side where land is mostly agricultural. However, the Study Team found little difference on the damage level between these two areas after field surveys.
- The extent of damage on adobe (sun-dried brick) structures is rated Grade 5.
- The damage of steel frame buildings in the center of Bam city is mostly rated Grade 4.
- The damage of masonry and steel frame structures in western side of Bam city is mostly rated Grade 4, heavily damaged, and some of them are rated Grade 3.
- The damage of adobe structures in Baravat is rated Grade 5.
- Building structures in Arg-e-Jadid, mainly built with masonry, steel frame and RC, are less damaged than those in Baravat and Bam city.
- The damage observed at most buildings in Arg-e-Jadid is rated Grade 3, if they are inspected from outside, but the inside damage can be downgraded to Grade 4.

Table 1.2.3 Damage State in EMS-98

Classification of damage to masonry buildings	
	**Grade 1: Negligible to slight damage** **(no structural damage,** **slight non-structural damage)** Hair-line cracks in very few walls. Fall of small pieces of plaster only. Fall of loose stones from upper parts of buildings in very few cases.
	**Grade 2: Moderate damage** **(slight structural damage, moderate** **non-structural damage)** Cracks in many walls. Fall of fairly large pieces of plaster. Partial collapse of chimneys.
	**Grade 3: Substantial to heavy damage** **(moderate structural damage,** **heavy non-structural damage)** Large and extensive cracks in most walls. Roof tiles detach. Chimneys fracture at the roof line; failure of individual non-structural elements (partitions, gable walls).
	**Grade 4: Very heavy damage** **(heavy structural damage,** **very heavy non-structural damage)** Serious failure of walls; partial structural failure of roofs and floors.
	**Grade 5: Destruction** **(very heavy structural damage)** Total or near total collapse.

Classification of damage to buildings of reinforced concrete	
	**Grade 1: Negligible to slight damage** **(no structural damage,** **slight non-structural damage)** Fine cracks in plaster over frame members or in walls at the base. Fine cracks in partitions and infills.
	**Grade 2: Moderate damage** **(slight structural damage,** **moderate non-structural damage)** Cracks in columns and beams of frames and in structural walls. Cracks in partition and infill walls; fall of brittle cladding and plaster. Falling mortar from the joints of wall panels.
	**Grade 3: Substantial to heavy damage** **(moderate structural damage,** **heavy non-structural damage)** Cracks in columns and beam column joints of frames at the base and at joints of coupled walls. Spalling of conrete cover, buckling of reinforced rods. Large cracks in partition and infill walls, failure of individual infill panels.
	**Grade 4: Very heavy damage** **(heavy structural damage,** **very heavy non-structural damage)** Large cracks in structural elements with compression failure of concrete and fracture of rebars; bond failure of beam reinforced bars; tilting of columns. Collapse of a few columns or of a single upper floor.
	**Grade 5: Destruction** **(very heavy structural damage)** Collapse of ground floor or parts (e. g. wings) of buildings.

Source: IIEES

Adobe

The majority of old buildings in the Bam areas are built with "adobe," or sun-dried brick. A typical shape of house is one-story, rectangle-shape with dome or cylindrical roof. Adobe is recognized as one of traditional forms of masonry in Iran, although the structure is significantly different from normal structure of masonry commonly known. Adobe is made with sun-dried brick and grouting materials, such as lime and clay mixture. A room of this type of building does not have a bind-up effect as a diaphragm; as a result, sidewalls easily fall down at the corner of building.

A foundation is not formed for this type of building, but a mixture of lime and clay, or lime and sand is put and compressed on the ground as a floor. Very thick walls are usually built for adobe and they have caused large numbers of human casualties, once natural disasters such as an earthquake hit the areas.

Masonry

Masonry building is relatively new in the areas and masonry is made of burned brick, but sun-dried brick is used in some cases for inside core, i.e. burned brick is used only for surface layer of walls. It was found that almost all masonry buildings have flat roof supported by steel beam; yet, some of steel beam are not connected to brick walls. In some cases, steel column is used instead of internal brick walls, and this type of building looks like a steel-frame structure, but beam-column connections do not have sufficient strength and bracing is not installed in many cases; thus, steel frames do not have enough resistance against horizontal inertia force.

Masonry with Tie

The structural type of "masonry with tie" has horizontal tie on brick walls. Bricks are firstly piled and concrete tie is cast in those bricks, so there is no void between bricks and tie, and then brick walls are confined by surrounding tie. The brick walls are relatively resistant against vertical force. The role of tie is to bind up the walls, especially, binding effects of walls in different directions are effective for resistance against horizontal force.

Steel Frame

The concept of steel frame in Iran is somehow different from that of Japan. A steel frame in Japan requires having sufficient strength to every beam-column connection against base material; therefore, the connections form moment resisting frame and ductility is gained to earthquake resisting motion. Nevertheless, most buildings in Iran do not reach to this technological stage, although some standard and instruction manual introduce the concept same as that in Japan.

Beam-column connection, in most cases, does not have sufficient strength comparing the base material because it is welded at site by filet welding. As a result, it does not form moment resisting frame. Some bracings are set to share resistance against horizontal force, but welding in gusset plate is also defective.

A space between frames is filled with infill wall, which is made of hollow brick or porous brick. The infill wall does not support vertical dead load because a slight void exists between frame and infill wall, so it does not provide sufficient resistance against horizontal inertia force due to insufficient shearing capacity of bricks. A brick wall is very heavy comparing to recently developed materials, and it is one of the main reasons that most buildings in Iran do not have enough strength against an earthquake.

Reinforced Concrete

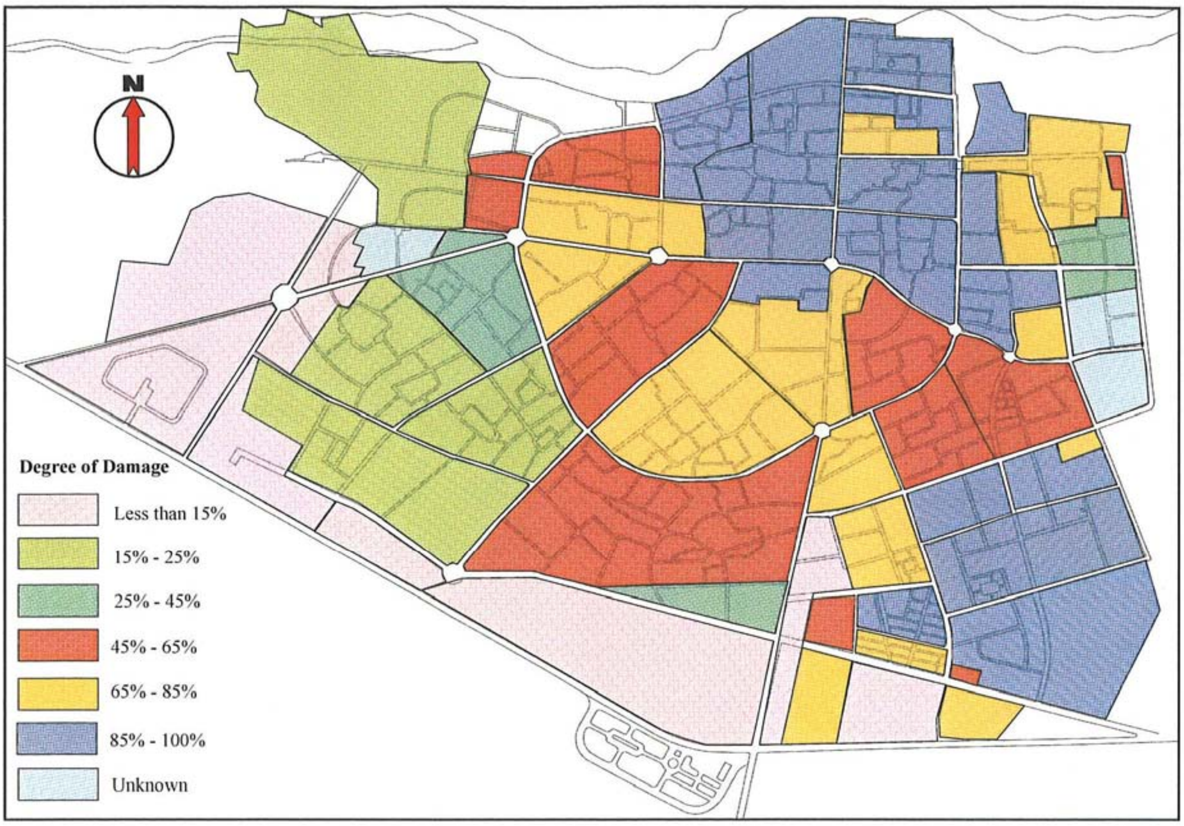
Only a small number of buildings are built as reinforced concrete structure in the Bam areas, and most of walls in the areas are made from hollow brick or porous brick. Since some void can be found between brick wall and reinforced concrete frame, the brick wall does not share a vertical dead load and there is no resistance on horizontal load when an earthquake hits. A floor in reinforced concrete structure is “joist and brick.” This type of floor is very heavy comparing to materials developed recently, and consequently it ruins the seismic resistance capacity of buildings.

Table 1.2.4 shows the estimated monetary damage caused by the earthquake. The estimate was done by a consultant hired by the Housing Foundation of Kerman. Figure 1.2.8 illustrates the damage of building structure due to the earthquake in Bam municipality.

Table 1.2.4 Estimated Monetary Damage caused by the Earthquake

Type of Facility	Number of Facility	Land Measure (m^2)	Damage Ratio (Max: 100%)	Amount (per m^2)	Total Damag in Monetary Value '000 (Rial)	Total Damage in Monetary Value Eqv. To '000US$
Education	83	544,208.42	60%	2,000,000	653,050,100	74,640
Medical facility	21	190,626.63	70%	4,000,000	533,754,580	61,010
Public & Municipality Bldg.	41	270,720.90	60%	2,500,000	406,081,350	46,410
Military	1	237,303.89	60%	2,500,000	355,955,840	40,690
Police	11	81,974.11	50%	2,500,000	102,467,630	11,720
Religious facility	54	77,867.76	60%	1,300,000	60,736,850	6,950
City services/Infrastructure	18	571,514.61	60%	3,500,000	1,200,180,680	137,170
Residential Bldg.	-	2,380,000.00	80%	150,000	285,600,000	32,640
Industrial Estate	50	135,190.84	60%	3,500,000	283,900,770	32,450
Roads	-	7,477,815.18	50%	200,000	747,781,520	85,470
Others	-	26,439,572.78	40%	700,000	7,403,080,380	846,070
Total		38,406,795.12				1,375,220

Source: Bam Reconstruction Master Plan. Bam Reconstruction Committee



Source: Bam Reconstruction Master Plan. Bam Reconstruction Committee

Figure 1.2.8 Building Structure Damage Map

1.3 Natural and Social Profile of the Bam Areas

Bam Township is located in the eastern part of Kerman province and its area in 19,374 km². According to the latest national administration system in 2002, it is composed of five regions, five cities and thirteen rural districts. Bam municipality is composed of two districts, seven sub-districts and twenty neighborhoods.

1) Geographical and Climatic Conditions

Bam municipality is located in the southeast of Iran and the eastern part of Kerman province, where lies southeastern edge of Iranian highland. It is situated in a flat land created by the dry river of Posht-rood. The altitude is around 1,000 m in height and the terrain is slightly tilting toward east. On its west and south, there is the mountain range of Jebal Barez. The mountains have a peak of as high as 3,700 m and serve as the catchment to water resources for the Bam areas.

The temperature of the Bam areas is relatively low with an average temperature throughout the year of around 24.3ºC and an average lowest temperature in the winter of 6.4ºC given its high altitude.

2) Population

The population of Bam Township before the earthquake in 2003 was estimated at about 223,415people, which is almost 10% that of Kerman province, according to the Statistical Centre of Iran (SCI). The Township's most populated area is Bam municipality. The population of Bam municipality in 2003 was 87,661 with population growth rates at 3.29% in urban area and 1.34% in rural area, and the average population density was 30 persons per hectare. The population of Baravat town in 2003 was 16,888 people.

Table 1.3.1 shows the population of Bam Township in 1996 and the estimated population based on the analyzed growth rate from 1991 to 1996.

Table 1.3.1 Population in the Bam Areas

Area/Administrative Boundary	National Census (1996)	Estimated Population	
		2002	2003
Bam Township	198,435	219,790	223,415
Urban areas	91,538	111,255	114,774
Rural areas	106,897	108,535	108,641
Bam municipality	70,079	85,016	87,661
Baravat town	13,857	16,439	16,888
Total	83,936	101,455	104,549

Note: After the latest national census in 1996, population of Bam Township was adjusted to correspond to the new administrative boundary.
Source: Statistical Centre of Iran

After the earthquake, several institutions have announced the number of before the earthquake casualties, the population after the earthquake and their projections on population growth; yet, as it was foreseen, their figures widely differed, for the most part, as shown in Table 1.2.2. Considering continuous inflow of legal and illegal migrants and/or seasonal labors, who are unregistered from surrounding provinces and even from neighboring countries, it is presumed that capturing the exact number of residents in the affected areas is rather complicated.

Table 1.3.2 Population before and after the Earthquake

		UN OCHA	Statistical Centre of Iran (SCI) *2	Bam Reconstruction Committee
Before Earthquake	Bam	120,760	89,145	n.a.
	Baravat	20,800	15,324	n.a.
	Total	141,560	104,469	92,361
After Earthquake	Bam	67,595	55,167	n.a.
	Baravat	15,875	13,532	n.a.
	Total	83,470	68,699	60,000

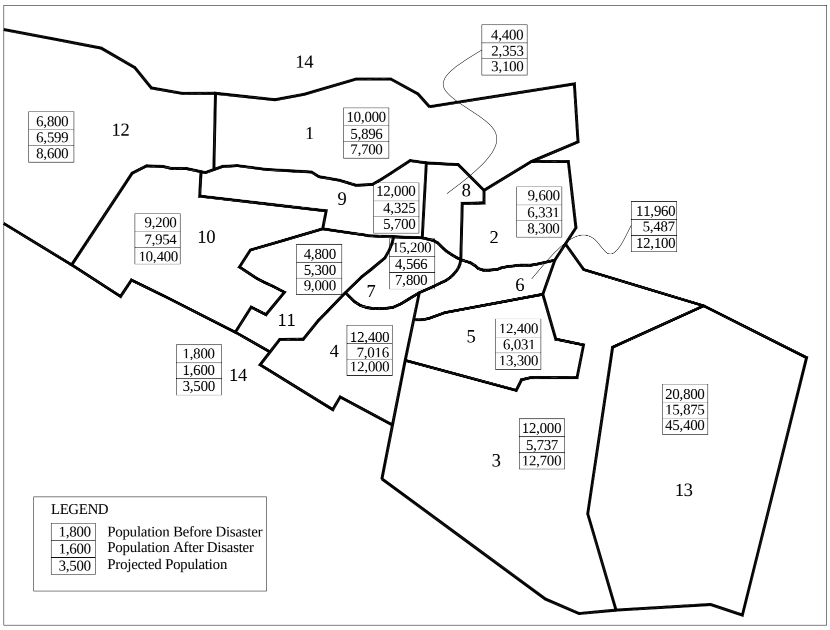
Note: 1. UN OCHA
2. Latest projection of SCI was applied. (June 2004).
Source: UNOCHA, SCI and Bam Reconstruction Committee

Several population projections were announced from various institutions, such as UN OCHA, SCI and Bam Reconstruction Committee, and their projections, as was expected, differed from one another. Yet, all institutions estimated the population in year 2015 will be around 120 thousand to 160 thousand and in year 2025, the projection is around 150 thousand to 220 thousand. The Study Team has decided to adopt the projection estimated by UN OCHA as the base to estimate water demand in the Bam areas and design mid- and long-term water supply master plan. The population projection below seems to be between moderate to conservatively high growth rate.

Table 1.3.3 Population Projection

	Zone	Before & After Disaster		Projected Population		
		Before	After	2004	2015	2023
Bam	1	10,000	5,896	2,603	3,920	7,700
	2	9,600	6,331	5,375	8,100	8,300
	3	12,000	5,737	26,424	39,820	12,700
	4	12,400	7,016	11,701	17,640	12,000
	5	12,400	6,031	11,255	16,960	13,300
	6	11,960	5,487	4,225	6,370	12,100
	7	15,200	4,566	2,937	4,430	7,800
	8	4,400	2,353	1,389	2,090	3,100
	9	12,000	4,325	2,680	4,040	5,700
	10	9,200	7,954	3,512	5,290	10,400
	11	4,800	5,300	2,340	3,530	9,000
	12	6,800	6,599	2,914	4,390	8,600
	14	1,800	1,600	706	1,060	3,500
Sub-total (Bam)		122,560	69,195	78,061	117,640	114,200
Baravat	13	20,800	15,875	7,009	10,570	45,400
Grand Total		143,360	85,070	85,070	128,210	159,600

Source: UNOCHA



Source: UNOCHA

Figure 1.3.1 Population Projection by Zone

Source: UNOCHA

Figure 1.3.2 Zoning of Bam and Baravat Areas

3) Administrative Boundary

Kerman province is composed of thirteen townships (shahrestan), and each township is further divided into districts (bakhsh) that include city (shahr) and village (dehestan). Bam Township has an area of 19,374 km^2 and a population recorded at 242,438 in year 2002. The main study area of this study is referred to as "Bam municipality," which is the urbanized area of Bam district having an area of 39 km^2.

1.4 Outline of the Reconstruction of Water Supply System in the Bam Areas

1) Water Supply System in the Bam Areas

Bam Water Supply Company (BWSC) provides service (tap) water to Bam city and its surrounding areas through distribution pipes from several distribution reservoirs owned by BWSC in Bam and Baravat. The main facilities supplying service water to the eastern area of Bam city were built around 20 to 25 years ago. Since then, BWSC has expanded and improved its services, and it provided approximately 28,000 m^3 per day covering about 130,000 people in the urban area of Bam, Baravat and the surrounding areas before the earthquake.

BWSC relies solely on its water source to groundwater, and owns seventeen operational production wells, fifteen wells for Bam and two wells for Baravat. The groundwater from eight wells in Bam is conveyed to three reservoirs, which have a combined capacity of 30,000 m^3. The groundwater pumped up from four wells in Bam is conveyed to a reservoir, which has a capacity of 5,000 m^3, and two wells in Baravat is conveyed to a reservoir with a capacity of 1,600 m^3 for the users in Baravat.

The earthquake inevitably damaged the water supply facilities and infrastructure in both Bam and Baravat, and their major damaged facilities are:

- distribution pipes,
- pump houses and control panels of production wells (No.1 and No.2 wells in Bam and No.1 and No.2 wells in Baravat), and
- reservoir with the capacity of 1,600 m^3, disinfection house and gatehouse in Baravat.

Subsequent to the fact-finding reconnaissance of water supply facilities, the JICA Study Team had prepared preliminary design to reconstruct the pipe network in the Bam areas. It was then suggested by the Study Team to restore the damaged facilities properly and promptly to provide reliable and safe service water to the residents.

2) Reconstruction Movement

The reconstruction of the Bam areas in all aspects, i.e. social economic, physical, psychological and cultural, will be major challenges for Iran over the next few years. Given the magnitude of the disaster, the administration of both central and local governments needs huge amounts of financial resources, skilled human resources and innovative institutional arrangements and management to accomplish prompt and comprehensive recovery.

As in all large-scale reconstruction programs, the focus should be on normalization efforts in livelihoods, shelter, social services and basic infrastructure, and so on, as soon as possible. However, there is also an opportunity to initiate innovational practices that could reduce the risk of future disasters. In achieving a balance between these two, setting priorities must be always a major challenge. The government has already set up a multi-sectoral Task Force, in order to coordinate the reconstruction efforts and programs and to sub-divide the reconstruction by their specialties.

According to the recent report from the Bam Reconstruction Committee, the government decided to rebuild the city in the existing urbanized area with some modification on the future city structural planning.

The master plan of Bam municipality and neighboring areas has been prepared by Armanshahr Architecture & Urban Design Consultant; yet its subsequent Action Plan, which contains comprehensive programs and projects by sector for the reconstruction of the Bam areas, schedule and required capital finds, financial resources and investment plans, is not ready at the moment of this report. According to the consultant, it will be ready sometime in year 2005.

3) Financial Assistance

Table 1.4.1 shows the various assistance provided by domestic and mostly international NGOs. The list does not necessarily show a complete list of activities operated in the Bam areas since the earthquake hit the areas; yet it could be rather said that the list comprises activities that the Bam municipality has been trying to render. According to some international NGOs, Bam municipality has attempted to coordinate the efforts of NGOs and to organize periodical coordination meeting to update information on NGOs' activities and the progress of assistance.

The tangible information on bilateral financial assistance, however, has been sought at local governments, the Bam reconstruction committee and other sources, but it seems such information is unavailable at least at the local government level. Because of such conditions, it is challenging for the local governments to make comprehensive recovery plans to rebuild the affected areas and provide necessary social support in sustainable manner. It was often indicated that the central government must have such information, but somehow the information has not been disclosed to the public. Thus, it is difficult to estimate the total amount of financial assistance, yet, it has been widely acknowledged that not all financial assistance pledged right after the disaster has been in fact delivered or in some cases such commitments were withdrawn.

Table 1.4.1 Assistance from Domestic and International NGOs for Earthquake-Hit Bam

Project Components	Name of NGO	Country	Fund Amount	Progress of the Project
3 schools & 20 temporary housing	Malteser	Germany	€60,000	Completed
4 Workshops	Malteser	Germany	€20,000	50%
Procurement of 3 air conditioners for schools	Malteser	Germany	€6,000	Completed
3 school buildings	Malteser	Germany	€42,000	20%
Micro-scale projects	Malteser	Germany	€70,000	20%
Rebuilding of medical facilities (clinic, laboratory)	Malteser	Germany	€250,000	10%
6 classrooms in Baravat	Malteser	Germany	€150,000	10%
Procurement of 650 refrigerators & 650 potable water tanks	Agiran Al Kuwait	Kuwait	€78,000	Completed
Construction of 200 houses (framework only)	Act of Netherlands	Netherlands	€800,000	10%
Construction of orphanage	SVA	Japan	US$68,000	10%
2 container-houses for special medical treatment	Private donation	Iran	Rls.100 mil.	Completed
Construction of educational facilities	Peace of Spain	Spain	€20,000 2 yrs expense	60%
3 workshops	Save the Children	UK	US$30,000	50%
Transportation fee of containers "German helps"	Daimler-Chrysler	Germany	€150,000	Completed
Construction of medical center for special medical needs	Special Disease Organization	Iran	Rls.3,500 mil.	10%
Construction of school buildings (temporary buildings)	Daimler-Chrysler	Germany	€110,000	Completed
Construction of educational centers for mitigation management	Kobe municipality	Japan	Not fixed	-
Construction of clinic for the poor	Iranian in USA	USA	US$820,000	Completed
Donation and in-kind donation	Iranian in USA	USA	US$23,000	
Construction of kindergarten	Message from Kobe	Japan	US$12,000	Completed
Construction of orphanage	UAE	UAE	Rls.3,500 mil.	0%
Job placement services (Loan)	Iranian in USA	USA	US$200,000	0%
Total Amount			Approx. US$4 million	

Note: As of October 2004
Source: Bam Municipality