China "Qingdao Development Project (Water Supply and Sewerage)"

Report Date: March 1999

Field Survey: November 1998

Evaluator: The Tokyo Institute
for Municipal Research
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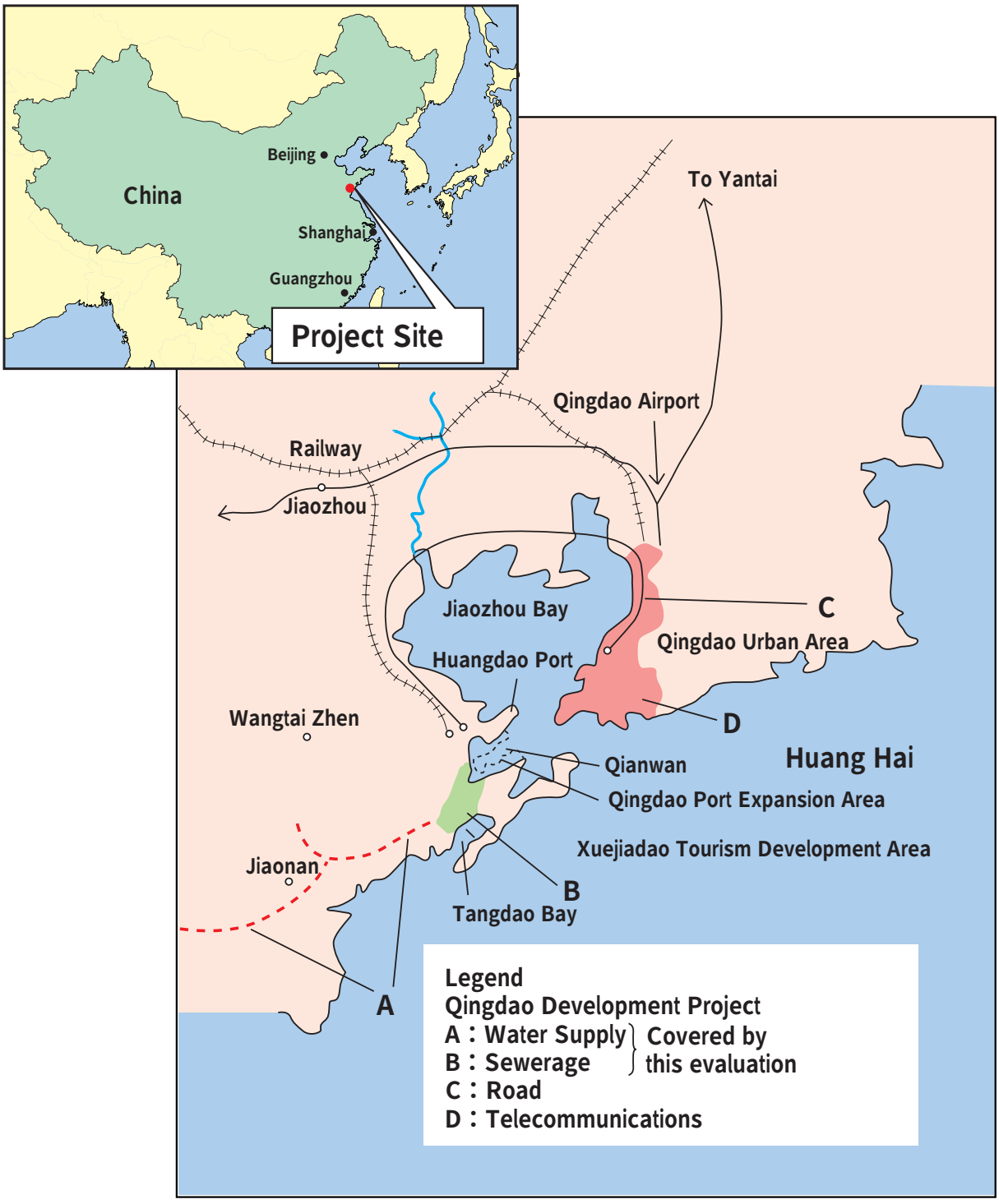
Project Summary

Borrower:	Foreign Trade and Economic Cooperation Department, People's Republic of China (in 1998)
Executing Agency:	Qingdao Municipal Government
Exchange of Notes:	August 24, 1993
Date of Loan Agreement:	August 25, 1993
Final Disbursement Date:	September 30, 1998
Loan Amount:	¥2,513 million
Loan Disbursed Amount:	¥2,512 million (including charges)
Procurement Conditions:	General Untied
Loan Conditions:	Interest: 2.6%
	Repayment Period: 30 years (10 years grace period)

Project Location



Third-Party Evaluation Report

The Tokyo Institute for Municipal Research

Akira Yamagata

1. Evaluation Summary

This is a third-party post-evaluation report on the Qingdao Development Project (Water Supply and Sewerage), which was implemented as a part of the FY 1993 Yen loan.

2. Project Background and Summary

(1) History leading to the plan, and plan summary

The city of Qingdao is situated on the southern tip of the Shandong Peninsula, around Jiaozhou Bay. It is a port city which has light industry, spinning and foreign trade among its industries. It is one of the ten Separate Planning Cities[1] and one of the fourteen Technological Development Zones, allowing it special development plans, and it has province-class economic management authority. Its total land area is 10,654km^2 and as an administrative zone, it comprises seven Qingdao city wards (Shinan, Shibei, Taidong, Sifang, Laoshan, Yankou, Huangdao) and five cities (Jiaozhou, Jimo, Caixi, Pingdu and Jiaonan). In 1995 its total population reached 6,846,000. The production in the area grew by a nominal 698% over the 11 years from 1985 to 1995, reaching 64.2 billion Yuan. Growth was particularly remarkable in secondary and tertiary industries (Qingdao Statistics Yearbook, 1996). Compared to the 8% real economic growth achieved by China as a whole in 1997, Qingdao achieved 12% economic growth, the highest of any city in China.

This development received a major boost from the establishment of the Qingdao Economic and Technical Development Zone (on the other side of Jiaozhou Bay, opposite to the City Zone), which received approval from the National People's Congress in October 1984 and has been developed since March 1985. Development is divided into two phases: the Northern Zone (approximately 9km^2) scheduled to be developed by 1995 and the Southern Zone (approximately 7km^2) by 2000. The construction of industrial, residential and commercial zones is planned for the Northern Zone. The Administrative Committee of Qingdao Economic and Technical Development Zone (QETDZ) has set final targets of 3 billion Yuan for production and 45,000 for resident population. (At the end of 1992, there were 119 enterprises and a population of 17,000). However, the construction of basic infrastructure in the zone, particularly water supply and sewerage, is falling behind schedule. As a temporary measure, water supply of 10,000m^3 per day was being taken from Jiaonan to supply businesses and residents in the development zone. The sewerage was also incomplete, allowing untreated sewage to be discharged directly into Jiaozhou Bay.

In November 1992, this situation led the Chinese government to request the Japanese government for a Yen loan for a the Qingdao Development Project to support the progress of basic infrastructure construction in the development zones. Acting on this request, the Overseas Economic Cooperation Fund (JBIC) conducted SAPROF (Special Assistance for Project Formation) in China and Japan between November 1992 and February 1993. This survey was necessary for the formulation of Yen loan project. The survey findings indicated that ① water supply was an essential element of the development plan and had to be put in place urgently, ② out of consideration for development in harmony with the natural environment, building proper sewerage system was also made an urgent and important task. Hence, both were carried out as a project under the Yen loan.

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[1] It is accorded the same level of authority over economic management as authorities at the provincial level. In 1995 there were a total of 14 cities in this position. They are equivalent to ordinance-designated cities in Japan.

The development zone of approximately 16km^2 is divided into two phases. This project covered one of these, the Northern Zone (approximately 9km^2). It was planned to construct water supply and sewerage systems by the end of 1995 with a total project cost of ¥6,271 million, of which ¥2,513 million was provided by the Yen loan.

(2) Changes in the plans for the entire development zone after the start of construction and the status of the development zone

In May 1993, the Northern Zone was merged with the administrative zone of Huangdao ward to greatly expand the Technological Development Zone. The development zone grew to a land area of 220km^2 and a total population of 220,000. This change made it an important part of the whole of Qingdao and is aimed at making this into a new international city.

The former development zones (Northern and Southern Zones) became Central Administrative and Commercial Zones and the rest of the development zone was divided to a heavy chemical industry zone, a port-side industrial zone, an international trade zone, a food supply center zone, a tourism zone and others. The second phase of the ODA loan[2] financed the Qianwan Harbor (container and mixed freight berths with capacity for 3.15 million tons per year). The Huangdao Oil Terminal is also equipped with a two-berth wharf which ships 30 million tons of crude and refined oil per year. The road from Huangdao to the former Qingdao metropolitan area was developed into an expressway (the Jiaozhou Bay Expressway) using Yen loan, with a total length of 67.7km. The distance along the road to the airport is 63km. Sea lanes consist of freight/passenger ferries and high-speed passenger boats. Ferries reach the Qingdao city center in 30 minutes and high-speed passenger boats take 12 minutes. In addition, the 40km Jiaohuang Railway, which joins Jiaonan to Huangdao, was newly constructed using the ODA loan. It links with the Jiaoje Railway which links Qingdao to Jinan, allowing rail passengers to connect with the nationwide rail network at that point.

The economic environment in which businesses operate provides all necessary conditions, and foreign companies locating in the development zone receive various kinds of preferential treatment, such as reduction or exemption of business income tax. In the bonded zone within the development zone, no import/ export permits are required, which means import duties are also exempted. Preferential measures are building up.

(3) Status and problems for water supply and sewerage in the development zone

After the merger with Huangdao, the total settled resident population of the development zone was 171,000 in 1997, with a population density of 5,700/km^2 in the DID (the most densely populated area). Of these, approximately 150,000 people used water supply, a water supply rate was 88.2%. The capacity of the water treatment works was 110,000m^3/day. There were almost no sewerage facilities other than the sewage and waste water facilities built in the Northern Zone under this Yen loan (with capacity of 35,000m^3/day).

In the areas of the development zone which lacked water supply, each household had to raise water from wells (using shallow groundwater from 5~10m below ground). In the development zone as a

[2] The first phase of the project constructed one berth each for lumber, mixed goods, sand and ore and two berths for coal in the Huangdao area. It was completed in November 1994.

whole, the water sources other than those built under this loan are 40,000m^3/day from the Xiaozhu Shan Reservoir, which serves as the reservoir for Huangdao, 5,000m^3/day from groundwater, 20,000m^3/day from the Tie Shan Reservoir via old Gaojiatai water treatment plant in the Northern Zone (a separate project from this one), and 5,000m^3/day from the Jiahe Reservoir via the Jiahe water treatment plant. However, these water sources have little actual storage. For example, the water intake volume from the Xiaozhu Shan Reservoir is around 10,000m^3/day. Therefore a plan has been proposed to divert water about 150km from the Huanghe River to the Xiaozhu Shan Reservoir. In the development zone, Huangdao ward lacks sewerage facilities. Factories there must treat their own water discharges to meet factory discharge standards (set in 1979 and in effect from 1989) before discharging it directly to Jiaozhou Bay. Household greywater discharges from residents' homes are treated by central facilities for each housing group before discharging directly to Jiaozhou Bay. There is a plan for construction of a new wastewater treatment plant after 2000 with a final capacity of 270,000m^3/day, but the National Planning Committee has not yet ratified the plan.

In Huangdao ward, which is planned as the site for heavy chemical industry, coastal industry, and a large number of other enterprises, sewage treatment facilities were urgently required to maintain and improve the quality of the Jiaozhou bay as a public water area, and also to protect the environment.

3. Observations Based on Comparison of Original Plan and Actual Implementation

This Yen loan project was limited in coverage to the Northern Zone within the development zone and was implemented according to that plan. However, during implementation of the plan, the development zone was greatly expanded by merging with Huangdao ward. This made the original administrative meaning of the Northern Zone unclear. It also became difficult to find statistics specific to the former Northern Zone. However, we have tried to clarify statistics for the Northern Zone as far as possible to enable comparison with the original plan.

(1) Attraction of foreign businesses and population trends

At the time of the original plan at the end of 1992, approximately 119 businesses were located in the Northern Zone and it had a population of 17,000. This project was planned to draw in 250~300 foreign businesses to the 9km^2 area and raise its resident population to 45,000 and its total production value to 3 billion Yuan.

Subsequent figures show that there were 173 business in place by the end of 1993 (69 from Hong Kong, 27 from Taiwan, 22 from the USA, ten from South Korea and nine from Japan) rising to 220 by the end of 1995 and 350 in 1998 (estimated figure). Compared to the original plan, the entry of new foreign businesses was somewhat sluggish, but considering the worldwide recession of recent years, this appears to have been unavoidable.

In 1995 the population was approximately 30,000, considerably below the target. However, by 1998 it was estimated to have reached approximately 45,000 and the total value of production in the area was estimated at 2.8 billion Yuan.

(2) Planned construction of water supply and sewers and implementation status

As an element in building the basic infrastructure of the city, the plan called for construction of water supply and sewers in the 9km^2 of the Northern Zone by the end of 1995 in order to provide a stable water supply and to protect public water resources. Before the plan, water supply to residents and businesses in the Northern Zone depended on a temporary supply of approximately 10,000m^3/day from the city of Jiaonan. The provision of water supply and to keep up with the increasing demand was an urgent task. Therefore priority was given to the construction of water supply facilities which were scheduled for completion by June 1995 6 months ahead of the schedule.

The sewer construction was completed around two and a half years later, in July 1998, because its domestic currency funding was delayed as a result of priority giving to water supply. The Nibu Bay sewage treatment plant went into operation from July 1998, but automation using a centralized treatment control system (made in Germany) was scheduled to begin in December, following delays for program settings etc. Therefore the system is now operating manually, but its water treatment function is not impaired.

[Water supply]

The area of the development zone was altered, expanding the area supplied with water from the Gaojiatai water treatment works beyond what was initially planned. As a result, the plan had to be revised to some extent.

① Water intake and channels from the dam

Comparison of Original Plan and Actual

	Plan	Actual	Difference
Water intake facilities	Four pumps (660-950m^3/h)	Five pumps (Breakdown) Four pumps (900-1,300m^3/h) One pump (550-750m^3/h)	One additional pump
Transmission facilities	13,000m × D 1,000m 21,000m × D 800m	Same Same	None

Note) D = Diameter (same in tables below)

Source) Documents at the time of the appraisal, reports from the Development Zone Management Committee

Under the initial plan, four pumps were to be installed in the Jilihe Reservoir (of which one pump is a spare for backup) to take in 42,000m^3/day. Eventually, considering its use as a water source to substitute for the Tie Shan Reservoir, its water intake capacity was boosted to 55,000m^3/day with the addition of one more pump, bringing the total to five (photo 2). The water intake volume in 1998 consisted of the 42,000m^3/day used in the Gaojiatai water treatment plant which was part of this project, but from 2000 onward it will also be used at the old Gaojiatai water treatment plant (20,000m^3/day), which is why capacity is to be expanded to 55,000m^3/day.

A large number of high-rise residential block are now under construction, and as the way of life improves with the addition of flush toilets and other changes, water demand is expected to increase considerably. The demand forecast made at the planning stage was calculated on a base unit of 125l/person per day for domestic use, but that demand has already reached 133l/person-day. The

maximum containment volume of the Jilihe Reservoir is 70,000,000m^3, and as it draws its water from the Huanghe River, it normally holds 30,000,000m^3. Therefore it appears to have adequate capacity to meet future demand.

The pipeline from the Jilihe Reservoir to the Gaojiatai water treatment plant has a total length of 95km, of which the first 34km from the Reservoir was built under this Yen loan and has already been connected to existing water pipes. Under the initial Chinese Government's plan, the pipes were to be made of pre-stressed concrete, but JBIC suggested ductile cast iron pipes for reasons of ease of construction and reliability, and this option was chosen. The topography rises and falls, necessitating considerable pump pressure to send the water from the Reservoir. Therefore ductile cast iron pipes were a highly appropriate choice for the pipeline.

② Water treatment and distribution facilities

The water treatment facilities (planned treatment volume 40,000m^3/day) and water distribution facilities (four water distribution pumps: 3 × 890m^3/h, 1 × 450m^3/h, ductile cast iron water distribution pipes: 32,080m x D200~1,000mm) were constructed as planned (photos 4 and 5).

Average Recorded Water Supply From the Gaojiatai Water Treatment Plant
(Northern Zone: 1995 ~ 1998) (Units: m^3/day)

	1995	1996	1997	1998
Northern Zone	30,000	31,000	34,000	36,000

Documentation) Prepared by the Water Supply Corporation of QEDZ for the Qingdao Economic and Technological Development Zones.

Under the plan, the Gaojiatai water treatment plant only supplied the Northern Zone, but with the expansion of the development zone, the water distribution network was expanded to be able to supply water over the entire development area. A further 2,000m^3/day is distributed to the heavy chemical industrial parts of the Huangdao area, bringing the total water supply from the Gaojiatai water treatment plant to 38,000m^3/day. This brings the capacity utilization now to 95%, and it is expected to rise to 100%, or 40,000m^3/day, in 2000.

After the merger, the average water demand for the entire combined development area was 50,576m^3/day in 1998. However, large businesses are now moving into the former Huangdao area and water demand is expected to reach 92,000m^3/day in 2000 (20,000m^3/day for industries related to oil refining and 18,000 a day for the power station).

Against this demand, the water treatment capacity of the entire development area was 110,000m^3/day in 1998 (comprising 40,000m^3/day from the Xiaozhu Shan Reservoir, 5,000m^3/day from the Jiahe River, 20,000m^3/day from old Gaojiatai, 5,000m^3/day from ground water and 40,000m^3/day from Gaojiatai). Thus, at least the water treatment capacity will be able to keep up with the demand for the next several years. However, the Development Zone Management Committee estimates that the future increase in industries which consume large amounts of water, such as heavy chemicals and petrochemicals, will push water demand up to 210,000m^3/day by 2010. Therefore they plan to build the new Guanjialou water treatment plant with a supply capacity of 100,000m^3/day, but at present, it

has not yet been finalized. Obtaining water supplies from dams and other water sources will remain an important task in the future.

The distribution pipes for the Northern Zone (cast iron pipes, total length 32,080m, D200~1,000mm) were laid as planned and buried to a depth of 50cm, which avoids all risk of freezing, even in the coldest weather. The leakage rate is 8% (12% in the development area as a whole), which is a great improvement from the 20.95% seen in 1992. One of the factors reducing the leakage rate is that the Water Supply Corporation of QEDZ in the development area has been replacing the concrete pipes used in the past with cast iron pipes, both in the existing installations and in the newly constructed ones (under the Yen loan). Other factors include more frequent monitoring of leaks and more thorough testing of water meters.

[Sewers]

Local currency funding for the sewers was delayed, pushing back their completion by approximately two and a half years to July 1998. Other than the schedule, the construction was completed largely as planned.

Comparison of Original Plan and Actual

	Plan	Actual	Difference
Storm sewer facilities	Steel-reinforced concrete pipes: 15,705m Stone culverts: 3,215m Flood prevention channels: 925m	Same as left	None
Sewage sewer facilities	Sewage culverts: Steel-reinforced pipes 18,225m × D 300-800mm Sewage pumping pipes 6,800m × D 200-800mm Sewage pumps 2 pumps (3-7m^3/min.・4,000mm^3/day) 5 pumps (7m^3/min.・35,000m^3/day)	Same as left	None
Sewage treatment plants	Secondary treatment facilities: Secondary treatment facilities 35,000m^3/day・ Semi-batch Oxidation ditch method Sewage discharge pipe: Land 1,500m × D 800mm Sea 150m × D 800mm	Same as left Land Same as left Sea 180m×D 800mm	None None ＋30m

Source) Documents at the time of the appraisal, explanatory documents from the Development Zone Management Committee.

The sewage discharge pipe was planned to discharge treated water at a point 150m from the shore, but the length was extended to 180m because there were concerns that it might be exposed above water level at low tide. This made sure that the end of the pipe would be under 1m of water at low tide and 4m at high tide. The water quality of water discharged after secondary treatment satisfies China's environmental standards, but out of consideration for the possible impact on swimming and fish farming at low tide (the general range for swimming and fish farming is 2~3m) these activities are prohibited in an area of 1km^2 around the outflow. Measures were taken within the local currency budget to cover the 30m extension to the discharge pipe (photo11).

① Operation status of the sewage treatment plant

The sewage treatment plant (treatment capacity 35,000m^3/day) treats sewage from the whole of the Northern Zone (a daily average of 20,000m^3), but there is no treatment plant for the rest of the development zone. Therefore the factories in the rest of the area must treat their waste water to comply with the industrial waste water standard (grade one standard). Residents must process their waste collectively in a certain location. These waste are then discharged directly to Jiaozhou Bay. In order to cope with this situation, one additional treatment plant (capacity of 40,000m^3/day) is planned to be constructed. An eventual increase in total treatment capacity to 270,000m^3/day after 2000 is now being

considered.

Planned Sewage Volume and Actual Volume

Zone	Area (ha)	Maximum daily sewage volume (m^3/day)	
		Plan	Actual (1998)
Residential zone	285	6,328	7,215
Commercial and public zone	58	5,625	7,096
Industrial zone	355	14,555	16,078
Subtotal	698	26,508	30,389
Volume permeating to groundwater[3]		7,952	1,054
Total		34,460	31,443

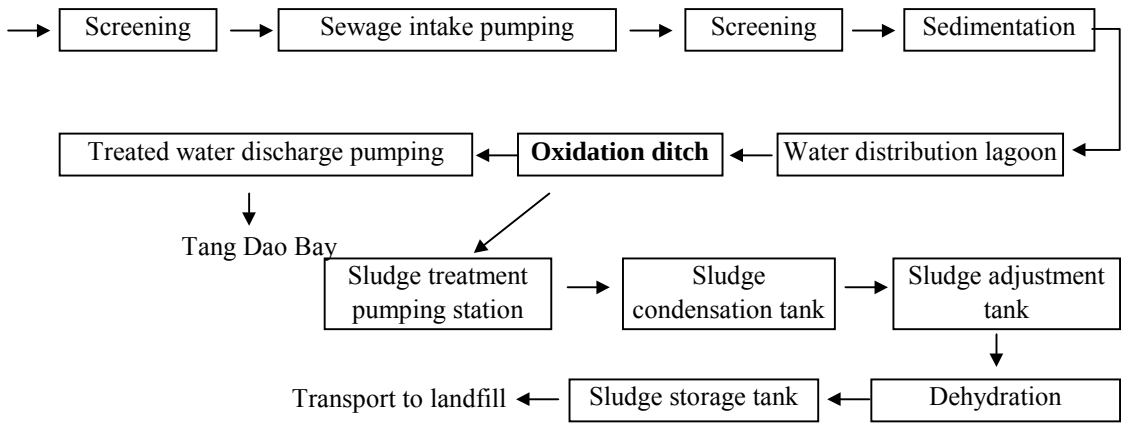
Source) Prepared by the municipal corporation (Sewer Maintenance Management Department)

The volume permeating to groundwater was estimated at 30% of each type of water, based on the local level of the water table (GL-1m in rainy season, GL-6m in dry season), but in practice the volume was greatly reduced due to the installation of new pipes and construction techniques and other factors.

② Treatment process in the sewage treatment works

The treatment method used, as in the plan, was the semi-batch oxidation ditch method, which requires relatively easy maintenance and generates less sludge.

Sewage treatment system



[3] Permeation to groundwater depends on many factors, such as soil quality, water table level, culvert cross section, couplings, materials, distance and construction quality. In general it is expected to account for 10~20% of maximum daily sewage volume.

The quality of the waste water flowing into the treatment plants in September 1998 was 208~369mg/l COD, averaging 285mg/l for the month, and 107~179mg/l BOD, averaging 140mg/l. The water quality of the treated water at discharge over the same period was 35mg/l COD and 14mg/l BOD. The elimination rate is somewhat lower than the planned rate, as shown in the table below, but as the water quality itself satisfies China's environmental standards (COD 60mg/l, BOD 20mg/l), there does not seem to be any problem. For reference, according to Tokyo Municipal Pollution Prevention Ordinances the discharge water quality standards are COD 35mg/l and BOD 25mg/l.

The sewage flowing into the treatment works often contains high concentrations of colon bacilli and continuous chlorine disinfection is applied the same way as for household water, out of consideration for environmental health. The volume of sludge produced from sewage treatment is approximately 10t/day, of which 4~5t/day is passed to farmers as fertilizer. The residue is sun dried and disposed of as ordinary waste in landfill disposal. At the landfill site which is used for final disposal (in Huangdao ward), the discarded sludge is covered over with soil. Some flies are visible in the area, but there does not seem to be a serious public health problem. In future it is worth considering that the sludge be incinerated together with ordinary waste or baked into blocks for reuse in applications such as road paving.

Rates of Elimination of COD etc. at the Sewage Treatment Plant

Item	Plan	Actual
COD	89%	90%
BOD	93%	92%
SS	81%	80%

Note) Figures are readings recorded in September 1998.
Source) Response from the municipal corporation (Sewer Maintenance Management Department).

(3) Implementation Schedule and Project Cost

① Implementation schedule

As noted above, the water supply side of the project was given priority in the implementation schedule as a more urgent problem, and it was completed approximately half a year ahead of schedule. The sewerage side was completed approximately two and a half years behind schedule due to delays in internal currency funding.

Planned Implementation Schedule and Completion

	Planned implementation schedule	Implementation Period	Difference
(Water supply)			
Basic design	1991/09～1992/03 (6 months)		
Detailed design	1992/06～1993/06 (12 months)		
Land acquisition	1993/03～1993/10 (8 months)		
Bidding ~ contracts	1993/07～1994/02 (8 months)	1993/08～1994/05 (9 months)	
Shipping ~ installation	1994/01～1995/07 (19 months)	1994/01～1994/12 (12 months)	
Construction work	1993/10～1995/07 (22 months)	1993/10～1995/03 (18 months)	
Inspection and test running	1995/07～1995/12 (6 months)	1995/01～1995/05 (5 months)	
Completion and start of operation	1996/01	1995/06	－7 months

	Planned implementation schedule	Implementation Period	Difference
(Sewerage)			
Basic design	1991/09～1992/07 (11 months)	Same as left	
Detailed design	1992/10～1993/07 (10 months)		
Land acquisition	1992/01～1992/03 (3 months)		
Bidding ~ contracts	1993/07～1994/02 (8 months)		
Shipping ~ installation	1994/01～1995/07 (19 months)	1994/01～1997.12 (36 months)	
Construction work	1993/10～1995/07 (22 months)	1997/03～1998/07 (17 months)	
Inspection and test running	1995/07～1995/12 (6 months)	1997/12～1998/09 (10 months)	
Completion and start of operation	1996/01	1998/07	＋30 months

Source) Explanatory documents from the Development Zone Construction and Environment Department.

② Project Cost

The total project cost in the original plan, converting the foreign currency and local currency portions into Yen, was ¥6,271 million. The final calculation of project cost came to ¥4,688 million, a reduction of ¥1,583 million. The reduction was possible because the land acquisition, technical and management costs, which were covered by the local currency portion, were cheaper than anticipated, and because of favorable exchange rate movements. At the planning stage, the exchange rate was 1Yuan = ¥20.9, but at the time of execution in 1996 the rate was 1Yuan = ¥13.04.

Comparison of Planned and Actual Total Project Costs

	Plan	Actual	Increase/decrease
Total project cost	¥6,271 million	¥4,688 million	△¥1,583 million
Foreign currency (Yen loan)	¥2,513 million	¥2,512 million	△¥1 million
Local currency	179.77 million Yuan	166.88 million Yuan	△12.89 million Yuan
Project cost of water supply facilities	¥3,822 million	¥3,042 million	△¥779 million
Foreign currency (Yen loan)	¥1,843 million	¥1,842 million	△¥1 million
Local currency	94.66 million Yuan	92 million Yuan	△2.66 million Yuan
Project cost of sewerage facilities	¥2,449 million	¥1,646 million	△¥802 million
Foreign currency (Yen loan)	¥670 million	¥670 million	0
Local currency	85.11 million Yuan	74.88 million Yuan	△10.23 million Yuan

Source) Development Zone Management Committee

4. Operations and Maintenance

(1) Organization and maintenance scheme

The office in charge of water supply and sewers at the time of the plan was the Public Works Department, which was one of nine Departments and one office under the Qingdao Economic and Technological Development Zone. Subsequent reorganization merged the Public Works Department and the former Environmental Protection Department to form the new Construction and Environment Department, which is now the department in charge of these facilities.

The Construction and Environment Department comprises six divisions, such as the Planning and Operation Division and the Accounting Division, one section, one sub-section and seven corporations. Of those, the Water Supply Corporation of QEDZ is responsible for the operation and maintenance of the water supply and the municipal corporation is responsible for sewers.

The Water Supply Corporation of QEDZ had a total of 398 staff in 1998, divided between the management department, which has 45 staff, and the operational (field) department, which has 164 staff in the head office and 165 in the field. The operational department's organization in head office has six sections equivalent to sections and subsections. Of these, the chemical testing section (11 staff) handles chemical investigations, the measurement section (15 staff) handles regular testing and repair of water meters, the materials section (17 staff) handles distribution of materials and parts, and the building safety section (50 staff) handles building safety measures. The No.1 water supply section (34 staff) has branches at Xiaozhu Shan water treatment plant (60 staff) and the No.2 water supply section has branches at Gaojiatai water treatment plant (59 staff) and Jilihe pumping station (19). These two sections are responsible for the maintenance of the water treatment plant and the dam pumping station.

An important development to note here is that the new Sanchang Corporation, which is essentially a third sector corporation, has been set up as an external body attached to the Water Supply Corporation of QEDZ in order to raise the operation and maintenance efficiency of the project. At present the Sanchang corporation is divided into three groups for water treatment, trade and repairing which have 25 staff dispatched from the Overall Water Corporation. Each of these takes on some aspect of improvement works or other operations that were previously handled by the Corporation. They appear to be working towards benefits such as greater operating efficiency and reduced personnel costs in the project.

The Municipal Corporation, which is responsible for sewer maintenance, has a total of 280 staff and still has exactly the same organizational structure as it did at the time of the plan. It comprises two offices, six departments and one plant, such as the administrative office, the accounts section, the materials section, the construction section and the sewage treatment plant. The sewage treatment plant has a materials office, a testing office, a technical office, an accounts office, a machinery repair office and a security office or six offices in all. In 1998 it had 60 staff, scheduled to be increased to 84 in 1999.

The environmental conservation office (30 staff), a subordinate agency of the Construction and Environment Department, handles matters such as the testing of waste water from factories etc. and water quality testing for the Nibu Bay.

(2) Operations and maintenance status

① Development of staff abilities and project execution systems

Considerable attention appears to be paid to raising the practical skills of the staff and ensuring their safety in order to carry out work tasks effectively.

Articles on wages, working hours and health and safety in the workplace are basically laid down in the China Labor Act, but each organization makes its own rules for the specific and detailed application of the rules. For example, in the sewage treatment plant, there is a 29-article set of "Rules for Safe Production Management" which aims to ensure safety at work and proper fulfillment of duties. There is also a set of "Production Shift Rules" for the system of four teams and three shifts which allows 24-hour operation. In addition, the Outline of the Preparation and Management of Production Statistics explains the recording of daily, monthly and annual report, the preparation and management of data and documents and other administrative procedures.

The training and development of the staff is achieved through training in the workplace and study testing. In particular, experienced engineers give instructions, based on the manuals, (in both Chinese and English) on the proper maintenance of machinery and other facilities. Regular monthly inspections are made on all equipment and its operational status.

In order to maintain the close cooperation between Water supply and Sewers, a forum has been established for regular discussions between the staff of the Water Supply Corporation of QEDZ and the Municipal Corporation to foster good communications between the two sides. Meetings are monthly, with semiannual studies of specific problems and a final study at the end of the year.

The attributes that the Construction and Environment Department values most highly in their staff are specialization (level of experience) and sense of responsibility for their work. Therefore they emphasize staff's record of gaining qualifications and improving abilities, and staff who perform well in that regard are given preference in pay raises and promotion. This personnel policy appears to be highly effective.

In the future, computerization and office automation in China can be expected to increase, and there will be environmental changes, particularly concerning global environmental problems, therefore, it will become increasingly important to tackle these heightening and diversifying administrative demands. Therefore, from a long term viewpoint, the stable continuation of the project both now and in the future will require the training of staff with the ability to meet new challenges.

② Financial management

Water supply charges in 1998 were set at 1.20 Yuan/m^3 for households, 1.50Yuan/m^3 for industry and 2.00 Yuan/m^3 for commercial and public use. Sewerage charges, which are included within the above charges, were set at 0.10 Yuan/m^3, 0.15 and 0.20 respectively. This method of collecting sewerage charges according to water supply usage is also used in Tokyo.

Under the original plan, the charge for water supply for households was to have been substantially increased from 0.30 Yuan/m^3 to 3 Yuan/m^3 in 1997, after the completion of the sewer system. In the end, the size of the increase was reduced. Calculation of the Financial Internal Rate of Return (FIRR) for the water supply and sewers in the Northern Zone only shows a negative value, as it did at the time of appraisal. Therefore the civil government of Qingdao pays a 1/3 subsidy for the maintenance of the

water supply and sewers through the Development Zone Finance Department. Future increases in charge, if implemented, would remove the need for subsidy. Therefore the Qingdao civil government wants to see a rate of at least 1.8 Yuan/m^3, but are willing to allow a grace period for the time being.

The rate for household water supply, converted to Yen, comes to approximately ¥15.7/m^3, which might appear cheap for the users compared to the water charge for household use in Tokyo, which is ¥240/m^3 (including sewerage charge). However, considering the disparity between the income of a Qingdao resident (¥29,000/year according to the Qingdao Statistics Yearbook) and a Tokyo resident (¥4,395,000 in 1996), and the gap in consumer prices (rice costs ¥16/kg in Beijing and ¥493/kg in Tokyo, according to the Modern China Databook by Kokin Shoin, 1994), the Qingdao residents who have to pay for it must feel that the rate is very high.

The world recession is delaying the anticipated entry of foreign companies to the area, and those that have moved in the area are relatively small. As a result, the revenue from water supplied to industry is somewhat below initial expectations.

However, the costs of maintenance for the water supply and sewers are systematically guaranteed allocation from the general account, funded by taxation. Therefore there does not seem to be any problem at present, but the amount of the allocation is determined each year by the regional assembly.

Water charges are not collected systematically, either directly through personal collection or through bank transfers. Therefore each company, apartment block association or residents association must take the collected money to the Water Supply Corporation of QEDZ's collection office. This is an inconvenient payment system, but as those who fail to pay face immediate disconnection, almost no users fall behind on their payments.

Water Supply Maintenance Status and Estimates (Units: Yuan×10,000)

FY	Personnel cost	Repair cost	Fuel cost	Electrical power	Chemicals	Other	Totals
1996	59	4.0	2.1	120	23.2	20.8	229.1
1997	59	4.0	2.2	135	25.3	22.5	248.0
1998	59	4.0	2.0	80	24.4	16.9	186.3
1999	59	4.5	2.5	100	26.8	19.3	212.1
2000	59	4.5	2.5	125	29.5	22.0	242.5
～							
2025	59	4.5	2.5	156	32.5	25.5	280.0

Sewerage Maintenance Status and Estimates (Units: Yuan×10,000)

FY	Personnel cost	Maintenance Cost	Electrical power	Chemicals	Other	Totals
1998	59.2/2	69/2	200/2	28/2	45/2	401.2/2
1999	59.2	69	200	28	45	401.2
2000	59.2	69	200	28	45	401.2
～						
2025	59.2	69	200	28	45	401.2

Note) "Other" includes administrative and financial costs.
Personnel costs: For water supply = 90 staff ×6,555 Yuan/year-person.
For sewerage = 84 staff × 7,047 Yuan/year-person.
Source) Documents submitted by the Construction and Environmental Conservation Department.

In this project, which targeted the Northern Zone, the entry of new businesses to the area was slower than anticipated and the water charges were set low, leaving the project in a difficult financial position. The Water Supply Corporation of QEDZ is working to second staff elsewhere and reduce leakage rates, but, similar to the Municipal Corporation, its finances are not necessarily sound. In the future an increase in water rates is probably unavoidable.

Comparison between water operations in Tokyo and China may be impossible because those in Tokyo operate under the Regional Public Enterprises Act, which emphasizes efficiency and economy as well as public benefit, and those in China operate under different socio-economic systems. However, even in the case of water supply operations in Tokyo, revenue from water charges is mainly used for operating expenses (profitable income and expenditure) and capital expenditure for construction improvements and similar applications are generally funded from corporate bond issues and state expenditure (Metropolitan Tokyo: Share of charge revenue within total business revenue: 60% for water, 23% for sewerage, FY 1997).

Water supply and sewers are among the basic facilities of cities and they have wide ranging effects on improving the quality of life and guarding the quality of common water resources. Thus these are very much in the public's interest. The issue of whether to emphasize public benefit or economics in public works is strongly influenced by the country and city concerned and the socio-economic forces of the times.

5. Economic and Social Effects

(1) Economic effects on companies and industry

The recession of the last few years has slowed down the entry of foreign companies, compared to the original plan, but the number of foreign companies in the whole development zone rose from 309 in 1993 (total value of foreign capital = 590,080,000 Yuan) to 432 (1,158,970,000 Yuan) in December 1997.

In the Northern Zone, there were 119 companies at the end of 1992, rising to 350 by the end of 1997. Thus the growth was most rapid in the Northern Zone. The total number of companies, both Chinese and foreign, in the development zone as a whole is 1,038, of which 950 (92%) are located in the Northern Zone. The companies in the Northern Zone are relatively small, but many are in fields such as foodstuffs and chemicals which are highly dependent on water supply and use it in large volumes. The forecast in the original plan for industrial water demand in 1995 was 14,555m^3/day, but actual demand was 20,300m^3/day.

This situation indicates that the provision of water supply has had a major impact on the development of industry and the economy in the Northern Zone. Furthermore, the excess water from Gaojiatai water treatment plant, which supplies the Northern Zone, is supplying 2,000m^3/day to areas of the development zone outside the Northern Zone. That supply has made a great contribution to the development of heavy chemical industry and other large water users in the Huangdao area.

As noted above, the construction of the sewer system was delayed by two and a half years and only went into operation in July 1998. Therefore we can still do no more than conjecture concerning the economic effects, but the financial and operational burden on factories appears to have been considerably reduced.

Before the sewer system was built, the existing sewer pipes were discharging up to 10,000m^3/day of untreated sewage from businesses to the bay in front of Huangdao. Furthermore, untreated household greywater from the area without a sewer system was being discharged to the Huangdao Bay. Both bays are enclosed bodies of water and their environmental condition had been worsening steadily since 1990 with the increasing numbers of businesses in the area. These near coastal waters hold farms for raising shrimp etc. and the fishing industry was suffering considerable damage. Therefore the Development Area Management Committee was paying compensation to fishermen and the final burden was placed on businesses. With the implementation of the Factory Waste Water Regulation Act (1989), the strictest level of standards (grade one standards) were applied to the direct discharge of waste water from factories to public bodies of water. This placed a considerable financial burden on factories which were not equipped with facilities for treating their waste water. The construction of the sewer system gave businesses in the Northern Zone a considerable business advantage.

The Development Area Management Committee explains the roles of this project, which concentrates on water supply and sewers, in economic and other development, as follows.

① The Qingdao Economic and Technological Development Zone was established in Qingdao in 1985, but the basic urban infrastructure of water supply and sewers were not provided. This shortcoming created many obstacles. Later, this infrastructure was built with the assistance of JBIC, and many companies, particularly those in high-technology and export-oriented fields, achieved remarkable growth. The Northern Zone became an important element of the city of Qingdao as a whole, becoming a new international city.

② Before the project, water supply came from Jiaonan Bay, but the completion of the construction enabled a smooth, independent supply of water. This supply helped the area through the severe water shortage caused by the drought in 1995~1996, provided emergency supplies to other areas, and helped in the business activities and investment affairs of the whole development area.

③ The facilities provided indirect benefits, creating employment during their construction and creating a forum for activities by organizations and staff.

(2) Social effects such as improved city amenities and standard of living

Within the Northern Zone, the region to which the project is applied, residential land occupies 280ha, or 35% of the total land area (the planned area was 285ha). It is zoned into types 1~4 according to the characteristics of the area, as solely residential, mixed residential and commercial, low-rise and medium ~ high-rise.

As of 1998, the volume of water supplied to households was 8,800m^3/day, and the household sewage volume was 7,215m^3/day. The water supply coverage rate was 100% and the sewer usage rate was 88.9%. Before the water supply facilities were completed, the only source of water supply was from Jiaonan Bay (3,755m^3/day in 1992). The completion of the water supply facilities brought about great progress in water supply capacity, and the resident population also rose, reaching 45,000 by the present day.

There are now many residential buildings of 6~8 floors in the areas zoned for medium and high-rise commercial and residential usage, and over ten high-rise residential blocks are currently under construction. The residents' way of life is rapidly moving towards the modern western style, with an increase in the use of flush toilets, indoor baths and electric washing machines. However, those who buy a company-owned house or an apartment in a group block must pay around 110,000 Yuan (¥1.43 million) for a standard unit with two or three bedrooms and a kitchen/dining room. This is approximately 18 times the average annual income of a working household (6,852 Yuan, upper middle class) in metropolitan Qingdao, making these homes almost a prize beyond reach.

The low-rise residential zones have water supply, but the usage of flush toilets is extremely low and the majority still use tanks for collection of waste. The proportion who have indoor baths and electric washing machines is not known, but it can be inferred from the per-capita household water usage in the Northern Zone (133l/day in 1998) that their use is quite widespread. Incidentally, the number of washing machines owned in households in residential areas of Qingdao is 81.5 units per 100 homes (Qingdao Statistical Yearbook, 1996).

Until now, in residential areas with no water supply, residents have had to rely on ground water only. Some of them use hand-pumped well water. Most households are Chinese urban working families, where both husband and wife work. The provision of water supply has brought them a much more comfortable life, particularly in the form of reducing burden on the wives. In the households visited for an interview for this report, we found out that most still used some well water, because "well water is better for cooking".

The Water Supply Corporation of QEDZ conducted a "Questionnaire Survey of Water Supply" on residents in 1998. The survey targeted block delegates (one person in 6~10 houses) for the whole area. In their anonymous responses they were asked to give their evaluation as good, ordinary or improper

in seven categories (water pressure, water quality, water metering, charge payment, requests for water supply, water supply works, and staff attitude) and "other opinions". The results had not been collated by November 1998, but the following results were found from ten responses sampled at random.

[1] Water pressure: Good 60%. [2] Water quality: Good 100%.
[3] Metering (visit time): Appropriate 100%. [4] Charge payment: Convenient 60%.
[5] Requests for water supply: Convenient 90%. [6] Water supply works: Good 100%.
[7] Staff attitude: Good 100%

6. The Role of the Project in Preservation of the City's Environment and Reduction of Environmental Impact

(1) Public health effects

The water source for the Northern Zone is the Jilihe Reservoir. The water is initially purified by passing it through a sedimentation lagoon at the Reservoir management center before feeding it to a water pipeline for pumping to the Gaojiatai water treatment plant.

When a dam is the water source, the volume and quality of the water supplied are generally more stable than when it is taken from surface sources such as rivers. This is the case with this project. In particular, the dam is in a good location with almost no dwellings nearby. The water is relatively transparent and it passes the Chinese National Environmental Standards for water quality. Thus it is confirmed as being a suitable source for water supply.

The water pipes and other facilities are new, the bankfull rate is low at 8% and the water leaving the faucet has good quality and pressure.

According to the explanation of the Construction and Environmental Conservation Department, there has been no incidence of cholera and dysentery in the Northern Zone in the last several years.

National Water Quality Standards and Water Quality Test Results (1997)

Item	Unit	Water quality standard		Water quality test results	
		Surface water	*Daily drinking water*	*Jilihe Reservoir*	*Gaojiatai Water Treatment Plant*
Color	degree	—	15 or less	15	5 or less
Turbidity	degree	—	5 or less	19	1.3
pH	mg/l	6.5～8.5	6.5～8.5	7.9	7.49
Total hardness	mg/l		450 or less		83.8
Iron	mg/l	0.5 or less	0.3 or less	0.06	0.05 or less
Manganese	mg/l	0.1 or less	0.1 or less	Not Detected	Not Detected
Copper	mg/l	1.0 or less	1.0 or less	0.05	0.01 or less
Zinc	mg/l	1.0 or less	1.0 or less	0.3	0.04 or less
Volatile phenol	mg/l	0.005 or less	0.002 or less	Not Detected	Not Detected
Fluorid	mg/l	1.0 or less	1.0 or less	0.4	0.161
Cyanide	mg/l	0.2 or less	0.05 or less	Not Detected	Not Detected
Arsenic	mg/l	0.05 or less	0.05 or less	0.0025	Not Detected
Selenium	mg/l	0.01 or less	0.01 or less	Not Detected	Not Detected
Mercury	mg/l	0.1 or less	0.001 or less	0.0001 or less	Not Detected
Cadmium	mg/l	0.005 or less	0.01 or less	Not Detected	Not Detected
Chromium	mg/l	0.05 or less	0.05 or less	Not Detected	Not Detected
Zinc	mg/l	0.05 or less	0.05 or less	Not Detected	Not Detected
Total No. of bacteria	mg/l	10000 or less	100 or less	270	0
No. of coliform bacili	mg/l	Not Detected	3 or less	140	0

Source) Appraisal materials at the time of and one submitted by Water Supply Corporation of QEDZ.

(2) Water quality improvement, environmental conservation and other impact on common bodies of water

The role of sewers varies with changes in the social, economic and environmental forces of the times and the country concerned, but the most important at present are:

① Improvement of the living environment through the removal and treatment of sewage.
② Prevention of flooding through the removal of rainwater.
③ Protection of water quality in public bodies of water.

Particularly in recent years in any city, household greywater, which is not subject to the same kind of sewage discharge standards as waste water from factories, commonly causes environmental degradation in public bodies of water. The provision of sewage facilities is essential if the water quality in these bodies of water is to be protected.

Due to delays in the implementation schedule, this project to build sewers was not completed until July 1998. It is too early to obtain adequate data and therefore the results are not necessarily clear cut, but the project appears to have had considerable effects in protecting the water quality of the bodies of water concerned.

The monitoring of waste water from factories is conducted by the Environmental Conservation Office, which is a subsidiary agency of the Construction and Environmental Conservation Department, as

described above. Nationally-qualified expert engineers carry on strict and systematic monitoring. The monitoring locations are near the waste water outflows from major businesses (about 20 locations). BOD, COD and other main pollutants are measured once every three months, with additional tests taken at any time, as required. Companies discharging waste in breach of standards face stiff penalties of either fines (averaging approximately 5,000 Yuan) or suspension of business. Since 1996, eight companies have been suspended from business and some are under suspension now.

Although this strict monitoring system is in place and the discharge standards are observed, there is also the problem of household greywater. A survey of the water finally flowing into the sewage treatment works in September 1998 found COD at 208~369mg/l (average 285mg/l) and BOD at 107~179mg/l (average 140mg/l). Compared to the forecast levels from the initial plan (COD 422mg/l and BOD 249mg/l), there is some margin but the levels are similar. If this waste water was discharged without treatment it can be assumed that it would have a severe impact on the surrounding aquatic environment.

After the above water was treated at the sewage treatment works, it was reduced to COD 35mg/l and BOD 14mg/l before being discharged offshore in Tang Dao Bay (photo 11).

Marine Environmental Impact Results for COD Near Sewage Water Outflows

	(Untreated)	Plan	Actual
Peak value	3.3mg/l	1.5mg/l	2.0mg/l
Average value	2.4mg/l	1.28mg/l	1.5mg/l

Note) Recorded figures from September 1998.
Source) Documents submitted by the Construction and Environmental Conservation Department.

The above results for marine COD levels are above the planned values for both peak and average concentrations, but they comply with Marine Environmental Standards (In China, for marine produce grade one = 3mg/l or less, bathing = 4mg/l or less. In Japan, for marine produce grade one = 2mg/l or less, grade two = 3mg/l or less.). Therefore these levels do not indicate a problem.

There is a general tendency for COD/ BOD values to be higher in summer. Therefore continuing monitoring over a longer period of time is required.

(3) Removal of rainwater and flood prevention

The sewage facilities built under this project are divided in a dual flow method into two separate systems for rainwater and sewage. Rainwater flows through steel-reinforced concrete pipes and stone culverts (19,845m of channels were constructed under this Yen loan) which are separate from the channels used for waste water from homes and factories. Rainwater gathered through this system then flows to the Tangdao and Huandao Bays through natural channels.

The general principle adopted in sewer projects is that rainwater is handled by public expense and sewage by private expense. The elimination of rainwater is essential to prevent urban flooding and has a high level of public benefit on a par with roads and rivers.

In the Northern Zone there was occasional flooding of roads and other areas in the summer rainy season before the rainwater facilities were built. In particular, a village area in the east of the Northern

Zone experienced flooding every year. Water rose to 62~80cm in 1989 and to 30cm in 1993, flooding about 60 dwellings above floor level.

After the facilities were in place to handle rainwater, it was removed efficiently and there has been no flooding or other urban water damage since 1996. Before that, the flow of rainwater was accompanied by soil and gravel flowing directly into surrounding rivers. In the Mahao Canal in the Northern Zone, the accumulation of this soil raised the level of the canal bed, impeding the flow of water. Apparently the provision of rainwater handling facilities also solved this problem, resulting to another major additional benefit of the project.

7. Pending Tasks

(1) Obtaining and conserving water supply resources

The merger with Huangdao Ward expanded the Qingdao Economic and Technological Development Zone to a major development zone of 220km^2 and 220,000 people at a stroke. This change necessitated a major revision of the plan for future water demand. A large number of major water users, such as petrochemical industries, are expected to move into the area and measures to maintain the system, particularly by securing water supply sources, are still not adequate.

The Jilihe Reservoir, which is the water supply source for the Northern Zone, has abundant water that will be adequate for the present, but the Xiaozhu Shan and Tie Shan Reservoirs which serve the Huangdao area has strong tendency of being unstable in its water volume. In the dry period of 1997 their storage rate dropped to 25%.

Therefore the idea of building a new dam drawing water from the Huanghe River is one option being considered, but it has not progressed beyond that stage. Apparently the Huanghe River itself has not always had abundant water in recent years, and thorough investigation will be required in the future. The issues of water rights and supply and demand require regional coordination at a level beyond individual municipalities. It will be much more important in the future to build cooperative relationships with neighboring municipalities and local governments over water issues. As noted earlier, the Jilihe Reservoir is approximately 95km away from the built-up areas of the Northern Zone. Its surrounding environment is good and there appear to be no problems with the quality of its water at present. Although this area currently lacks any means of public transportation, it will be receiving more leisure visitors in the future with the advancement of motorization, thus raising concerns over degradation of the natural environment. Environmental protection measures, such as the planting of trees against erosion, must be devised for the area around the dam.

(2) Use of rainwater and recycled water

In 1998 the development zone as a whole had a total population of 220,000, but that is expected to rise to 600,000 by 2010. This is estimated to bring water demand up to 210,000m^3/day at that time.

The water supply capacity of the facilities in 1998 was 110,000m^3/day, and the dams other than Jilihe Reservoir already have low storage rates and unstable intake volumes. Construction of a new dam is being considered, but it is only an idea with no concrete plans.

Therefore, in parallel with securing dam water resources, consideration should be given to the

technical, financial and other aspects of the potential for water reuse. This reuse would include rainwater and highly-processed (tertiary processed) sewage water. Considering the fact that a majority of the future demand for water will be for industry, recycling of water for industrial applications appears to be an effective policy option for improving the balance of water supply and demand. (In Tokyo 7% of treated sewage water is now being recycled for industrial use).

The temperature of sewage water varies little throughout the year, being generally cooler than air temperature in summer and warmer in winter. This property could be used as a heat source for heating and cooling. If it was used in conjunction with the heat supply project now under way in a part of the Northern zone, it could serve to save energy.

8. Conclusions

These days, environmental problems are global issues which reach beyond any country or region. Pollution of one part of the marine environment by China spreads from the Sea of Japan to the oceans of the world with no regard for national boundaries. It is not too much to say that the implementation of environmental conservation in China is for the benefit of Japan.

While there are differences in income and prices, a project of this scale has been achieved for an investment of ¥2.5 billion, achieving a major environmental improvement. For comparison, in 1985 a four-story, 4,133m^2 underground pit under a building in the new area of Shinjuku, Tokyo, for storage of water for reuse cost ¥2.858 billion. The Qingdao city government is very grateful for being able to build this project with ODA loan, as it has built other projects for ports, roads and communications, and I recall being deeply moved by this project, which benefits so many of the people of Qingdao.

① Pumping Station (Gaojiatai Water Treatment Plant)

② Oxidation Ditch/Half Turn Type (Sewage Treatment Plant)

③ A water tap in a house of northern zone
Meters are maintained in good condition.