Country	: Kingdom of Thailand
Project	: Bangkok Water Supply Improvement Project (1)Tunnel Rehabilitation, (2)Stage II- Phase 1B
Borrower	: Metropolitan Waterworks Authority (MWA)
Executing Agency	: Metropolitan Waterworks Authority (MWA)
Date of Loan Agreement	: (1)November 1988, (2)November 1988
Loan Amount	: (1)¥2,985 million, (2)¥4,380 million
Local Currency	: Baht
Report Date	: March 1998 (Field Survey: October 1997)

Sam Lae Raw Water Pump Station

[Reference]

1.Terminology

① Classification of water conveyance, water distribution, and water supply

Water conveyance indicates the transport of clean water produced at water treatment plants to water distribution facilities that are relay points. The facilities employed for this purpose (pumps, etc.) are called water conveyance facilities, and the water pipes used to convey the water are called service pipe lines.

Water distribution refers to the distribution of water from relay points to end-users. The facilities employed for this purpose are called water distribution facilities, and the water pipes used to convey the water are called distributing pipes. The water pipes that link distributing pipes to water faucets are called water supply pipes, and water supply pipes and water faucets are collectively referred as water-service installations. Normally, water-service installations are owned by the end-user.

② Steel lining method

In order to prevent water loss, lining, which consists of laying the inside of already laid pipes with steel plates, concrete, resin, etc., is used. In the case of steel lining, steel plates are used. Grout is injected to fill gaps between the lining and the pipes.

③ Pipe insertion method

In order to prevent water loss, new pipes with a diameter equal to or smaller than that of existing pipes are inserted. The gaps are filled with grout.

④ Charged ratio, non-changed ratio (for details, see Water Consumption Breakdown on the next page.)

Non-charged ratio: The ratio (%) of water consumption that is not charged

Non-changed ratio = (Valid non-charged water amount + invalid water amount)÷Water consumption x 100

Charged ratio: The ratio (%) of water consumption that is charged

Charged ratio = Charged water amount÷water consumption x 100 or Charged amount = 100 - non-charged ratio.

Water loss ratio: The ratio (%) of water loss against the water consumption

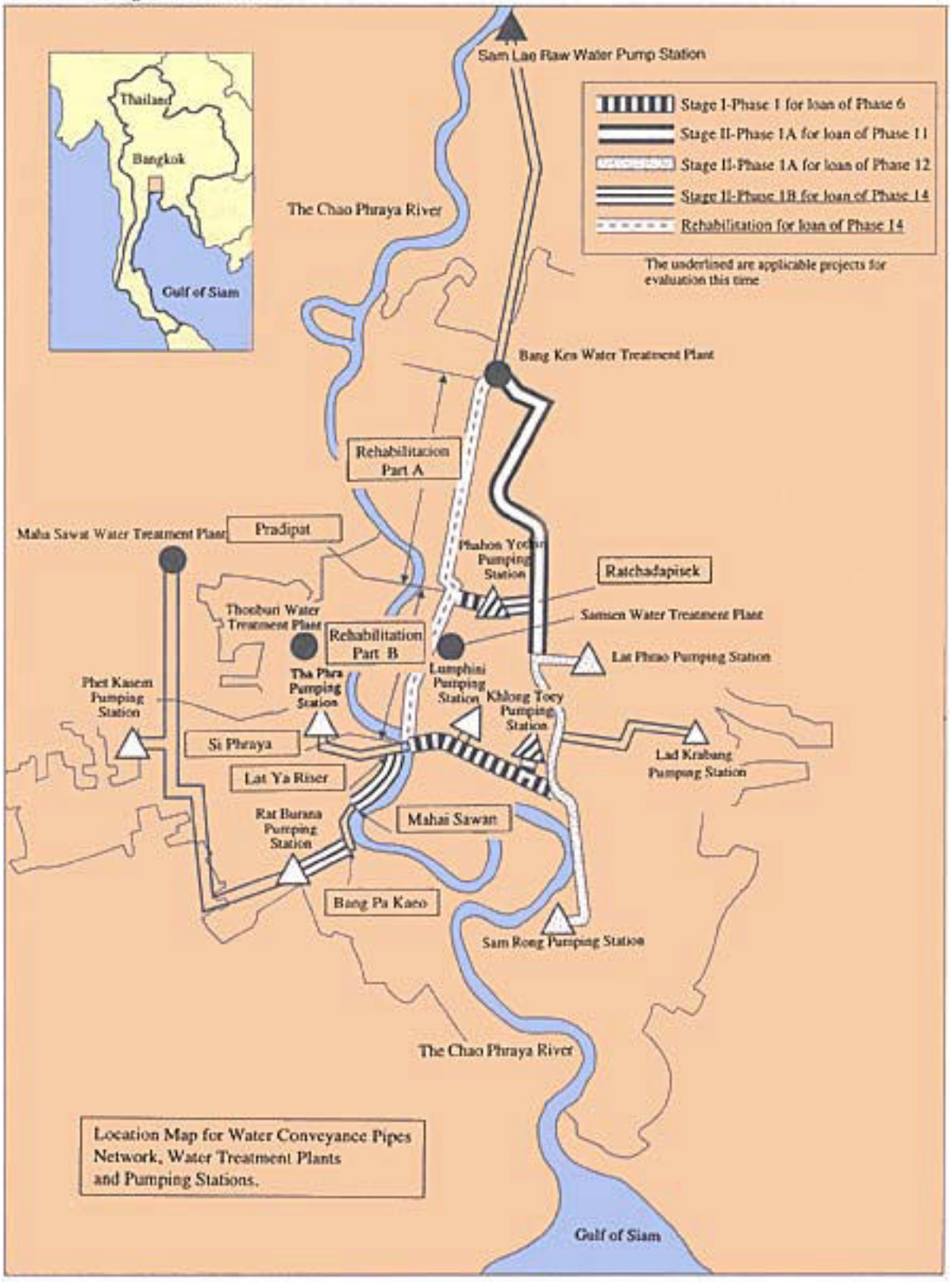
⑤ MWA: Metropolitan Waterworks Authority

Water Consumption Breakdown

Water consumption	Available water	Charged water	Paid water	(1) Water amount serving as basis for collection (2) Fixed rate faucets and allowed water amount
			Diverted water	Water diverted to other channels
			Others	Water used for public purposes including parks and fire fighting for which a charge is collected using a different account.
		Non-charged water	Non-metered water	Effectively used water that is not charged due to failed meter detection
			Water used by Water Department	Water used by Water Department for water distribution facilities, including pipe cleaning and water loss prevention
			Others	Water used for public purposes such as parks and fire fighting that is charged using a different account.
	Non-available water		Reduced charge water	Water discounted at time of collection, due to red water
			Water loss	(1) Water distribution water main water loss (2) Water distribution sub-water main water loss (3) Water loss from water feed pipe upstream from meter
			Others	Water that has become non-available due to other damage in water facilities and non-accounted-for water

1. Project Summary and Comparison of Original Plan and Actual Result

1.1 Project Location



1.2 Project Summary and ODA Loan

Of the two projects subject to this post-evaluation, the Bangkok Water Supply Improvement Project Stage II-Phase 1B (hereafter called "Improvement Project") was a part of the Bangkok Metropolitan Water Supply Improvement Project Master Plan (hereafter called "1984 Master Plan"), which was established in 1970 with completion targeted for 2000 and was revised in 1984. This project aims to expand the capability of the Bang Ken Water Treatment Plant (from 2,000,000 m^3/day to 2,400,000 m^2/day), which supplies water from the Chao Phraya River and expand the service pipe line network, so that improve water service conditions in the Bangkok metropolitan area. (For the positioning of the improvement project within the master plan, see sections 1.3.2 and 1.3.3.)

The other project subject to this post-evaluation, the Bangkok Water Supply Improvement Project (Tunnel Rehabilitation)(hereafter called "Rehabilitation Project"), aims to secure the original capacity of the water tunnel between the Bang Ken Water Treatment Plant and Si Phraya, which was completed in 1980 but subsequently suffered damage.

The applicable ODA loan corresponds to the entire amount of foreign currency for both projects.

1.3 Background

1.3.1 National Economic and Social Development Plan and Waterworks Sector

Since the establishment of the 1st National Economic and Social Development Plan[1] in 1961, the Thai economy has achieved an annual growth rate of nearly 7%, but the growth rate declined slightly to 5.4% during the 5th Plan (1982 to 1986).

Under this economic environment, the 6th Plan (1987 to 1991) has adopted program-centered approaches to specific problem areas. As part of its aim to develop the Bangkok metropolitan area, the 6th Plan aimed to expand basic services (transportation, flood control, water supply, housing, overcrowding measures, etc.) in order to alleviate overcrowding and promote more efficient use of land so as to create an orderly metropolitan area and urban area.

One of the above issues addressed by the 6th Plan, the waterworks sector aimed to secure the water consumption amount and improvement of water quality required by areas with a remarkable rate of economic development, including the Bangkok metropolitan area[2].

1.3.2 Positioning of Improvement Project within 1984 Master Plan

The long-term plan (Master Plan) for the improvement of water supply in the Bangkok metropolitan area was first established in 1970 with the participation of U.S. consultants as a plan to fulfill water requirements up to the year 2000. Thereafter, this master plan was revised in 1984, leading to the 1984 Master Plan. Improvement Project is positioned as Stage II-Phase 1B Plan within this master plan.

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1 Drafted for 5-year periods by the National Economic and Social Development Board (NESDB).

2 Source: Japanese Chamber of Commerce and Industry in Bangkok, Economic Conditions in Thailand, 1986/87 Edition, MWA

1.3.3 Capacity of Waterworks Facilities in Bangkok Metropolitan Area and Water Supply Conditions

In 1988, when the appraisal of the two projects constituting the target of this post-evaluation was done, the Bangkok metropolitan area had three water treatment plants (Bang Ken: 1,600,000 m^3/day, Samsen: 547,000 m^3/day, and Thonburi: 173,000 m^3/day), and 42 deep wells (447,000 m^3/day) as underground water usage facilities. Combined, these facilities had a total capacity of 2,767,000 m^3/day.

While water consumption projections at the time were based on the water demand predictions of the 1984 Master Plan, actual demand exceeded the projected figures. In addition, ground subsidence due to underground water pumping became a grave problem in Bangkok, and total banning of underground water pumping from 1989 was planned. For this reason, as can be seen in Table 1.1 below, the actual facility capacity of 1988 (2,767,000 m^3/day) would become inadequate for satisfying the demand level in 1990, and as a result efforts were made to quicken the completion of Stage II-Phase1 Plan.

【Table 1.1 Demand Projected by 1984 Master Plan and Facility Capacity Reinforcement Plan】

(Unit: 1,000m^3/day)

Year	～ '83	'84-'85	'86-'87	'88-'90	'91-'93	'94-'96	'97-'00
Capability of water treatment plant	Stage I			Stage II		Stage III	
	Phase 1	Phase 2		Phase 1	Phase 2	Phase 1	Phase 2
Bang Ken	800	1,200	1,600	2,400	2,800	3,400	3,800
Samsen	547	547	547	530	530	530	530
Thonburi	173	173	173	170	170	170	170
Sub-total	1,520	1,920	2,320	3,100	3,500	4,100	4,500
Well water	447	198	160	0	0	0	0
Total	1,967	2,118	2,480	3,100	3,500	4,100	4,500
Projected demand figure	2,042(*2)	2,568	N. A.	3,100	3,500	3,826(*3)	4,500

Source: 1984 Master Plan

*1: Projected demand figures indicate maximum daily demand.

*2: Actual FY1981 figure

*3: Projection for FY1995. Other demand projections indicate maximum demand for the last fiscal year of each Plan.

1.3.4 Problem of Ground Subsidence Caused by Underground Water Pumping

At the beginning of the 1980s, large-volume pumping of underground water at wells belonging to the Metropolitan Waterworks Authority (MWA) and privately owned wells caused ground subsidence. In response to this problem, the Thai government announced underground water pumping restrictions in May 1983, and began strict enforcement of these restrictions. The areas affected by these restrictions have been divided into the three areas in the Bangkok metropolitan area indicated below. The Thai government has established guidelines for stopping use of underground water by 1987 for Critical Areas No. 1 and No. 2 for the MWA.

- Critical Area No.1: Area where ground subsidence is progressing at an annual rate of 10 cm or

more.

Bang Ken District, Phra Khanong District, Bang Kapi District, Huey Khwang District, Phra Pradaeng District (However, eastern bank of the Chao Phraya River only), Amphoe Muang Samut Prakarn, Min Buri-Lat Krabang Phli Districts (residential and industrial area within these districts)

- Critical Area No.2: Area where ground subsidence is progressing at an annual rate of 5 cm to less than 10 cm.

  Dusit District, Phya Thai District, Pathum Wan District, Bang Rak District, Yanawa District

- Critical Area No.3: Area where ground subsidence is progressing at an annual rate of less than 5 cm. Areas except No. 1 and No. 2 areas of Bangkok metropolitan area described above, Nonthaburi, Pathum Thaniand Samut Prakarn.

1.3.5 Necessity of Rehabilitation Project

The water supply tunnel constructed during Stage I construction became damaged, leading to a decrease in the water supply capacity of the Bang Ken Water Treatment Plant from 1,600,000 m^3/day to 900,000 m^3/day by June 1988. In December 1988, the Bang Ken Water Treatment Plant's water supply capacity was increased to 400,000 m^3/day through the implementation of Stage II-Phase 1A Plan[3]. However, using only the service pipe lines that were also newly constructed through the Stage II-Phase 1A Plan with the Bang Ken Water Treatment Plant work at full capacity, it was not possible to transport the total extra water supply capacity corresponding to the sum of the 700,000 m^3/day that could not be transported through the existing tunnel and the increased water supply capacity of the Bang Ken Water Treatment Plant (400,000 m^3/day) (a total of 1,100,000 m^3/day). Thus the rehabilitation of the existing water tunnel became a pressing issue for securing the water supply required by the city center.

[3] The Bang Ken Water Treatment Plant's capacity increase was achieved with ADB loan.

1.4 Comparison of Original Plan and Actual Result

	Plan (at time of appraisal)	Actual Result	Difference
1. Project Scope			
Rehabilitation project			
1 Repairment of water-conveyance tunnel	10.3km×3,400mm 7.5km×2,800mm	10.3km×3,400mm	▲7.5km× 2,800mm
2 Consulting service	182M/M	95M/M	▲87M/M
Improvement project			
1 Sam Lae Water Intake Plant Raw water pump	4	Same as left	—
2 Expansion of Bang Ken Water Treatment Plant (Water treatment capacity)	2 sedimentation basins, 8 filter basins, 3 pumps (400,000 m^3/day)	Same as left	—
3 Service pipe line [4]	2.0-diameter×5.8km	1.5-diameter×5.8km	Reduction of diameter
4 Service pipe line [5]	2.0-diameter×2.5km	Same as left	—
5 Consulting service	310M/M	513M/M	+203M/M
2. Implementation Schedule			
Rehabilitation project			
1 Repairment of water-conveyance tunnel (Start of construction ~ completion)	1992/01～1992/11 (11 months)	1992/03～1993/06 (16 months)	+7 months (+5 months)
2 Consulting service (Start of service ~ completion)	1989/05～1993/01 (45 months)	1991/12～1993/07 (20 months)	+6 months (▲25 months)
Improvement project			
1 Sam Lae Water Intake Plant Raw water pump (Bidding ~ completion of construction)	1988/09～1990/05 (21 months)	1989/03～1991/06 (28 months)	+13 months (+7 months)
[Implementation Schedule]	[16 months]	[16 months]	[0 months]
2 Expansion of Bang Ken Water Treatment Plant	1988/09～1991/05 (33 months) [25 months]	1989/07～1993/01 (43 months) [34 months]	+20 months (+10 months) [9 months]
3 Service pipe line	1988/09～1990/12 (28 months) [20 months]	1990/10～1993/02 (29 months) [20 months]	+26 months (+1 months) [0 months]
4 Service pipe line	1988/09～1991/01 (29 months) [22 months]	1989/05～1991/11 (31 months) [22 months]	+10 months (+2 months) [0 months]
5 Consulting service (Start of service ~ completion)	1988/02～1991/06 (41 months)	1988/02～1993/02 (61 months)	+20 months (+20 months)
3. Project Cost			
Rehabilitation project			
Total project cost	¥5,170 million	¥2,962 million	▲¥2,208 million
Foreign currency (OECF Portion)	¥2,985 million	¥2,066 million	▲¥919 million
Local currency (MWA Portion)	437 million Baht	210 million Baht	▲227 million Baht
Improvement project			
Total project cost			
Foreign currency	9,549 million	11,777 million	+2,228 million
(OECF Portion)	4,380 million	3,929 million	▲451 million
Local currency (MWA Portion)	1,034 million Baht	1,839 million Baht	+805 million Baht

Rate at time of appraisal (or plan): US$1=B25.3=¥125 (B1=¥5) (1988)
Rate at actual result: B1=¥4.268 (1996)
Source: PCR, MWA

[4] ③ Service pipe lines It indicates Lat Ya Riser ~ Mahai Sawan, Bang Pa Kaeo ~ Rat Burana.
[5] ④ Service pipe lines It indicates Phahon Yothin Pumping Station ~ Ratchadapisek.

2. Analysis and Evaluation

2.1 Evaluation of Project Implementation

2.1.1 Project Scope

(1) Improvement Project

The plan to expand the capacity of the Bang Ken Water Treatment Plant's capacity by 400,000 m^3/day, which is the main part of the Improvement Project, was implemented as planned, but the plan for the installation of a central monitoring system (CMS) inside the Bang Ken Water Treatment Plant was cancelled. Moreover, with regard to facilities other than the Bang Ken Water Treatment Plant, the diameter of the service pipe line was reduced from 2.0 m to 1.5 m.

Regarding the installation of a CMS, overall project cost for improvement project were increasing and it became necessary to reduce the project scope. As a result, it was decided to stop construction of CMS having only a small impact on the overall project. Therefore, information about the water supply amount is now collected over the telephone from each facility, and managed at the Bang Ken Water Treatment Plant. From the viewpoint of water supply system operations, no particular problem has emerged yet. However, as the scale of the overall clean water system is expanding, the early introduction of an automatic monitoring system is desirable for the efficient use of limited water resources.

With regard to the plan to reduce the diameter of the service pipe line from 2.0 m to 1.5 m, per the 1990 Master Plan established after the Loan Agreement signing and by the start of construction[6], a new water treatment plant, the Maha Sawat Water Treatment Plant, was newly constructed on the western bank of the Chao Phraya River. As a result of this change, the water supply amount transported from the eastern bank to the western bank of the Chao Phraya River was lowered compared to the initially projected amount (353,000 m^3/day to 180,000 m^3/day). This change is deemed appropriate in order to avoid excessive investments in facilities.

(2) Rehabilitation Project

With regard to the rehabilitation project, although rehabilitation of the entire 10.3 km length of the water tunnel running from the Bang Ken Water Treatment Plant to Pradipat (hereafter called Part A) was performed by lining its entire internal surface, the method employed was changed from the steel lining method initially considered at the time of appraisal to the pipe insertion method. Moreover, the plan to line the entire 7.5 km distance of the tunnel from Pradipat to Si Phraya (hereafter called Part B) was abandoned.

The abandonment of Part B resulted from the judgment that it would be possible to achieve the initially targeted water supply pressure just by repairing the joints of the water tunnel[7], based on the results of a survey conducted by the Asian Institute of Technology (AIT). Actually, the water supply pressure following the rehabilitation of Part A was restored to the initially planned figure increased from 2.0 kg/cm^2 to 6.5 kg/cm^2: water pressure under maximum operation), and based on

[6] For details, see section 2.3.3 Clean Water Supply Amount.

[7] Repair of the joints of Part B of the tunnel was implemented using funding from MWA.

the consideration that the construction costs for the Rehabilitation Project were also increasing in the same way as for the Improvement Project, it was deemed appropriate not to go ahead with the plan to line the entirety of Part B.

The problem with changing the lining method for Part A was that it lead to a reduction in the amount of water that could be supplied due to the reduction in the cross-sectional area (10% reduction in this case). However, as mentioned previously, when the lining method was changed, a decrease in the amount of water transported to the western bank of the Chao Phraya River was foreseen, and the reduction in the amount of water that could be transported was confirmed as not posing a problem. Therefore, the change in lining method did not represent a problem within the overall project.

2.1.2 Implementation Schedule

(1) The start of construction for the Improvement Project was delayed, causing a similar delay in the project's completion. The delay in the construction start, as will be described later, was caused by a sudden rise in the construction material prices, which resulted in bid prices not matching the set budget, leading to delays in the bidding procedure. This delay is therefore considered to have been unavoidable.

(2) With regard to the Rehabilitation Project, consulting services were shortened by 25 months due to the discontinuance of lining work for Part B. The reasons for canceling the lining work are described in the section on the project scope. Moreover, the delay in the consulting services for Part A was caused by the delay incurred in the bidding procedure of the service pipe lines for the Improvement Project. Considering that the Rehabilitation Project could not have started prior to the completion of these service pipe lines, the delay in the start of the consulting services is deemed to have been unavoidable[8].

2.1.3 Project Cost

(1) A 20% cost overrun was incurred for the entire Improvement Project. A look at the composition of this cost overrun reveals that it was due mostly to cost overruns for the Bang Ken Water Treatment Plant expansion and service pipe lines. The cause of the former is thought to be the sudden increase in the cost of construction materials in Thailand due to the construction boom in Thailand (approximately 35% increase from 1987, when the costs were estimated, to 1990, when the contract was signed) (see Table 2.1). Moreover, in the case of the service pipe lines in the latter case, although their diameter decreased, construction costs rose for the same reason as in the former case, and this is held as the factor behind these cost overruns. The causes that brought about these delays are considered to have been unavoidable. This sort of price increase exceeds the price escalation that was envisaged at the time of the appraisal, and as mentioned earlier, MWA handled these cost overruns by reducing the scope size.

[8] During the implementation of the Rehabilitation Project, Part A was cut off and clean water was supplied from Ratchadapisek to the Phahon Yothin pumping station and Part B.

(2) With regard to the Rehabilitation Project, a considerable cost underrun resulted from the abandonment of the plan to perform the lining for Part B. However, regardless of the fact that the relatively inexpensive pipe insertion method was employed, from a foreign currency viewpoint, 70% of the entire planned budget was spent on Part A only. Consequently, if the lining for Part B is also performed, a cost overrun will occur. Based on this consideration, the decision to stop the plan to line Part B could be said to have been appropriate from the viewpoint of project costs.

【Table 2-1 Movements in Wholesale Price Index of Construction Materials 】

Year	1987	1988	1989	1990	1991	1992	1993
Index	100	110.8	124.1	135.1	142.2	141.1	142.8
Over the year (%)	-	110.80	112.03	108.86	105.26	99.18	101.24

Source: Japanese Chamber of Commerce and Industry in Bangkok, Economic Conditions in Thailand, 1994/1995 Edition

2.1.4 Implementation Scheme

(1) Executing agency

The executing agency for these projects (Improvement Project and Rehabilitation Project) is the Metropolitan Waterworks Authority (MWA). Since its establishment under the Department of the Interior in 1967, the MWA has supplied clean water to the Bangkok metropolitan area. Project Management Department within the MWA took responsibility for the implementation of the two projects in this report.

(2) Consultants

With regard to the consulting services, in response to the wish of the executing agency to continue receiving support for the implementation of these two projects from the consultants (joint venture among Japanese consultants and Thai consultants) who made the 1984 Master Plan and did the detailed design of the Stage II Plan, an optional contract was signed. The scope of the contract went from support for the bidding procedure for the two projects to trial operation.

(3) Contractors

Since both the Improvement Project and the Rehabilitation Project were completed without important delays in their implementation schedule, and moreover, since there have been no major problems in the equipment following the projects' completion, the ability of the contractors has been judged to be satisfactory.

(4) Overall implementation scheme

Although, apart of the initial delays in construction start due to the fact that the bid prices did not match the allotted budget, the subsequent construction work was free of major delays, and both projects were completed almost according to the initial plan. Based on this achievement, no major problems have been deemed to exist in the ability of the executing agency, the consultants, and the contractors.

2.2 Evaluation of Operations and Maintenance

2.2.1 Operations and Maintenance Scheme

(1) Operations and maintenance scheme

The MWA is an organization consisting of approximately 6,000 employees (as of October 1997), 985 of who work in operations and maintenance (including 56 working in water quality control). Moreover, the operations and maintenance organization is configured as shown in Appendix 1, MWA Operations and Maintenance Organization Chart.

(2) Fostering of technicians and specialists

MWA aims to increase the skill level of its workers in each field at the National Waterworks Technology Training Institute (NWTTI), which was established and is managed with grant assistance from Japan and project-type technical cooperation of Japan.

Japanese project-type technical cooperation was implemented over two periods at NWTTI, in Phase I from 1987 to 1991, and Phase II from 1995 to 1999. In Phase I, 809 MWA employees in a total of five fields, water supply planning, management, water treatment and water quality control, pipe line maintenance, and machinery and electric equipment installation, received training. In Phase II, a total of 229 MWA employees (cumulative count since October 1997) in five fields, water resources management, maintenance technology, water distribution planning, non-charged water and water loss control, and service improvement, received training. In this way, MWA is actively working to raise the quality of its employees. (Numerical data source: MWA)

2.2.2 Operations and Maintenance

(1) Clean water supply quantity

The Improvement Project raised the clean water capacity of the Bang Ken Water Treatment Plant by 400,000 m^3/day. Upon completion of the Improvement Project (FY1993), the total clean water capacity reached 2,800,000 m^3/day. Table 2-2 shows the water supply status. As can seen in this table, the Bang Ken Water Treatment Plant continuously maintains approximately 90% of its clean water supply capacity, which is considered to be very acceptable. In FY1991, the plant even achieved a higher clean water supply capacity. Since was made possible by designing the capacity of equipment in the plant taking to some degree the safety factor into consideration, future clean water capacity will be within these figures.

【Table 2.2 Actual Record of Clean Water Supply in Bang Ken Water Treatment Plant】

(Unit: 1,000m^3/day)

Year	1991	1992	1993	1994	1995	1996
Actual record of clean water supply in Bang Ken Water Treatment Plant	2,103	2,243	2,388	2,441	2,825	3,020
Clean water capacity in Bang Ken Water Treatment Plant	2,000	2,400	2,800	2,800	3,200	3,200
Water supply ratio (actual record/capacity) (%)	105.2	93.5	85.3	87.2	88.3	94.4

Source：MWA

(2) Water quality

The water quality of the Chao Phraya River at the Sam Lae raw water pump station has not changed significantly compared to four years ago. Moreover, the water quality after treatment (average at city pumping stations) is within the Thai drinking water standard value (max. value), and no particular problem is thought to exist[9] (see Table 2-3 below).

【Table 2.3 Water Quality】

Year	1993 April	1997 April	Water quality standard value of Thai drinking water	1997 December
Name of facility / Item	Sam Lae water pump station		(Max. value)	Average of 5 places[10] at city pumping stations
Color	10	6	15	1.8
Turbidity	57	75	20	2.03
pH	7.49	7.49	6.5～9.2	7.43
Hardness (mg/l)	92	92	-[11]	98
Magnesium (mg/l)	-	6.7	150	7.3
Calcium (mg/l)	-	25.6	200	28.48
Total Solids (mg/l)	250	225	1500	168
Oxygen Consume (mg/l)	4	3.28	-	3.25
Nitrate and Nitrite (mg/l)	0.19	0.27	10	0.40
Iron (mg/l)	0.67	0.97	1.0	0.06
Fluorine (mg/l)	0.24	0.24	1.0	0.31
Manganese (mg/l)	0.06	0.1	0.5	0.01
Numbers of coliform bacilli[12]	480,000	660,000	-	0

Source: MWA, OECF appraisal materials of Bangkok Water Supply Network System Improvement Project

(3) Charged ratio and water loss

Table 2.4 below shows the charged ratio and water loss ratio trends for the entire water supply region under MWA's responsibility over the past ten years. According to this data, the non-charged ratio and water loss ratio have been increasing since FY1992, but in the year following the completion of the Rehabilitation Project, the water loss ratio fell momentarily, and is believed to be the effect of the Rehabilitation Project. (However, the rising trend resumed the following year. Yet a rate of 30% to 40%, compared to Jakarta's 57% and Manila's 58%[13], is at a level which cannot be judged to be bad.)

An analysis of these figures shows that water loss accounts for approximately 80% of the non-charged ratio, and since prevention of this water loss is linked to improvements in the charged ratio, measures to prevent water loss should promptly be implemented. The MWA, after

[9] In 1997, the MWA declared Bangkok's water to be drinkable.

[10] Average values of Khlong Toey, Lat Phrao, Lumphini, Sam Rong, and Tha Phra pumping stations.

[11] Although there is no standard regarding hardness, reference values for calcium and magnesium have been established. Normally, hardness is measured as the calcium and magnesium contents of water. Since the concentration of both ingredients falls within these reference values, no problem is thought to exist.

[12] Japan's water quality standards dictate that no coli bacteria is to be detected.

[13] Source: Water Utilities Data Book, Asia and Pacific Region, ADB, published in 1993

completion of the Rehabilitation Project, established a Water Loss Reduction Department and started implementing measures. According to this survey, almost all water loss occurs at the joints that link water supply equipment (mainly common homes) and distributing pipes. The MWA has been implementing a program to replace deteriorated joining parts, distributing pipes (pipes of 2 inches to 300 mm: extension 12,787,166 m, approximately 80% of total MWA service pipe lines, water distribution pipes, and water supply pipes, as of 1996), as well as couplings since 1996. However, the annual rate of progress being 4%, results have not yet translated into water loss improvements. In order to speed up the pace of water loss reduction, it is thought necessary to raise the pace of this replacement program. Incidentally, the MWA has set itself the target of improving the non-charged ratio to 30% by the year 2001. (MWA 3rd Plan)

The largest portion of distributing pipes are asbestos pipes (8,317,875 m, or 54% of the total of 15,327,271 m of water supply pipes and distributing pipes as of 1996). From the viewpoint of durability[14], these pipes are also thought to require replacement with other types of pipes.

【Table 2.4】

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Clean water (Mil. m^3)	841.3	859.6	934.3	1,049.3	1,109.2	1,175.5	1,224.9	1,234.3	1,405.2	1,549.4
Water supply (Mil. m^3)	523.0	570.4	628.2	718.7	781.3	823.4	836.1	816.1	870.3	911.2
Charged ratio (%)	62.17	66.36	67.24	68.49	70.44	70.05	68.26	66.12	61.93	58.81
Non-charged ratio (%)	37.83	33.64	32.76	31.51	29.56	29.95	31.74	33.88	38.07	41.19
Water loss ratio (%)	31.84	28.27	26.71	25.43	23.3	23.71	25.82	23.62	28.79	32.45

Source: MWA Annual Report etc.
Note: Water loss ratio is part of non-charged ratio.

According to the MWA, the non-charged ratio (without water loss) breaks down into ① meter errors, ② reading misses by meter inspectors, and ③ water theft. With regard to water theft, which is particularly a problem in developing countries, a countermeasure implemented by the MWA is to reward persons reporting water theft with a cash award equal to 50% of the price of two years of the amount of water illegally used by the water thief (as calculated by the MWA). The MWA holds that all water theft can be monitored through this system.

(4) Current status of distributing tunnel Part B

Following completion of the Rehabilitation Project, the water supply amount in Part A from the third year to the fourth year increased, and unpredicted water losses in water tunnels were detected according to a survey newly done by the Asian Institute of Technology (AIT) in 1989 for Part B[15]. For this reason, of the two water tunnels branching out of the Bang Ken Water

[14] Asbestos pipes are weak against shocks and are considered to have a low shear resistance. Particularly in Bangkok, where the ground is weak, asbestos can easily become the source of water losses.

[15] Major water loss locations (discovery period): Thoet Damri Rd. (May 1996), vicinity of Samsen Station (January 1996), Khrung Kasem (February 1997)

Treatment Plant, approximately 3% of the water supply was shifted to the main not falling under the Rehabilitation Project, thus preventing the major water losses at the present time. However, to support clean water demand, rehabilitation of Part B is considered to be required.

2.3 Project Effects and Impacts

2.3.1 Waterworks Diffusion Effect

The waterworks diffusion rate in the Bangkok metropolitan area continued to grow satisfactorily after the completion of the Improvement Project in 1993 (see Table 2.5). In 1996, it had reached 80%. This diffusion rate, compared to Jakarta's 25%, Manila's 71%, and Kuala Lumpur's 100%[16], is at an acceptable level. Furthermore, the MWA is aiming for a diffusion rate of 85% to 90% by the year 2001 (MWA 3rd Plan). On the other hand, a water supply area increase of 784.4 km^2 has been achieved, which clearly exceeds the initial target of the Improvement Project of a 50 km^2 increase (the target at the time of the OECF appraisal for the time the project was completed was an increase from 580 km^2 to 630 km^2). This figure includes the increase resulting from the Bang Ken Water Treatment Plant emergency expansion work, which was planned and executed at the same time[17], but even taking this into consideration, the initial plan was fully achieved and this project is thus considered to have been effective (See Table 2.6).

【Table 2.5 Waterworks Diffusion Rate】

(Unit: 1000)

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Water supply population	4,886	5,120	5,230	5,330	5,450	5,565	5,730	5,929	6,206	6,557
Waterworks Diffusion Rate (%)	66.2	72.6	74.4	74.8	75.3	77.9	78.0	78.4	79.6	81.7
Number of residents in Bangkok metropolitan area	7,381	7,052	7,030	7,126	7,238	7,144	7,346	7,563	7,796	8,026

Source: MWA

【Table 2.6 Water Supply Area】

Year	1989	1990	1991	1992	1993	1994	1995	1996
Water supply area (km^2)	625	680	710	740	784.4	822.3	892.9	968.9
Growth rate over the year (%)	—	8.8	4.4	4.2	6.0	4.8	8.6	8.5

Source: MWA Annual Report

2.3.2 Ground Subsidence Prevention Effects

Regarding the underground water pumping restrictions announced by the Thai government at the time of OECF appraisal, actual conditions as determined by a survey conducted by the Department of Mineral Resources and described in Section 1.3.4 Problem of Ground Subsidence

[16] Source: Water Utilities Data Book, Asian and Pacific Region, ADB published in 1993.

[17] 1992 completion: Treatment capability of Bang Ken Water Treatment Plant reinforced by 400,000 m^3/day (see section 2.3.3 Contribution to Clean Water Supply Amount).

Caused by Underground Water Pumping, were as follows (detailed data about ground subsidence in each region could not be obtained.)

Critical Area No. 1 Area where ground subsidence is progressing at an annual rate of 3 cm or more

Critical Area No. 2 Area where ground subsidence is progressing at an annual rate of 1 cm to less than 3 cm

Critical Area No. 3 Area where ground subsidence is progressing at an annual rate of less than 1 cm

As indicated above, the measured subsidence values for each area, compared to the figures announced by the Thai government at the time of OECF appraisal, have been reduced to half, which represents a large improvement. As shown in Table 2.5, considering the growth of the population around the Bangkok metropolitan area, the increased water supply capacity of the MWA is thought to have contributed to the reduction in ground subsidence.

On the other hand, as shown in Table 2.7, the amount of underground water pumping has been increasing since 1990. However, this is thought to be unavoidable considering the remarkable rise in the population of the Bangkok metropolitan area and the effect of the 1994 drought.

Furthermore, the average underground usage for 1996 of 251,800 m^3/day (approximately 5.9% of the total MWA water supply, 4,245,000 m^3/day in 1996) consisted mainly of water pumped in areas without distribution pipes within the central system, and thus this amount is expected to fall through the Bangkok Water Supply Network System Improvement Project currently being implemented with ODA loan (completion planned in February 1998). The Thai government has in principle banned underground water pumping since 1989, and if underground water pumping is required, the pumping amount must be authorized by the government every year.

【Table 2.7 Movements in Ground Water Pumping in Bangkok Metropolitan Area 】

(Unit: 1,000 m^3/day)

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Central System	183.6	170.4	127.7	40.8	46.3	61.4	86.0	146.3	187.4	196.4
Separate System	24.7	25.8	30.4	32.6	41.9	44.7	34.2	45.5	51.0	55.3
Total	208.2	196.2	158.1	73.4	88.2	106.0	120.3	191.8	238.4	251.8

Source: MWA Annual Report

Note: Central System: Water supply to most of Bangkok Metropolitan Area
Separate System: Water supply to towns on the outskirts of Bangkok[18]

2.3.3 Contribution to clean water supply amount increase

As water demand in the Bangkok metropolitan area exceeded the projections of the 1984 Master Plan, the figures of the 1994 Master Plan for demand from 1990 to 2017 (hereafter called 1990 Master Plan) were revised in 1990 during the Improvement Project construction work. This lead to the execution of the Bang Ken Water Treatment Plant emergency expansion work, through which the treatment capacity was expanded by 400,000 m^3/day in 1992. This in turn resulted in

[18] It indicates seven areas: Minburi, Bang Yai, Sai Noi, Bang Phlee, Bang Bo, Nong Chok and Bang Bua Thong However, the absorption of the Separate System into the Central System from 1997 has been decided.

creating a treatment capacity of 2,800,000 m^3/day for the Bang Ken Water Treatment Plant combining both projects.

(See Appendix 2　1984/1990 Master Plan Comparison of Water Treatment Capacity for Bang Ken Water Treatment Plant.)

Table 2-8 shows the demand-supply relationship in the Bangkok metropolitan area. The sharp growth in the population of the Bangkok metropolitan area caused excess demand until FY1995. However, through completion of this project, the difference in demand from 1994 started falling, and the Improvement Project is thought to have contributed in the area of clean water supply expansion.

【Table 2.8 Demand Projection and Supply Results in the Bangkok Metropolitan Area】

(Unit: 1,000m^3/day)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Maximum demand	3,160	3,350	3,540	3,690	3,670	3,870	3,910	4,550	4,710	4,870	5,020	5,170
Total supply amount	2,875	3,039	3,221	3,356	3,382	3,850	4,245	4,540	4,940	4,940	5,280	5,680
Difference between demand and supply	-285	-311	-319	-334	-288	-20	335	-10	230	70	260	510

Source：MWA Annual Report etc.

Note: Maximum demand: Demand projected by the 1990 Master Plan

Total supply amount: Total of Bang Ken, Samsen, Thonburi, well water, and Maha Sawat water treatment plants.

Figures until FY1996 are actual values, and from 1997, planned figures.

2.3.4 Economic Value

(1) Financial situation

The ordinary profits of the MWA have been satisfactorily growing following the completion of the Improvement Project and Rehabilitation Project, and have doubled compared to the start of the projects in FY1994. However, from FY1995, ordinary profits have declined by half. One major factor behind this decline is the fact that the depreciation period for buildings, etc., was reduced from 50 years up to the previous year to 25 years in FY1995. As a result, operating expenses rose, while operating income and ordinary profit shrank. However, the reduction of the depreciation period is thought to be the result of a conservative accounting approach.

Furthermore, the current ratio fell by half since FY1995, but this is due to the fact that corporate bonds floated in FY1990 and FY1991 whose redemption period was approaching were changed from fixed liabilities to current liabilities. However, this reduction was only temporary, and from 1997 the current ratio began rising again. Yet since another batch of corporate bonds (long-term loan) will reach redemption date in FY2000, the current ratio is expected to decline again. On the other hand, it can be pointed out that the total value of long-term loans is in a rising trend.

Moreover, the ratio of fixed assets to long-term capital has exceeded 100% from FY1995. This means that assets are not financed with stable long-term obligations, and that new long-term loans will be increased when new capital investments become required again in the future (see Appendix 3　Financial Statement).

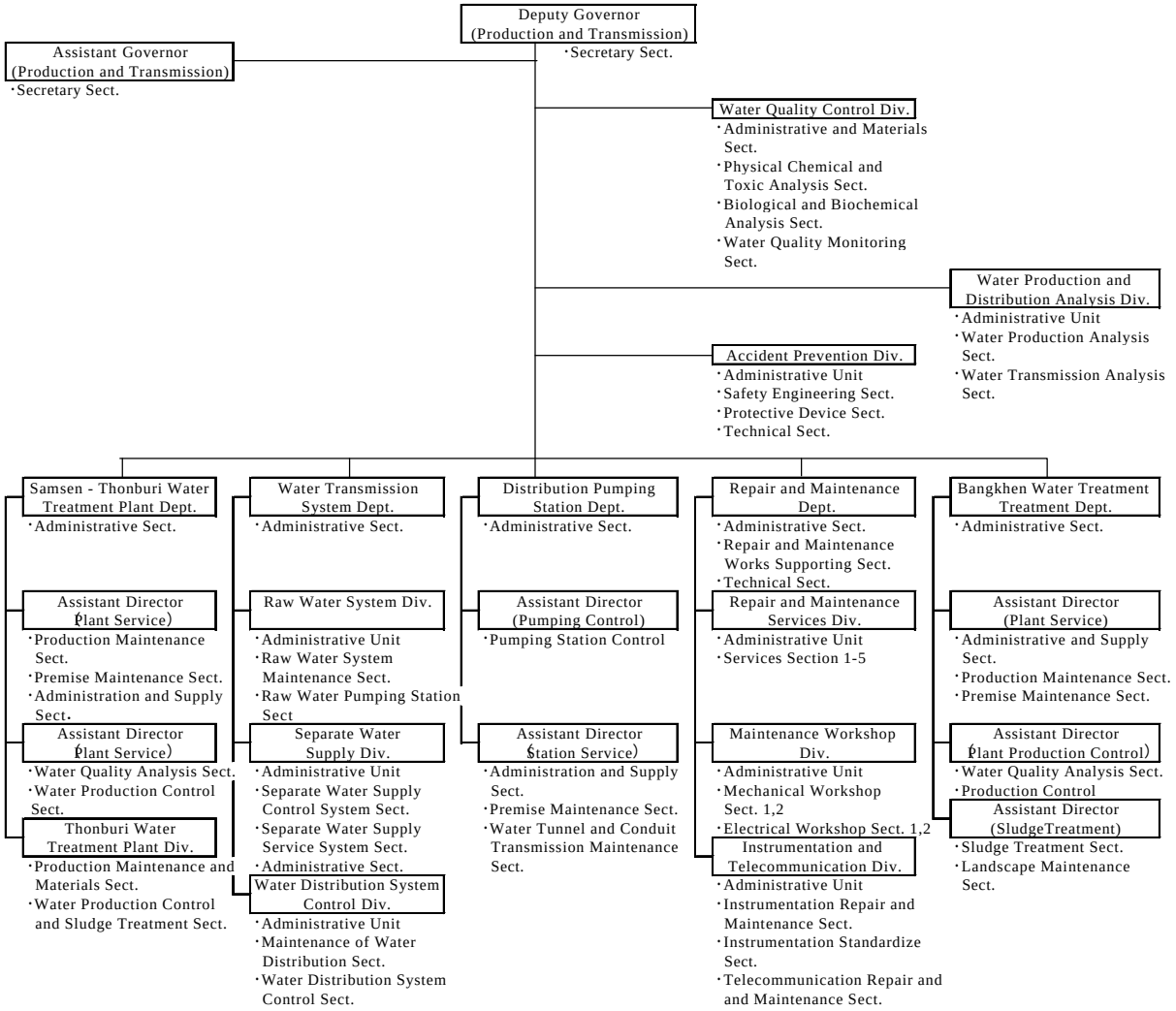
(2) Financial internal rate of return

The financial internal rate of return (FIIR) for the Rehabilitation Project was calculated to be 8.23% at the time of OECF appraisal. However, due to the reduction in the initial investment amount caused by the discontinuance of Part B in the Rehabilitation Project, the FIRR figure recalculated following completion of the project showed an increase of 12.42%[19].

Moreover, with regard to FIRR of the Improvement Project, setting the project life at 25years, the calculation after the project completion shows 11.94% as opposed to 15.01% at the time of revised calculation of OECF appraisal. This is due to the fact that the initial investment amount has ballooned compared to the time of appraisal.

[19] With regard to this calculation, since the manufacturing and sales expenses only for this project could not be obtained, the figure at the time of OECF appraisal was used.

MWA Operations and Maintenance Organization Chart



Appendix 2

1984/1990 Master Plan Comparison of Water Treatment Capacity for Bang Ken Water Treatment Plant

(Unit: 1,000m^3/day)

1984 Master Plan	Stage I			Stage II			Stage III	
	Phase 1	Phase 2		Phase 1		Phase 2	Phase 1	Phase 2
		1	2	A	B			
Water Treatment Capacity of Bang Ken	800	1,200	1,600	2,000	2,400	2,800	3,400	3,800
Water Treatment Plant (increased portion)	(800)	(400)	(400)	(400)	(400)	(400)	(600)	(400)
Targeted year	1983	1984	1985	1987	1990	1993	1996	2000
					Improvement project			

1990 Master Plan	Phase 1	Phase 2	Phase 3	Urgent expansion of Bang Ken	Phase 3 addition	Phase 4	Phase 5	Phase 6
Water Treatment Capacity of Bang Ken	800	1,600	2,000	2,400	2,800	3,200	3,200	3,200
Wate Treatment Plant (increased portion)	(800)	(800)	(400)	(400)	(400)	(400)	(-)	(-)
Targeted year	1983	1986	1989	1992	1993	1996	1998	2000
OECF loans	-	Phasej6	Phase 11 Phase 12	-	Phase 14	Phase 16 Phase 17	Phase 18	Phase 19
Loand from other agencies	ADB W.B.	ADB	ADB	-	-	-	-	-
Water Treatment Capacity of Mahai Sawan Water Treatment Plant (increased portion)	-	-	-	-	-	400 (400)	800 (400)	1,200 (400)
Other supply facilities	-	-	-	-	-	940	940	880
Total supply capacity	-	-	-	-	-	4,540	4,940	5,280

(Souce: MVA)

Appendix 3-1
(Units: 1 million Baht)

Statements of Income

Fiscal year	1990	1991	1992	1993	1994	1995	1996
Operating Income	5,199	5,679	5,653	6,709	6,619	7,063	7,390
Direct Business Expenses	1,806	2,027	2,310	2,553	2,716	3,271	3,607
Depreciation Expenses	907	890	895	891	994	1,698	1,900
Doubtful Debt	11	12	15	20	9	10	14
Total Business Expenses	2,724	2,929	3,220	3,464	3,719	4,979	5,521
Business Profit	2,475	2,750	2,433	3,245	2,900	2,084	1,869
Non-operating Income	213	449	456	342	443	454	499
Exchange Loss	271	256	224	225	233	320	281
Interest on Payments	905	957	891	881	906	1,011	1,014
Others	75	145	103	68	74	100	120
Non-operating Expenditures	1,251	1,358	1,218	1,174	1,213	1,431	1,415
Ordinary Profit	1,437	1,841	1,671	2,413	2,130	1,107	953
Business Profit Ratio on Turnover(%) =Business Profit/Sales	47.6	48.4	43.0	484.4	43.8	29.5	25.3
Recurring Profit Ratio on Turnover(%) =Ordinary Profit/Sales	27.6	32.4	29.6	36.0	32.2	15.7	12.9
Business Profit Ratio on Total Liabilities and Net Worth(%)=Business Profit/Total Liabilities and Net Worth	12.5	12.5	10.2	12.0	9.4	6.2	5.2
Recurring Profit Ratio Total Liabilitiesand and Net Worth (%)=Recurring Profit/Total Liabilites and Net Worth	7.2	8.4	7.0	8.9	6.9	3.3	2.6
Turnover Ratio Liabilities and Net Worth(%)=Turnover/Total Liabilities and Net Worth	26.2	25.9	23.8	24.8	21.5	21.0	20.5

Souce: MWA Annual Report

Appendix 3-2

(Units: 1 million Baht)

Balance Sheet

Fiscal Year	1990	1991	1992	1993	1994	1995	1996
Current Assets	899	2,834	2,247	1,832	2,429	1,579	1,382
Cash and Deposit	527	-	39	-	-	-	-
Short-term Loan	1,300	1,158	914	1,021	934	1,100	985
Sales Credit	375	496	462	359	393	461	330
Material	30	79	60	54	43	54	85
Others							
Total Current Assets	3,131	4,567	3,722	3,266	3,799	3,194	2,782
Fixed Assets	14,375	14,652	15,077	15,532	17,703	20,179	22,987
Estate, Buildings, Equipment	1,094	1,457	3,513	6,382	7,201	8,140	8,403
Construction Temporary Account	653	645	626	696	756	868	971
Deferred Asset	593	604	810	1,201	1,341	1,223	856
Deferred Exchange Loss							
Total Fixed Assets	16,715	17,358	20,026	23,811	27,001	30,410	33,217
Total Assets	19,846	21,925,	23,748,	27,077	30,800	33,604,	35,999
Current Liabilities	449	487	687	708	726	811	1,037
Accounts Payable	356	432	496	558	614	673	731
Deposits Received	639	648	629	643	1,067	2,042	3,151
Corporate Bond (to be refunded	-	-	-	-	-	525	959
within a year)	85	98	157	165	234	401	386
Borrowings form Ministry of Finance							
Others							
Total Current Liabilities	1,529	1,665	1,969	2,074	2,641	4,452	6,264
Fixed Liabilities	11,091	11,281	11,267	12,068	13,715	14,307	14,074
Long-term Borrowings	93	-	-	-	-	-	-
Others							
Total Fixed Liabilities	11,184	11,281	11,267	12,068	13,715	14,307	14,074
Total Liabilities	12,713	12,946	13,236	14,141	16,356,	18,759	20,338
Capital	6,173	6,497	6,779	7,159	7,338	7,650	8,202
Capital	1,455	2,927	4,130	6,123	7,412	7,460	7,683
Profit Carried Forward	-495	-446	-396	-347	-306	-266	-225
Loss from devaluation of Bath							
Total Equity and Reserves	7,133	8,978	10,513	12,935	14,444	14,844	15,660
Total Liabilities, Equity and Reserves	19,846	21,924	23,749	27,077	30,800	33,603	35,998
Current Ratio(%) = Current Assets/Current Liabilities	204.8	274.3	189.0	157.5	143.8	71.7	44.4
Ratio of Net Worth(%) = Net Worth/Total Liabilities and Net Wort	35.9	41.0	44.3	47.8	46.9	44.2	43.5
Ratio of Fixed Assets of Long-term Capital(%) = Fixed Assets/(Net Worth + Fixed Liabilities)	91.3	85.7	91.9	95.2	95.9	104.3	111.7

Over All Picture of Bang Ken Water Treatment Plant