Document of
The World Bank

Report No: ICR00001100

IMPLEMENTATION COMPLETION AND RESULTS REPORT
(IBRD-45660 TF-24121)

ON A

LOAN
IN THE AMOUNT OF US$ 349 MILLION

AND A

GLOBAL ENVIRONMENT FACILITY GRANT
IN THE AMOUNT OF SDR 18.9 MILLION (US$ 25 MILLION EQUIVALENT)

TO THE

PEOPLE'S REPUBLIC OF CHINA

FOR A

SECOND BEIJING ENVIRONMENT PROJECT

September 25, 2011

China and Mongolia Sustainable Development Unit
Sustainable Development Department
East Asia and Pacific Region

CURRENCY EQUIVALENTS

(Exchange Rate Effective: May 1, 2011)

Currency Unit = Renminbi Yuan
Renminbi Yuan 1.00 = US$ 0.15
US$ 1.00 = Renminbi Yuan 6.50

FISCAL YEAR
[January 1 – December 31]

ABBREVIATIONS AND ACRONYMS

AQMDSS	Air Quality Monitoring Decision Support System	GEF	Global Environment Facility
		GEO	Global Environment Objective
BCIC	Beijing Comprehensive Investment Company	GHG	Green House Gases
		GIS	Geographic Information System
BDA	Beijing Economic-Technological Development Area	HECC	Heating Energy Conservation Center
		ICB	International Competitive Bidding
BDC	Beijing Drainage Company	ICR	Implementation Completion & Results (Report)
BDG	Beijing Drainage Group		
BDRC	Beijing Development and Reform Commission	IEG	Independent Evaluation Group
		ISR	Implementation Status And Results Report
BEPB	Beijing Environmental Protection Bureau	JBIC	Japan Bank of International Cooperation
BMEC	Beijing Municipal Engineering Corporation	KPI	Key Performance Indicators
BMFB	Beijing Municipal Finance Bureau	MoC	Ministry of Commerce
		MoF	Ministry of Finance
BMG	Beijing Municipal Government	M&E	Monitoring and Evaluation
BMWAB	Beijing Municipal Water Affairs Bureau	NDRC	National Development & Reform Commission
		NH_3-N	Ammonia Nitrogen
BOD	Biological Oxygen Demand	NOx	Nitrogen Oxide
BPMO	Beijing Project Management Office	O&M	Operation and Maintenance
		PAD	Project Appraisal Document
CAS	Country Assistance Strategy	PDO	Project Development Objective
CCHP	Combined Cooling, Heating and Power (Plant)	PIU	Project Implementing Unit
		QEA	Quality at Entry Assessment
COD	Chemical Oxygen Demand	QSA	Quality of Supervision Assessment
CO_2	Carbon Dioxide	RAP	Resettlement Action Plan
CPS	Country Partnership Strategy	RCR	Resettlement Completion Report
DO	Dissolved Oxygen	SEPA	State Environmental Protection Agency
EA	Environmental Assessment		
EIRR	Economic Internal Rate of Return	SO_2	Sulfur Dioxide
		WAB	Water Affairs Bureau
EMP	Environnemental Management Plan	WWTP	Wastewater Treatment Plant
		SJET	Shihuan Jietian Energy Technology Corporation. Ltd.
EPB	Environnemental Protection Bureau	TP	Total Phosphorus

GDP	Gross Domestic Product	TSP WHO	Total Suspended Particulates World Health Organization

Vice President:	Mr. James W. Adams, EAPVP
Country Director:	Mr. Klaus Rohland, EACCF
Sector Manager:	Mr. Ede Jorge Ijjasz-Vasquez, EASCS/ Mr. Vijay Jagannathan, EASIN
Project Team Leader:	Ms. Chongwu Sun, EASCS
ICR Team Leader:	Ms. Chongwu Sun, EASCS

CHINA

SECOND BEIJING ENVIRONMENT PROJECT

DATA SHEET

A. Basic Information			
Country:	China	Project Name:	Second Beijing Environment Project
Project ID:	P042109,P064924	L/C/TF Number(s):	IBRD-45660,TF-24121
ICR Date:	09/25/2011	ICR Type:	Core ICR
Lending Instrument:	SIL	Borrower:	PEOPLE'S REPUBLIC OF CHINA
Original Total Commitment:	USD 349.0M,USD 25.0M	Disbursed Amount:	USD 319.03M,USD 24.8M
Environmental Category: A		**Focal Area**:	
Implementing Agencies: Beijing Municipal Government			
Cofinanciers and Other External Partners:			

B. Key Dates				
Second Beijing Environment Project - P042109				
Process	**Date**	**Process**	**Original Date**	**Revised / Actual Date(s)**
Concept Review:	11/02/1998	Effectiveness:		05/11/2001
Appraisal:	04/17/2000	Restructuring(s):		11/02/2006
Approval:	06/20/2000	Mid-term Review:		11/08/2003
		Closing:	12/31/2006	03/31/2009

Second Beijing Environment Project – GEF Component - P064924				
Process	**Date**	**Process**	**Original Date**	**Revised / Actual Date(s)**
Concept Review:	11/02/1998	Effectiveness:		05/11/2001
Appraisal:	04/17/2000	Restructuring(s):		
Approval:	06/20/2000	Mid-term Review:		11/08/2003
		Closing:	12/31/2006	01/31/2011

C. Ratings Summary	
C.1 Performance Rating by ICR	
Outcomes	Satisfactory

GEO Outcomes	Satisfactory
Risk to Development Outcome	Low
Risk to GEO Outcome	Low
Bank Performance	Satisfactory
Borrower Performance	Satisfactory

C.2 Detailed Ratings of Bank and Borrower Performance (by ICR)			
Bank	**Ratings**	**Borrower**	**Ratings**
Quality at Entry	Satisfactory	Government	Satisfactory
Quality of Supervision	Satisfactory	Implementing Agency/Agencies	Satisfactory
Overall Bank Performance	Satisfactory	Overall Borrower Performance	Satisfactory

C.3 Quality at Entry and Implementation Performance Indicators			
Second Beijing Environment Project - P042109			
Implementation Performance	**Indicators**	**QAG Assessments (if any)**	**Rating:**
Potential Problem Project at any time (Yes/No)	No	Quality at Entry (QEA)	None
Problem Project at any time (Yes/No)	No	Quality of Supervision (QSA)	None
DO rating before Closing/Inactive status	Satisfactory		

Second Beijing Environment Project – GEF Component - P064924			
Implementation Performance	**Indicators**	**QAG Assessments (if any)**	**Rating:**
Potential Problem Project at any time (Yes/No)	No	Quality at Entry (QEA)	None
Problem Project at any time (Yes/No)	No	Quality of Supervision (QSA)	None
GEO rating before Closing/Inactive Status	Satisfactory		

D. Sector and Theme Codes		
Second Beijing Environment Project - P042109		
	Original	**Actual**
Sector Code (as % of total Bank financing)		
District heating and energy efficiency services	48	6

Other industry	2	0
Sewerage	49	93
Sub-national government administration	1	1

Theme Code (as % of total Bank financing)		
Climate change	20	6
Environmental policies and institutions	20	20
Other urban development	20	20
Pollution management and environmental health	20	20
Water resource management	20	34

Second Beijing Environment Project - GEF Component - P064924		
	Original	**Actual**
Sector Code (as % of total Bank financing)		
District heating and energy efficiency services	100	100

Theme Code (as % of total Bank financing)		
Climate change	29	6
Other urban development	28	34
Pollution management and environmental health	29	46
Technology diffusion	14	14

E. Bank Staff

Second Beijing Environment Project - P042109

Positions	At ICR	At Approval
Vice President	James W. Adams	Jemal-ud-din Kassum
Country Director	Klaus Rohland	Yukon Huang
Sector Manager	Ede Jorge Ijjasz-Vasquez	Keshav Varma
Project Team Leader	Chongwu Sun	Songsu Choi
ICR Team Leader	Chongwu Sun	
ICR Primary Author	Chandra Godavitarne/Eddie Hum	

Second Beijing Environment Project - GEF Component - P064924		
Positions	**At ICR**	**At Approval**
Vice President	James W. Adams	Jemal-ud-din Kassum
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ICR Team Leader	Chongwu Sun	
ICR Primary Author	Chandra Godavitarne /Eddie Hum	

F. Results Framework Analysis

Project Development Objectives (from Project Appraisal Document)
Visible and sustained alleviation of air and water pollution in Beijing by helping to: (a) convert scattered coal-fired boilers to natural gas boilers; (b) promote energy conservation in heating systems; (c) construct key wastewater trunk interceptors and associated treatment facilities; and (d) strengthen environmental management institutions of Beijing.

Revised Project Development Objectives (as approved by original approving authority)
Not applicable

Global Environment Objectives (from Project Appraisal Document)
The GEF-financed components support activities (a) and (b) above, by helping to establish viable models and markets of natural gas usage and heating energy conservation. In addition to the direct and significant reduction of greenhouse gas (GHG) emissions, these will make an effective demonstration of GHG reduction measures for China as a whole and thus help to decrease the risk of global climate change significantly.

Revised Global Environment and Development Objectives (as approved by original approving authority and Bank Management)
Not applicable

(a) PDO Indicator(s)
Indicators 1 and 2 below, though not directly attributable to the project, were used to monitor air quality improvements for which the project's air quality-related components served as a catalyst.

Indicator	Baseline Value	Original Target Values (from approval documents)	Formally Revised Target Values	Actual Value Achieved at Completion or Target Years
Indicator 1:	Ambient concentration of major pollutants			
Value (quantitative or qualitative)	SO_2: 120ug/m^3	60ug/m^3		36ug/m^3
Date achieved	12/31/1998	03/31/2008		12/31/2009
Comments (incl. % achievement)	SO_2 concentration reduction targets significantly exceeded due to (a) the results of the Bank project, and (b) the substantial impact of Government actions in the context of the Beijing Olympics.			
Indicator 2:	Number of days a year with air quality worse than Class II in Beijing			

Value (quantitative or qualitative)	265	91		80
Date achieved	12/31/1998	03/31/2008		03/31/2009
Comments (incl. % achievement)	This indicator was added during project implementation to monitor air quality improvements, and was exceeded due to the reasons indicated above.			
Indicator 3:	Concentration of major pollutants downstream of the Xiaohongmen WWTP (COD, OD, NH3-N) and the rate of wastewater treatment in the Liangshui River			
Value (quantitative or qualitative)	COD: 236.67 mg/l BOD: 88.89 mg/l Wastewater treatment rate: zero	COD: 100 mg/l BOD: 20 mg/l		COD: 68.8 mg/l BOD: 19.5 mg/l Wastewater treatment rate: 100%
Date achieved	12/31/1998			12/31/2009
Comments (incl. % achievement)	All targets were met or exceeded.			

(b) GEO Indicator(s)

Indicator	Baseline Value	Original Target Values (from approval documents)	Formally Revised Target Values	Actual Value Achieved at Completion or Target Years
Indicator 1 :	Carbon dioxide released from heating systems			
Value (quantitative or qualitative)	Metric tons of CO_2 equivalent		Deleted	
Date achieved	12/31/1998			
Comments (incl. % achievement)	This indicator was deleted because it was not a parameter in the environmental monitoring protocol in China, and no data was available.			

(c) Intermediate Outcome Indicator(s)

Indicator	Baseline Value	Original Target Values (from approval documents)	Formally Revised Target Values	Actual Value Achieved at Completion or Target Years
Indicator 1 :	Coal consumption for heating			
Value (quantitative or qualitative)	2.403 million t/yr		Deleted	
Date achieved	12/31/1998			
Comments (incl. % achievement)	This proposed indicator was not measurable because it was not possible to disaggregate coal used for heating from coal used for other purposes, e.g., power generation, etc.			

Indicator 2 :	Costs of gas boilers, services, and operations			
Value (quantitative or qualitative)	100 (index)		Deleted	
Date achieved	12/31/1998			
Comments (incl. % achievement)	This indicator was deleted because an adequate methodology was not available for measurement.			
Indicator 3 :	Emissions from heating boilers			
Value (quantitative or qualitative)	Dust: 7,200 t/yr SO_2: 21,634 t/yr		Deleted	
Date achieved	12/31/1998			
Comments (incl. % achievement)	This indicator was deleted because emissions from heating boilers cannot be distinguished from emissions from other sources.			
Indicator 4 :	Quality and timeliness of air quality data and analysis, regulatory responses			
Value (quantitative or Qualitative)	Eight automatic air quality monitoring stations, performing continuous real-time air quality monitoring within national guidelines	To add 10 automatic air quality monitoring stations		10 monitoring stations established and provide air quality data on a real time basis.
Date achieved	12/31/1998	03/31/2008		03/31/2009
Comments (incl. % achievement)	Beijing has expanded air quality monitoring in the entire city using non-project funding sources.			
Indicator 5 :	Treated wastewater volume and quality in the Liangshui River			
Value (quantitative or qualitative)	Zero	Three WWTPs with total treatment capacity 880,000 m^3/day		780,000 m^3/day Water quality: Class IV
Date achieved	12/31/1998	03/31/2008		03/31/2009
Comments (incl. % achievement)	During implementation, the capacity of the Luogouqiao WWTP was adjusted from 200,000 m^3/day to 100,000 m^3/day mainly due to the relocation of key industries, which were the major wastewater dischargers in the Liangshui River area. By project completion, 100% of the wastewater generated was collected and treated.			
Indicator 6 :	Cost per volume of wastewater collected and treated, operating cash flow			
Value (quantitative or qualitative)	No data available			0.99 RMB/m^3
Date achieved	12/31/1998			03/31/2009
Comments (incl. % achievement)	Wastewater tariff was increased three times during project implementation, and BDG receives adequate funding from BMG to meet its costs.			
Indicator 7 :	Number and capacity of natural gas boilers installed			
Value	Zero			700 boilers with the

(quantitative or Qualitative)				capacity of 2,000 tons of steam per hour
Date achieved	12/31/1998			03/31/2009
Comments (incl. % achievement)	In addition to project-financed gas boilers, there was substantial funding from the BMG to support boiler conversions from coal to natural gas.			
Indicator 8 :	MIS and GIS systems installed and staff trained for BDG			
Value (quantitative or qualitative)	Zero	Set up complete MIS and GIS to provide support in decision-making. Recruit 10 additional mgmt staff. Procure all equipment		MIS and GIS system is functioning, and 60 staff was trained.
Date achieved	12/31/1998	03/31/2008		03/31/2009
Comments (incl. % achievement)	MIS and GIS systems have helped BDG manage all its assets, including WWTPs and networks, effectively and efficiently.			
Indicator 9 :	Length of sewers and capacity of sewage treatment installed in the Liangshui River			
Value (quantitative or qualitative)	Zero	45 km of sewers and 880,000 m^3/day treatment capacity		45 km of sewers and 780,000 m^3/day treatment capacity installed
Date achieved	06/30/2000	03/31/2008		03/31/2009
Comments (incl. % achievement)	See comments under Indicator 5 above.			
Indicator 10 :	Length of interceptors built in the Qing River			
Value (quantitative or Qualitative)	Zero	26 km		26 km
Date achieved	06/30/2000	03/31/2008		03/31/2009
Comments (incl. % achievement)				
Indicator 11 :	Staff-months of studies and training; equipment procured			
Value (quantitative or Qualitative)	Zero			1,500 staff months
Date achieved	06/30/2000	03/31/2008		03/31/2009
Comments (incl. % achievement)	Beijing EPBs capacity for data analysis and air quality monitoring has improved. BDG capacity for project management, and treatment plant operation and maintenance has improved.			

Additional indicators of the projects' outcomes are provided in Annex 1.

G. Ratings of Project Performance in ISRs

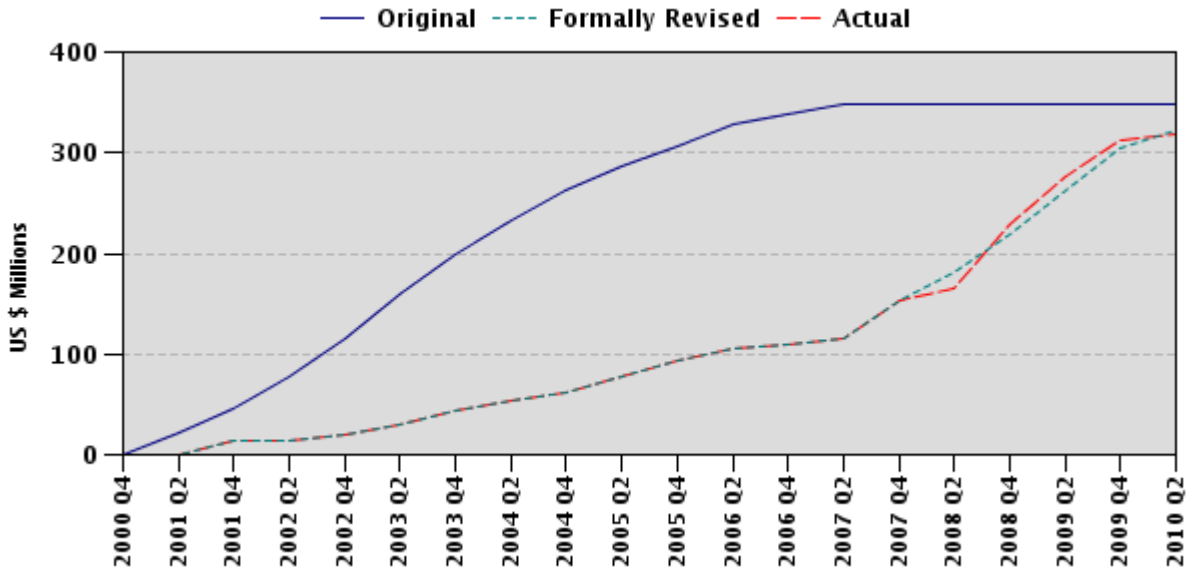
-						
No.	Date ISR Archived	DO	GEO	IP	Actual Disbursements (USD millions)	
					Project 1	Project 2
1	12/28/2000	S	S	S	0.00	0.00
2	06/22/2001	S	S	S	13.49	0.00
3	12/27/2001	S	S	S	13.49	1.30
4	06/21/2002	S	S	S	20.23	1.30
5	12/26/2002	S	S	S	29.04	1.33
6	06/23/2003	S	S	S	43.16	1.49
7	09/25/2003	S	S	S	43.16	1.61
8	06/24/2004	S	S	S	62.46	1.68
9	12/30/2004	S	S	S	76.74	2.19
10	06/23/2005	S	S	S	92.72	2.33
11	06/07/2006	S	S	S	108.90	3.31
12	06/29/2007	S	MS	S	154.13	5.10
13	06/28/2008	S	MS	S	228.33	8.96
14	06/29/2009	S	S	S	311.61	15.94
15	06/28/2010	S	S	S	319.03	22.89
16	11/08/2010	S	S	S	319.03	24.80

H. Restructuring (if any)

Restructuring Date(s)	Board Approved		ISR Ratings at Restructuring			Amount Disbursed at Restructuring in USD millions		Reason for Restructuring & Key Changes Made
	PDO Change	GEO Change	DO	GEO	IP	Project1	Project 2	
11/02/2006			S		S	114.89		

I. Disbursement Profile

P042109



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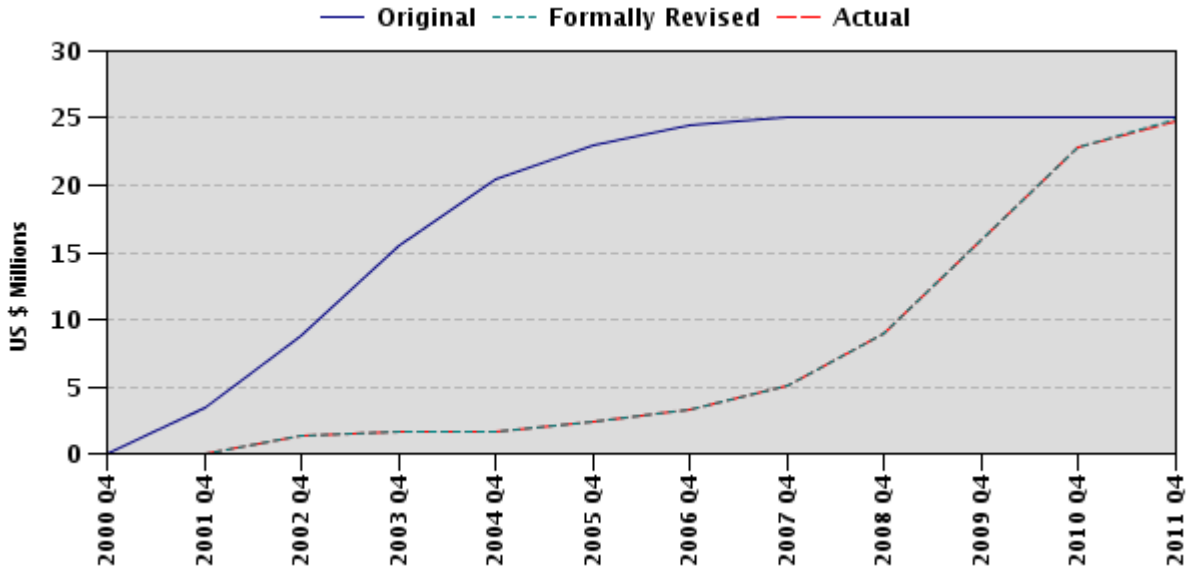

1. Project Context, Development and Global Environment Objectives Design

1.1 Context at Appraisal

The two most critical environmental issues in Beijing municipality, at project appraisal, were its rapidly deteriorating water and air quality. Due to relatively scarce water resources, accelerating urban construction, economic development, and escalating population growth, **water quality** was a long-standing, major environmental issue for Beijing. At the time of project preparation, the total volume of municipal wastewater generated from Beijing's inner city and city fringe areas (i.e., about 1,370 km^2) was about 2.5 million m^3/d of which only about a quarter was treated. The Liangshui River catchment, which received more than 40% of the municipal wastewater discharges, had no wastewater treatment facilities. As a result, the city's natural streams had little capacity to dilute pollutants from the large volume of wastewater discharges. Downstream flows of urban streams were not suitable even for economic uses such as industrial cooling or irrigation. To address these concerns, the Beijing Municipal Government (BMG) began a major environmental improvement program to expand wastewater and solid waste management capacities.

In 1998 Beijing's **air quality** was continuing to deteriorate. The average annual ambient concentrations of particulates and nitrates exceeded the daily healthy limit for residential areas (Chinese standard Class II, similar to World Health Organization (WHO) standards) due to increasing pollution emissions. During the heating season, sulfur dioxide (SO_2) and nitrogen oxide levels posed acute health risks, as they exceeded the limits allowed even for industrial areas (Class III). At appraisal, approximately 5.3 million Beijing residents in the urban central area were exposed to more than 150 micrograms of sulfur dioxide (China Air Quality Standards of one hour average in residential areas) for more than 60 days a year.

At that time, the main source of air pollution in Beijing was coal combustion, which was the city's dominant source of energy for heating and power supply (about 75%), and which contributed most of the sulfur dioxide and a major share of other pollutants. Industrial boilers, power plants, and scattered heating boilers, i.e., those with a capacity of less than 20 tons of steam per hour (capable of heating up to 160,000 m^2 of floor space) with chimneys lower than 35 meters, were the main sources of Beijing's air pollution. The BMG strategy for air pollution control was to: convert coal-fired boilers to natural gas boilers; strengthen regulatory and pricing systems; invest heavily in natural gas supply infrastructure; strengthen emission control; and close or relocate an increasing number of highly polluting industries out of the city. About 20% of the Beijing urban area was designated as "Coal-free Zones" (also known as smoke-controlled areas and mainly located in the city urban center) where no coal-burning devices under 20 tons per hour were permitted after 1999.

1.2 Original Project Development Objectives (PDO) and Key Indicators (as approved)

The project development objective (PDO) was to achieve visible and sustained alleviation of air and water pollution in Beijing by helping to: (a) convert scattered coal-fired boilers to natural gas boilers; (b) promote energy conservation in heating systems; (c) construct key wastewater trunk interceptors and associated treatment facilities; and (d) strengthen environmental management institutions of Beijing.

Related key performance indicators agreed were: Beijing's population exposed to air quality (based on SO_2 and NOx levels) worse than Class III over 60 days a year; carbon emission from heating in Beijing; COD discharged to the Liangshui River; and net internal cash flow of Beijing Drainage Company (see Annex 1).

1.3 Original Global Environment Objectives (GEO) and Key Indicators (as approved)

The global environment objective, which was consistent with the PDO, was to support activities (a) and (b) above, by improving efficiency, enhancing productivity, and promoting best practices in natural gas utilization through the provision of international expertise, training, and demonstration projects. The GEF support was designed to help: (a) establish viable models and markets for the conversion of scattered coal-fired boilers to natural gas boilers; (b) set best-practice models, standards and markets for the promotion of energy conversion in heating systems; (c) achieve direct and significant reduction of greenhouse gas (GHG) emissions; and (d) make effective demonstration of GHG reduction measures for China as a whole.

Carbon dioxide released from heating systems was the agreed key performance indicator to measure air pollution reduction.

1.4 Revised PDO (as approved by original approving authority) and Key Indicators, and reasons/justification

The PDO remained unchanged during implementation. Since carbon dioxide is not a parameter in China's monitoring protocol, monitoring data on carbon dioxide emissions was not available. While it was possible to compute total carbon dioxide emissions based on coal utilization, carbon emission attributable to heating alone could only be estimated. Two new indicators were substituted instead to monitor air quality improvements for which the project's air quality-related components served as a catalyst, namely: (i) annual average concentration of major pollutant—SO_2 only; and (ii) number of days Beijing's population exposed to air quality worse than Class II.

No additional water-related indicator was introduced during the project implementation, despite the addition of seven subcomponents at project restructuring.

1.5 Revised GEO (as approved by original approving authority) and Key Indicators, and reasons/justification

The global environment objective remained unchanged during project implementation. As stated in Section 1.4 above, the sole GEO indicator relating to carbon emissions deleted because it was not possible to separate coal consumption in heating systems from that used in industry and power generation.

1.6 Main Beneficiaries

The main beneficiaries of wastewater pollution abatement and air quality improvement, at project start in 2000, were 3.2 million residents in the Liangshui River and Qing River drainage catchments, and about 5.3 million residents in the urban central area of Beijing, respectively. In addition, people living downstream of the river catchments in Hebei Province and Tianjin Municipality, were also expected to benefit from the investments.

1.7 Original Components (as approved)

As summarized below, the project addressed the two main pollution issues of Beijing: wastewater management and air pollution.

Wastewater Management (Appraisal cost: US$ 332.85 million): (*Component outputs intended to reduce pollution discharges, and improve surface water quality in river systems*)

- ***Liangshui River Sewers*** (US$ 88.21million). Construction of about 48 kilometers of trunk sewers to intercept wastewater discharging to watercourses in the Liangshui River drainage catchment

- ***Liangshui River System Wastewater Treatment*** (US$ 185.06 million). Construction of three secondary wastewater treatment plants (WWTP) with a total capacity of 880,000 m^3/d
- ***Qing River System Sewers*** (US$ 53.44 million). Construction of about 26 kilometers of trunk interceptor sewers
- ***Beijing Drainage Company Institutional*** **Development** (US$ 6.14 million). Comprehensive institutional development including policy actions, technical assistance and training to improve technical and project management support

Air Pollution Control (Appraisal cost: US$ 458.87 million): *(Component outputs were intended to improve air quality, promote efficient use of natural gas and improve heating energy conservation***)**

- ***Boiler Conversion*** (US$ 417.37million). Conversion of about 2,000-2,500 small and medium-sized coal-fired boilers, (1 ton/hour-10 ton/hour), by providing financing (US$ 165 million of Loan) to import gas boilers for sale to boiler house owners
- ***GEF-supported Gas Boiler Market and Technology Development*** (US$ 27.14 million). Support for technology development, capacity building, market development, and demonstrations to overcome major barriers to conversion to natural gas (about US$ 16 million of Grant)
- ***GEF-supported Heating Energy Conservation*** (US$ 11.17 million). Support for activities for general overall sustained energy efficiency improvements in heating systems, and specifically in the remaining large coal-fired boilers (about US$ 9 million of Grant)
- ***Air Quality Monitoring and Decision Support*** (US$ 3.19 million). Assistance to improve the ability of BMG to acquire, analyze and use information on air quality and pollution sources for timely policy and planning, by financing equipment, software for monitoring, analysis, simulation, evaluation and training

1.8 Revised Components

By the 2003 mid-term review, Loan savings of about US$ 150 million had accumulated mainly due to policy adjustment, financial incentives and availability of various funding sources/channels for boiler conversions, after Beijing was selected to host 2008 Olympic Games. Project components were revised through amendment of legal agreements in August 2006, as described below.

Wastewater and Water Environment Improvement Components. Seven new water environment improvement subcomponents, estimated to cost US$ 366.06 million, were added, with the aim of improving the water environment and water quality of the relevant river sections by at least one level of the Chinese water quality standard. The new subcomponents were consistent with the PDO, and were appraised by the Bank during project implementation after the mid-term review, and no new indicators were added. The seven subcomponents were:

- ***River Rehabilitation****:* three water environment rehabilitation subcomponents in: (i) the North Moat and the northern reaches of the Liangma River; (ii) the lower reaches of the Qing River; and (iii) the Liangshui River section (Dahongmen Sluice Gate-BDA No. 1 Dam), including automatic water quality monitoring, studies and project management (US$ 164.50 million) *(Subcomponent output intended to enhance the PDO)*

- ***Chaoyang District Water Environment Rehabilitation****:* the Two-lake Connection Canal; rehabilitation of the Ba River, the Beixiao River and the Xiaotaihou River; and institutional strengthening (US$ 139.91 million) *(Subcomponent output intended to enhance the PDO)*
- ***Xinfeng River Rehabilitation in Daxing District****:* rehabilitation of the Xinfeng River, including flow regulation, automatic water quality monitoring, associated works and project management support (US$ 23.79 million) *(Subcomponent output intended to enhance the PDO)*
- ***Water Re-use Project****:* a reclaimed water treatment plant of 20,000 m^3/d capacity to supply water to industries in the Beijing Economic-Technological Development Area (BDA) (US$ 17.00 million) *(Subcomponent output intended to conserve water resources in a sustainable manner)*
- ***Reconstruction of a Solid Waste Transfer Station****:* reconstruction of the Datun solid waste transfer station with capacity of 1,800 tons/day (US$ 20.86 million) *(Subcomponent output intended to improve the operational efficiency of solid waste service and prevent ground water contamination)*

Boiler Conversion Component*.* The boiler conversion component was scaled down to 700 boilers from the originally planned 2,000; the total cost of the air pollution control component reduced from US$ 417.37 million to US$ 37.36 million, and the loan allocation was reduced from US$ 165 million to US$ 16.79 million.

1.9 Other significant changes

2008 Olympic Games. Beijing was selected to host the 2008 Olympic Games, three months after Board approval of the project. Consequently, new government policy and changed priorities necessitated accelerated construction of new facilities which, *inter alia*, required acceleration of the boiler conversion program using new funding channels that were made available; and improvement of facilities and water environment in the Games Village areas. The project was restructured in 2003, to utilize the large amount of loan savings accrued, through expanding the wastewater and river improvement component. Formal restructuring took place in 2006, after receipt of the Borrower's request.

***Amendments to the Loan Agreements*.** The necessary amendments for the restructuring were approved by the Board on August 24, 2006, on a 'no-objection' basis. The amendments: (i) significantly reduced the air pollution component; (ii) substantially increased the wastewater component, adding the seven new subcomponents described above; (iii) increased the disbursement percentage for civil works from 40% to 75%; (iv) deleted the covenant that allowed the Beijing Drainage Company (BDC) to retain wastewater revenues; (v) canceled US$ 26.51 million of the Loan; (vi) extended the Loan and Grant closing dates to March 31, 2009; and (vii) reallocated Loan and Grant savings.

In November 2007, the Borrower requested more amendments to the Loan and Project Agreements to: (i) reallocate the Loan proceeds among the categories of eligible expenditures and increase the disbursement rate of categories (1) (a), (1) (b) and (1) (c) in paragraph 1 of Schedule 1 to the Loan Agreement to 100%; and (ii) cancel US$ 1.509 million of loan savings.

***Amendments to the GEF Grant Agreement*.** The Grant agreement was amended on December 31, 2008 to: (i) to further extend the Grant closing date to January 31, 2010; (ii) enable completion of the largest contract-the tri-generation of combined cooling, heating and power plant, intended to demonstrate efficient and rational use of natural gas resources; and (iii) reallocate grant proceeds.

The Grant agreement was amended again in 2009 to: (i) utilize grant savings of US$ 2.3 million to allow BMG to carry out a study and analysis of sustainable climate change mitigation models and low-carbon economy development approaches to deal with the new challenges facing Beijing; and (ii) extend the Grant closing date by a further year to January 31, 2011.

Reconstitution of Beijing Drainage Company (BDC). At appraisal, a traditional integrated wastewater utility was envisaged with responsibility for this service in the urban area of BMG. This was to be confirmed by an institutional study to be carried out under the project, and implementation details were to be specified. BMG reviewed the results of the study, and proposed to retain overall responsibility for the sector directly at the municipal level, with BDC reconstituted as the Beijing Drainage Group (BDG), assigned limited responsibilities as one of the operators in the sector (private companies operate some of the other facilities, e.g., wastewater treatment plants), for a fee. The Bank accepted this alternative institutional arrangement as BMG, a financially strong municipal government, would be better able to ensure the provision of high quality wastewater services (compared to BDC) by making up any gaps between service provision costs (both capital and O&M costs) and revenues from wastewater charges.

The Board-approved restructurings comprised: (i) corrective restructuring to reduce SJET's role in the project due to its poor performance, delete some indicators and add new indicators; and (ii) adaptive restructuring to reduce the size of the boiler conversion program, due to the new Government policies and market forces, described in Section 2.2 (b).

Summary of Revised* Indicators

Original Indicators in the PAD	Revised Indicators, and Reasons for Change
DEVELOPMENT OBJECTIVE INDICATORS	
1. Carbon dioxide released from heating systems (metric tons of CO_2 equivalent (**GEO Indicator**).	**Deleted,** because CO_2 from heating cannot be separated from CO_2 emissions from other coal users. *Change Process*: *Board approval*
2. Ambient concentration of major pollutants (SO_2 ug/$m^{3)}$ (**PDO Indicator**)	**Deleted,** because a methodology for collecting this data not available. *Change Process*: *Board approval*
3. Concentration of major pollutants downstream of the Xiaohongmen WWTP (COD, OD, NH3-N) and the rate of wastewater treatment in the Liangshui River (**PDO Indicator**)	**No change**
	New Added Indicator. Annual average concentration of major pollutant—SO_2 only *Change Process: Management approval, and borrower consultations*
	New Added Indicator. Number of days a year with air quality worse than Class II in Beijing.' *Change Process: Management approval, and borrower consultations*
PERFORMANCE INDICATORS	
1. Coal consumption for heating (million tons/yr)	**Deleted** because coal consumption for heating cannot be separated from other coal users. *Change Process*: *Board approval*
2. Costs of gas boilers, services, and operations (Index)	**Deleted** because there was no way to collect this data *Change Process: Management approval, and borrower consultations*
3. Emissions from heating boilers (Dust:	**Deleted** because a methodology to collect this data was not

tons/yr; SO_2: tons/yr	available. *Change Process*: *Board approval*
4. Quality and timeliness of air quality data and analysis, regulatory responses	**No change**
5. Treated wastewater volume and quality in the Liangshui River (880,000 m^3/day of wastewater collected and treated)	**Amended** Treated wastewater volume and quality in the Liangshui River (780,000 m^3/day of wastewater collected and treated). Change resulted from downsizing one WWTP. *Change Process: Management approval, and borrower consultations*
6. Cost per volume of wastewater collected and treated, operating cash flow (No baseline data indicated)	**Amended** O&M cost/cubic meter of wastewater collected and treated. This excludes debt service which was assumed by BMG. *Change Process: Management approval, and borrower consultations*
7. Number and capacity of natural gas boilers installed (2000 boilers up to 20 tons/hr steam capacity)	**Amended** Number and capacity of natural gas boilers installed (700 boilers up to 20 tons/hr steam capacity) *Change Process*: *Board approval*
8. Technical documents, pilot boilers, conversion assisted, personnel trained	**No change**
9. MIS and GIS systems installed and staff trained for BDG (Item)	**No change**
10. Length of sewers and capacity of sewage treatment installed in the Liangshui River (km of sewers, and m3/d treatment capacity installed)	**No change:**
11. Length of interceptors built in the Qing River (km)	**No change** **:**
12. Staff-months of studies and training; equipment procured (Staff months trained)	**No change:**

* Represents indicators set out in the amended legal agreement dated October 10, 2000 (Supplemental Letter No. 2), and those amended with approval of Bank management and borrower discussions.

2. Key Factors Affecting Implementation and Outcomes

2.1 Project Preparation, Design and Quality at Entry

The PDO and scope were consistent with BMG's plans at the time and were also in line with the emerging priorities to address Beijing's water quality and air pollution issues. The project supported some of the core objectives of the Country Assistance Strategy (CAS), including infrastructure, human resource development, environmental protection and rural development. In addition, the project was consistent with the GEF Operational Program #5, promoting the removal of barriers to energy efficiency and energy conservation.

Wastewater Management. Project design addressed the serious environmental issues of untreated wastewater discharges and surface water quality in the river systems, which received nearly 40% of the untreated municipal wastewater generated. It focused on the priority development areas in the Liangshui River and the Qing River drainage catchments, which had high wastewater discharges and low coverage of wastewater collection and treatment. Project design established clear priorities and cost effective options to improve water quality in the city, and broader city-wide water pollution abatement programs.

Project design also addressed institutional reform and sustainability through measures to significantly enhance the autonomy of the BDC through consolidation of all wastewater assets under its ownership, and full control and use of wastewater tariff revenues (see section 2.2).

Air Pollution Control. The air pollution control component was highly innovative, and addressed a critical issue that faced Beijing. The project incorporated pioneering and essential inputs of gas boiler technology, coal-to-gas conversion design, heating system efficiency, heating conservation and energy audits to facilitate the emerging natural gas market. The scale of the commercial operation was necessary in the absence of an existing market for natural gas boilers, even though it carried significant risks. With the impending availability of natural gas in 1999, the Bank and BMG agreed on an investment plan for coal-to-natural gas boiler conversion in 40 coal-free zones within the third ring road and Shijingshan District. Project design addressed the key constraints of launching a large fuel conversion program, including: (i) the small market size and industry capacity; (ii) under-developed technical models and capacity; (iii) technical risks and technology information gap; (iv) high operating costs; and (v) capital cost and funding constraints. The project also addressed major constraints to: (i) promoting heating energy conservation; (ii) developing the local energy efficiency market, through the introduction of energy audits, studies and training to improve the data base, policy and institutional frameworks, demonstration projects; and (iii) developing policy and strategies for air pollution control through developing an adequate air quality monitoring and analytical capacity.

Institutional Model for Air Pollution Control. Lack of existing dealerships for natural gas boilers and reluctance of the private sector to venture into the unknown territory led to the decision to establish a government-owned project company - Shihuan Jietian Energy Technology Corporation. Ltd. (SJET), to manage the commercial venture of boiler conversions and to implement associated technical assistance, supported by the GEF grant. The project company was to be the focal point to promote gas technology, heating conservation, market development, and support implementation of the city and district regulations to discourage coal burning. The foreseeable risks were mitigated with international management support to SJET, and a significant amount of technical assistance on natural gas boiler technology and efficient natural gas utilization.

M&E Framework. The design of the M&E framework and indicators were appropriate. Some indicators for air quality improvements had to be deleted or amended to better reflect prevailing conditions and feasibility of data collection.

Risks and Mitigation Measures Identified at Appraisal

Anticipated risks of the wastewater management component were assessed satisfactorily at appraisal and appropriate mitigation measures were built into the project. The risks of rapid growth of wastewater discharges outpacing treatment capacity, and delays in construction of wastewater facilities due to counterpart financing or resettlement bottlenecks, were correctly assessed as substantial, and were mitigated appropriately through development of realistic financing and resettlement plans, with the assistance of international consultants, and support from BMG leaders.

The principal risks of the air pollution control component were correctly identified. Technological and financial risks associated with the developing gas boiler market were mitigated through substantial technical assistance for gas boiler technology demonstration projects, capacity building for local design institutes, and marketing. However, the risk of delay in boiler conversions due to insufficient capacity or incentives for implementing agencies, though assessed

as substantial, was not mitigated, but proved to be inadequate to meet the expectations of the private boiler houses. The challenges for a new company (SJET) to meet the challenges of its role were not adequately recognized.

The **key development** that could not have been foreseen at project appraisal was the onset of government campaigns to convert coal-fired boilers following the selection of Beijing, on August 29, 2000, as a candidate host for the 2008 Olympic Games i.e., three months after Board presentation, followed by Beijing's selection on July 13, 2001 to host the Games. BMG expanded the scope of the boiler conversions to cover both a much larger geographical area, as well as larger capacity coal-fired boilers. This accelerated and binding schedule overrode the gradual boiler conversion process envisaged at appraisal, and resulted in the boiler conversion component of the project to be substantially reduced as the private sector took over this massive time bound task.

The risk that a different institutional model for BDC could emerge was not expected due to prior agreements on the development of the sector. However, since the institutional study for organizing wastewater services was to be carried out during project implementation, financial performance covenants should have been developed for the sector as a whole, rather than for BDC only.

2.2 Implementation

(a) Wastewater Management

Expansion of Wastewater and River Improvement Investments. Strong support from government leaders, flexible implementing policies, and effective project management of the wastewater component enabled the original wastewater activities to be implemented efficiently and to achieve the targeted outcomes, thus allowing this component to be significantly expanded at restructuring. A key factor was the good coordination among the different departments and agencies; close and continuous consultations with the project affected persons, which satisfactorily addressed grievances regarding compensation; and timely implementation of land acquisition and resettlement.

BDC Institutional Development. Following the institutional study in April 2002, BMG reconstituted BDC as the Beijing Drainage Group (BDG). BDG has demonstrated strong capacity and high productivity in its business operations, and is considered a replicable model for China.

(b) Boiler Conversions

The 2008 Olympic Games. Selection of Beijing to host the 2008 Olympic Games was a catalyst for the accelerated construction of infrastructure, and improvements to the environment and air quality-all crucial to the success of the Olympic Games. Multiple measures and actions were taken to improve air quality, including accelerated coal-to-gas boiler conversions, rehabilitation of coal-fired boilers, relocation and closure of polluting industries, controls on vehicular traffic movement, promotion of public transport, etc. The central government and BMG appropriated additional funds to implement these measures and actions.

Favorable Financing Options and Simpler Procedures. Attractive financing and simplified procedures became available for boiler conversions, to complete the conversions in preparation for the Games. The certainty and large size of the market, the incentives and simplified approval procedures generated significant interest among commercial boiler vendors, and an active market for boiler conversions emerged quickly. The result was a significant drop in demand for project financing for boiler conversions. Project and the non-project vendors completed 700 and 16,000

sets of boiler conversions, respectively, before the opening of the Olympic Games. Only about a tenth of the loan allocated for boiler conversion was utilized.

Inadequate Capacity of SJET. SJET, a newly-established and under-resourced company, was not able to meet the challenges of the task, or compete in the environment of the expanded and accelerated boiler conversion market and the highly active private sector operating under more favorable conditions. In the final analysis, SJET's capacity to market natural gas was not a significant factor for the project outcome because the project intervention in marketing boilers had reduced to about 10% of the project cost. The project's grant technical assistance implemented by HECC after transfer from SJET, however, was the dominant contribution to project outcomes due to its highly catalytic role for the entire boiler conversion program of BMG.

Air Quality in Beijing. Air quality emerged as a priority to assure the success of the Games and BMG made additional investments outside the project to complement project activities on air quality monitoring, i.e., the establishment of ten automatic air quality monitoring stations, and the Air Quality Monitoring and Decision Support System (AQMDSS), financed under the project.

(c) GEF Grant-supported Components

Gas Boiler Technology and Market Development. As SJET was not effective in implementation of the project technical assistance, at the mid-term review in 2003, the Heating Energy Conservation Center (HECC) was made responsible for implementation of the remaining technical assistance activities for gas boiler market, technology development and heating conservation. Some delay in implementation occurred as: (i) HECC was not familiar with the Bank's ICB procurement procedures, (ii) the complex design and bid document preparation, and (iii) the time-consuming domestic approval procedures.

Heating Energy Conservation. At the mid-term review, this component was adjusted to: (i) address issues in the whole heating system, from heat sources to buildings; and (ii) change the focus of the pilot and demonstration project from small and medium coal-fired boilers to large coal-fired and gas heating systems, and enlarge pilot and demonstration schemes. At the second amendment to the Grant agreement, the tri-generation combined cooling, heating and power plant was added to demonstrate efficient and rational use of natural gas resources.

Climate Change and Low Carbon Economy Study. With the agreement of the Bank and GEF, a study on climate change and low carbon economy development was carried out using Grant savings available at the end of 2009.

Grant Utilization. The grant was almost fully utilized. The unutilized balance of US$ 200,000 was canceled at grant closure.

Compliance with Financial Covenants

(a) SJET. A project covenant required SJET "to sell natural gas boiler equipment at prices and installments terms that could cover all reasonable expenses it incurred for sale and installment, including the cost of equipment, transportation insurance, management, all financing expenses, as well as reasonable provision for bad debts and profits". This covenant was deleted at project restructuring with the substantial reduction in the boiler conversion component.

(b) ***Beijing Drainage Group***. Based on the Borrower's request, the Bank deleted, on February 4, 2008, the project covenant that required wastewater tariff revenues to be retained by BDG.

The wastewater sector in Beijing has been, and continues to be, financially sustainable, taking into account revenues from wastewater tariffs and funding provided by BMG. Financial covenants applicable to BDG on cost recovery and debt service coverage ratio became no longer relevant under the institutional arrangements in place**.**

2.3 Monitoring and Evaluation (M&E) Design, Implementation and Utilization

The M&E framework was well designed to capture the project's impact on air and water quality, incorporating highly appropriate and sufficient indicators, such as: SO_2 concentration; number of days Beijing population was exposed to air quality worse than Class II standard; COD discharges to the Liangshui River; progress in physical and financial expenditures by component; and resettlement implementation. Monitoring and evaluation was to be carried out primarily through monitoring the agreed outcome and output performance indicators, which were reported in the semi-annual progress reports, prepared by the Beijing Project Management Office (BPMO) in collaboration with the implementing agencies and the Beijing EPB.

Some monitoring indicators, selected at appraisal, could not be measured satisfactorily because of way information is collected in China's monitoring protocol. Data on coal consumption for heating and other uses was not available disaggregated. Moreover, a methodology was not available to measure fuel consumption per heating area. The task team realized these difficulties early in the project, and more appropriate and practical performance indicators (KPI) were adopted in a timely manner.

The air quality monitoring system developed under the project helped to monitor the impact of the air pollution control interventions and provide BMG and the public daily air quality information and health advisories, as necessary. The monitoring information was utilized to: support policy and actions to enhance air pollution reduction measures; make investment plans to further reduce pollution discharges to the river system; and accelerate project implementation and management.

2.4 Safeguard and Fiduciary Compliance

(a) ***Social Safeguards***. Resettlement activities were carried out satisfactorily in accordance with Chinese regulations and World Bank policies. External monitoring of safeguards implementation was carried out in accordance with the legal agreements. Annual safeguards compliance reports prepared by the project implementing units were submitted regularly. The comprehensive Resettlement Completion Report (RCR), submitted at the end of 2008, concluded that: resettlement implementation was successfully completed with the full participation of the affected persons; their standards of living had improved; and there were no outstanding resettlement issues at project closure. See Annex 6 for more details.

(b) ***Environmental Safeguards***. The project was correctly assessed as a Category "A" project, and a comprehensive environmental assessment was carried out in accordance with the policies and procedures of China and the World Bank. All the implementing agencies established independent environmental management teams that were responsible for implementation, supervision and monitoring of the Environmental Management Plans (EMP). Emergency response plans for environmental pollution were also prepared to guarantee environment protection at the construction sites. Specific environmental protection measures adopted were adequate, and included staffing and training, dust control, noise control, and disposal of sludge. During supervision, the Bank specialists recommended further improvements to environmental standards on a case-by-case basis, particularly, the management of sediment from river dredging. Internal and external environmental monitoring results have confirmed that through efficient implementation of the EMPs, the adverse environmental impacts resulting from the project

construction were mitigated and controlled to acceptable levels. There were no complaints on environment issues throughout the project implementation period.

(c) ***Financial Management***. Appropriate financial management arrangements were put in place to ensure proper use and accounting of project funds. Financial management was carried out satisfactorily, and no significant issues arose during implementation.

(d) ***Procurement***. Procurement activities were carried out satisfactorily by all agencies. BPMO and PIUs improved their procurement capacity progressively during project implementation. Some useful lessons emerged, e.g., the need for improved quality of detailed designs and bidding documents, and the need for closer communication among the project PIUs, the Ministry of Commerce (MoC) and the Bank task team, to avoid delays in bid evaluations for ICB procurement of equipment.

2.5 Post-completion Operation/Next Phase

With the availability of increased volumes of natural gas, the coal-to-gas boiler conversion has continued since Loan closing and is expected to proceed further with private and government funding. HECC plans to expand energy audits, and conduct training programs on gas technology, energy audits, and heating energy conservation, at the training center set up with GEF support. HECC has a core of competent professionals, and will continue to be adequately funded by an annual operating budget from BMG. It will play a key role as a resource center and provide available information on gas boiler technology, technical support for boiler conversion design, heating energy conservation, and energy audits and efficiency improvements.

BDG is well managed, staffed, and is assured of financial support from BMG, as necessary. BDG expects to increase the collection and treatment rate of wastewater generated from about 22 million people (both citizens and transient populations) in Beijing, and to improve the operational efficiency of the wastewater facilities through the use of the Geographic Information System-based management information system installed under the project. BDG will make further efforts to fully utilize the treated wastewater, through contracts with industries and other potential users.

The Beijing Municipal Water Affairs Bureau and the District Water Affairs Bureaus are expected to enhance their monitoring of water quality as stipulated by the national standards and management capacities to maintain water quality, flows and flood control, primarily during the rainy season.

3. Assessment of Outcomes

3.1 Relevance of Objectives, Design and Implementation

Rating: Satisfactory

The PDO and GEO were fully consistent with national and municipal priorities for improving water quality and flows in the major rivers and streams, improving air quality, and reducing greenhouse gas emissions in Beijing. The PDO was also consistent with the World Bank's Country Assistance Strategy (CAS) of 2000, with respect to safeguarding the environment and reducing infrastructure bottlenecks. Eleven years later, the PDO remained highly relevant with the Country Partnership Strategy (CPS) of 2006, especially with respect to pillar three, on managing environmental challenges.

During project implementation, the focus of the PDO shifted significantly from reducing air pollution to alleviation of water pollution, when the boiler conversion component was down-sized

at the project restructuring early in the project. Expansion of the wastewater and river improvement investments utilizing loan savings contributed to a higher removal rate of COD per year, and helped improve surface water quality in the rivers by one level, from worse than Class V or Class V to Class IV and Class III, in most of the river sections.

The GEF grant-financed technical assistance was highly relevant to enhance the PDO through: (i) support for boiler conversions, and transfer of technology for boiler conversion and efficient heating conservation; (ii) demonstration of efficient and rational use of natural gas in combined cooling, heating and power generation; and (iii) development of policy, strategies and action plans to address climate change, and low carbon economy development.

The relevance of the PDO, project design and implementation arrangements, complemented with GEF technical assistance, contributed to the satisfactory achievement of the PDO and GEO.

3.2 Achievement of Project Development Objectives and Global Environment Objectives

Rating: Satisfactory

PDO Achievements

Air Quality. The project set the stage for the private sector to take over the emerging market for delivery of small and medium size natural gas boiler conversions. Despite the project not achieving the target of 2,000 natural gas boiler conversions, PDO achievement is rated satisfactory based on the visible improvement in air quality, resident's appreciation of the improvements, the 70% reduction of SO_2 emissions from 1998 to 2009 (120 ug/ m^3 to 36 ug/ $m^{3)}$, and the recorded 285 days per year with good air quality of Class II standard or better, in 2009, compared to 265 days/year when the population was exposed to air quality worse than Class III in 1998.

Wastewater. Achievement of the PDO for the wastewater component under the original wastewater component was satisfactory: untreated wastewater discharges of 780,000 m^3/day to the Liangshui River were stopped; and COD discharged to the Liangshui River was reduced from 72,000 tons/year in 2000 to 26,000 tons/year in 2009. Surface water quality of the upper reaches of the Laingshui and Qing Rivers improved from worse than Class V to Class III/IV in most sections.

Pictures below illustrate conditions in the North Moat, before and after project:

Outcomes of the new added subcomponents for water environment improvements (in Liangma River, lower reaches of the Liangshui and Qing Rivers, Ba River, Beixiao, Xiaotaihou and Xinfeng River) were: reduced pollution discharges to the rivers, improvement of river water quality from Class V or worse than Class V, to Class III in some sections, and to Class IV in others; and reduced flood damage through river channel improvements; and environment improvements resulting in improved amenities and enhanced land prices. Specifically, outcomes for the Ba River and the Beixiao River in Chaoyang District were: reduction of wastewater pollution from about three million m3 per year of wastewater that would have otherwise entered the rivers; avoided flood damage to nearly 270,000 people through increase of the flood protection standard from 1:10 years to 1:20 years and 1:50 years in some sections of the rivers; and improved amenities along the rivers, and enhanced land prices.

Additional achievements in protection and sustainable use of water resources were: the increased supply of treated wastewater to industry through the construction of a 20,000 m3/day water re-use plant; and protection of groundwater through improvements in solid waste management.

GEO Achievements

Outcomes of the Grant were satisfactory and opportune, coming at the time when natural gas utilization was expanding, and there was a vast technology gap on gas boiler technology; and coal-to-gas boiler conversion was adopted as the strategy to address the deteriorating air quality in Beijing. Achievements of the Grant support comprised efficiency improvements, enhanced productivity and best practices in natural gas utilization, including: (i) demonstrations for boiler market development; (ii) introduction of viable models for the emerging boiler conversion market; (iii) introduction of best practices in gas technology, coal-to-gas boiler conversion design, including training; (iv) introduction of heating energy conservation as an essential element of the rational and efficient use of natural gas, and energy audits; (v) development and financing of an efficient combined cooling, heating and power plant (CCHP) in collaboration with a private entity; and (vi) establishment of a training center for gas boiler technology and design, energy audits, and best practices in heating conservation.

Institutional Achievements

The project succeeded in strengthening the capacity of: (i) BDG, for project design and management, operation and maintenance of the entire wastewater system, use of a GIS-based operation and management information system, and operation as a fee based service provider to BMG; (ii) HECC, as a resource center for all aspects of gas boilers, energy audits and a training center for the boiler industry; (iii) Beijing EPB, for air quality monitoring, data analysis, projections, and health warnings, using a state-of-the art Air Quality Monitoring and Decision Support System; and (iv) five design institutes with expertise in gas boiler conversion design.

Other Achievements

Sustainable Water Re-use. The project contributed to water resource conservation in a sustainable manner through financing a water re-use plant for supply to industry.

Climate Change, and Energy and Environment Studies. Technical assistance studies provided BMG: (i) options for managing the long-term municipal energy demand and supply, and address environmental impact of high energy consumption; and (ii) policy and strategies for low carbon economy development for key urban infrastructure sectors, demonstrations and specific actions.

Timely Project Restructuring. The need for a major project restructuring was identified in a timely manner, following the mid-term review in 2003, when it became clear that the air quality component would have substantial loan savings. The restructuring was completed after a comprehensive appraisal of the new investments proposed by Government.

Achievements of the PDO and GEO were measured through the following key performance indicators agreed at project appraisal, and those that were adjusted during the project implementation. See Data Sheet and Annex 1 (Additional Indicators of Project Outcome).

3.3. Efficiency

Economic Analysis

Rating: Satisfactory

Cost-benefit analysis was conducted at appraisal for both boiler conversion and wastewater components. However, it was not possible to compare the appraisal assessment with the end of project assessment because: (i) the major restructuring of August 2006 significantly altered the project's composition and impact; and (ii) it is extremely difficult to quantitatively separate and assess the contributions of the project to the significant economic and environmental benefits achieved in Beijing from other environmental improvements undertaken by BMG.

Boiler conversion. As the total number of 700 gas-fired boilers procured to replace coal-fired boilers through the project was lower than the appraisal target of 2,000, the overall emission reduction and air quality improvement directly attributable to the project is well below original estimates. However, the overall air quality improvement in Beijing as a result of the heating fuel switching program undertaken by government during the life of the project is substantial and the public health benefit is very significant. The overall cost and benefit of the air quality improvement can be assessed, but is beyond the scope of the ICR.

Wastewater. Wastewater treatment and river rehabilitation subcomponents brought economic benefits including flood control, environment and health improvements, as well as amenity and land value increases. The river rehabilitation investments in the Ba River and the Beixiao River in Chaoyang District significantly improved the water quality by intercepting 3 million m^3 of wastewater each year. They also raised the flood control standard from 1:10 years to 1:20 to 1:50 years, depending on river sections, protected 270,000 local residents, and avoided potential flood damage of up to RMB 50 billion (US$ 7.7 billion) per flood event. The project improved the amenity value along the rivers and increased land and property values; e.g., the price of real estate in Dongba Jiayuan (a residential neighborhood of Chaoyang District) increased from RMB 2,800/m^2 (US$ 431/m^2) before the project to RMB 8,500/m^2 (US$ 1,308/m^2) after the completion of the river rehabilitation subcomponent. Excluding the price impact of other factors, it is estimated that the river rehabilitation works contributed to an increase in property values of a minimum of RMB 2,000/m^2 (US$ 308/ m^2).

Implementation Efficiency. Taking into account the complexity of the project, and the major restructuring that became necessary at the time of the mid-term review due to external reasons, implementation efficiency is considered satisfactory. The original wastewater components were completed by the mid-term review in 2003, when the boiler conversion component was scaled down. The seven new subcomponents added in 2006, were completed by late 2009. The combined cooling, heating and power generation plant, agreed in 2008, was completed at the end

of 2010; and the Study of Climate Change and Low Carbon Economy Development was completed during the last one-year extension of the Grant.

Financial Analysis

BMG increased wastewater tariffs several times during project implementation, most recently in December 2009. At project appraisal, the wastewater tariff for residential consumers in Beijing was RMB 0.30/m^3. This tariff was increased to RMB 0.90 m^3 (US$ 0.14/m^3) and RMB 1.04/ m^3 (US$ 0.16/ m^3) in December 2008 and December 2009, respectively. BMG intends to increase wastewater tariffs to meet the full cost of wastewater collection and treatment in a phased manner. BMFB allocates funds to BDG as a treatment fee to cover the cost of O&M of the network and wastewater treatment, based on the volume of wastewater treated, and retains responsibility for all sector debt service obligations, including loans from the World Bank, JBIC, and the Asian Development Bank. The current new institutional and financial arrangements have made the loan financial covenants (that BDC generate revenue from wastewater and drainage operations sufficient to cover operation expenses and the greater of either depreciation charges or debt service payments) irrelevant.

Table below summarizes the funds flow for the operation of wastewater treatment by BDG.

Fund Flows for O&M of Wastewater Collection and Treatment by BDG (RMB million)

	2005	2006	2007	2008	2009
Total Wastewater Collection and Treatment Fee Allocated by BMFB to BDG	318	339	365	445	600
Subsidies from BMFB			126	165	165
Operating Cost of Wastewater Collection and Treatment by BDC	273	438	537	608	715
Payments of Debt Service (*now paid by BMG*)	-	-	-	-	-
Cost Recovery Ratio (Including Subsidies)	1.16	0.77	0.86	1.00	1.07

3.4 Justification of Overall Outcome and Global Environment Outcome Rating

Rating: Satisfactory

Air Pollution Control. Even though the number of natural gas boilers marketed through the project was only about a third of what was planned, a 'satisfactory' rating is justified because the project was a pioneer intervention in promoting coal-to-gas boiler conversion, providing gas boiler technology, and contributing to the initial development of the gas boiler market through information campaigns and providing market reference prices through ICB procurement. Assistance to build Beijing's heating energy conservation capacity through HECC was also fruitful, since HECC became a designated branch of the government in 2004. The project developed best practice technologies for heating energy conservation; supported demonstration of efficient gas boilers and more efficient tri-generation technology; enhanced the capacity of design institutes for boiler conversion design, introduced energy audit demonstrations; and raised public awareness. Based on data available on reduction in the use of coal for heating boilers, SO_2 emission and increased number of days with satisfactory air quality, the PDO and GEO were substantially achieved.

Water Quality Improvement. Water quality and management in the main rivers were improved by expanding the collection and treatment of wastewater, controlling river flows and installing flood control measures, and generally, improving the water environment. Water quality standard

in the rivers was increased by one level, in most river sections from Class V to Class IV. The institutional model adopted for BDG has enabled the achievement of sector development objectives i.e., to ensure a satisfactory quality of service at the lowest cost, and recover full costs in the long-term, in a phased manner through periodic tariff increases.

3.5 Overarching Themes, Other Outcomes and Impacts

Not applicable

(a) Poverty Impacts, Gender Aspects, and Social Development

The project did not contain specific poverty alleviation, gender or social development initiatives.

(b) Institutional Change/Strengthening

Overall responsibility for the wastewater service rests with BMG, with BDG and other operators each operating and maintaining a part of the Beijing wastewater facilities for a fee from BMG based on wastewater volume treated. This institutional model is working satisfactorily, and service provision is satisfactory (see also section 1.9).

(c) Other Unintended Outcomes and Impacts (positive or negative)

None

3.6 Summary of Findings of Beneficiary Survey and/or Stakeholder Workshops

Not applicable

4. Assessment of Risk to Development Outcome and Global Environment Outcome

Rating: Low or Negligible

China has a made a strong national commitment to improve the environment, as reflected in the five year plans. Efforts to improve air quality in Beijing are therefore certain to continue, and the risk that air quality in Beijing will deteriorate is low. The central government and BMG are expected to: continue programs to reduce pollution emissions from industries; expand the use of natural gas in Beijing through continuation of the coal-to-natural gas boiler conversions; improve efficiency in the remaining coal-fired heating units; introduce measures to control automobile emissions: and mainstream experience from the boiler conversions and heating energy conservation demonstration pilots.

With the high priority and financial support given to improving water quality by BMG, the risk that water quality will deteriorate is also low. BMG is expected to continue cost recovery for wastewater services in a phased manner, and ensure that BDG delivers quality service at the least cost.

5. Assessment of Bank and Borrower Performance

5.1 Bank Performance

(a) Bank Performance in Ensuring Quality at Entry

Rating: Satisfactory

Quality at entry of this complex and ambitious project was satisfactory despite the challenges and risks. The PDO and interventions were consistent with BMG's priorities, the Country Partnership Strategy (CPS), and the GEF Operational Program #5, promoting the removal of barriers to energy efficiency and energy conservation.

For the wastewater sector, project design incorporated expansion of wastewater collection and treatment in Beijing, continuation of the institutional reform to improve the autonomy of BDC, improvements in utility management, and long-term sustainability of the wastewater sector. For air pollution reduction, the project incorporated: a manageable segment of the potential market for boiler conversions; crucial financing to address a key constraint facing boiler houses at the time; comprehensive grant-financed technology transfer and demonstrations necessary to support the emerging coal-to-natural gas boiler conversion program; a novel mechanism to procure and market natural gas boilers; and capacity enhancement for air quality monitoring and projection.

To support BMG's "clean air program", which focused on converting small scattered coal boilers to cleaner fuels, the Bank selected a manageable segment of the boiler market that was relatively stable and mature, and the project addressed about a third of the potential market for boiler conversions. Recognizing the enormity of the challenge, the Bank included a significant degree of technical assistance from a GEF grant to provide the necessary technological expertise. Project design addressed the key technology void that existed in the expanding program of natural gas utilization through: introduction of best practices in gas technology; heating energy conservation technologies; training in coal-to-gas boiler conversion design for domestic design institutes; and in-the-field demonstration of coal-to-gas conversions, heating systems efficiency improvements; and energy audits.

In the absence of an established institutional model, the Bank took an innovative approach at a time of serious need to assist Beijing, despite the challenges of launching a large commercial operation using a new state-owned company. Even though a seasoned international consultant was hired at the start of the project to help develop SJET management capacity and business planning, this calculated risk did not pay off, and SJET was very slow to develop the necessary skills and the requisite competitive mentality and management capacity. In the end, SJET's performance in marketing natural gas boilers had little impact on project outcomes because of the small intervention resulting from the changed conditions.

The institutional model adopted for marketing natural gas boilers using a new and untested company was a risky venture. However, with the scaled down boiler conversion component (about 10% of total project cost) and BMG's acceleration of boiler conversions in the run up to the Olympic Games, the institutional model was not a key factor in achieving project outcomes. The design of the key performance indicators was weak, but was amended appropriately during project implementation.

The project design incorporated many innovative, appropriate and positive features that addressed all the critical issues. Project design of the grant technical assistance played a catalytic role for the emerging natural gas utilization through introduction of gas boiler technology, boiler conversion design, heating efficiency, heating energy conservation and energy audits. Despite weaknesses in the implementation arrangements for the boiler conversions, on balance, Bank performance in ensuring quality at entry is rated satisfactory overall, in view of the many positive outcomes of project design.

(b) Quality of Supervision

Rating: Satisfactory

Overall, the supervision performance of the Bank was satisfactory. Supervision missions identified and highlighted weaknesses in project management, contract management and institutional development. The Bank was flexible in accommodating SJET requests for variations in the boiler conversion market to spur increased sales of natural gas boilers. Despite discouraging progress in the early years, the task team diligently pursued the implementation of the GEF-financed technical assistance which was essential to promote gas boiler technology and heating energy conservation, and support SJET's activities. The Bank added further value by agreeing to include the combined cooling, heating and power generation demonstration project in 2006. At the same time, the Bank strongly advocated improvements in detailed designs, construction management and implementation, utility management and compliance with financial performance covenants in the wastewater sector.

The Bank identified the need to restructure the project at the mid-term review. The task team and Bank management responded favorably to the Borrower's request to restructure the project when large loan savings accumulated, and agreed to add seven new subcomponents that enhanced achievement of the PDO and maintained the project's relevance during a time of rapid change. The Bank supported BMG's choice of institutional reform for the wastewater sector that resulted in BMG purchasing wastewater services from BDG, which changed BDC to a service provider.

The slow progress in the implementation of the GEF technical assistance diminished some of the impact of the support for boiler conversions and gas technology development. Nevertheless, implementation progress was rated satisfactory until 2007, when it was finally downgraded to Moderately Satisfactory for a short time. However, the perseverance and flexibility of the task team made it possible to use the GEF Grant to demonstrate technology for heating energy efficiency and conservation through financing of the tri-generation cooling, heating and power plant with grant savings using an innovative public-private partnership.

The task team leader was based in Washington until early 2008, and the task team comprised relevant national and international experts from Beijing and Washington. Task team leadership was transferred to a Beijing based staff thereafter. The location of several key members (procurement, financial management, environment, and social) in Beijing throughout facilitated frequent contacts between the Bank and the BPMO, and resolution of issues in a timely manner.

Safeguards compliance. Specialists of the task team from the Beijing office satisfactorily supervised implementation of safeguard issues. The team carried out adequate field visits to review progress and ensured the submission of the external monitor's report on safeguard implementation. Resettlement reporting was reviewed, and commented on as necessary.

***Fiduciary Compliance*.** Oversight of financial management and procurement activities was carried out satisfactorily by members of the task team from the Beijing office, ensuring compliance with audit requirements and procurement procedures. Timely, and at times, immediate responses were provided to the clients' requests for clarification and guidance on procurement matters.

Justification of Rating of Overall Performance

Rating: Satisfactory

Design addressed the critical issue of poor air quality in Beijing, with an innovative project design featuring the much needed technology transfers for efficient natural gas utilization. Project design of the institutional model for marketing natural gas boiler fell short of expectation, but had little impact on project outcomes. The grant technical assistance on boiler technology and utilization, however, was highly effective to support the entire boiler conversion program of Beijing that was implemented on an accelerated pace before the Olympic Games.

Based on the project's overall performance, the Bank's value addition to improving air and water quality, satisfactory quality at entry, the high quality of supervision provided, timeliness of project restructuring, effective communications maintained with implementing units and other stakeholders, and achievement of the PDO and the GEO, the overall performance of the Bank is judged satisfactory.

5.2 Borrower Performance

(a) Government Performance

Rating: Satisfactory

The Beijing Municipal Government's (BMG) performance in achieving the air quality targets before the start of the Beijing Olympic Games was an exceptional achievement. This achievement occurred with limited project funding, but with significant and urgently needed technical assistance provided through the GEF Grant. BMG was fully supportive of the GEF-funded technical assistance for gas technology and heating energy conservation, and made every effort to accelerate implementation. BMG supported the establishment of HECC which has developed into an important resource center with a critical future role for the promotion of gas technology and heating energy conservation. A permanent training facility has also been established to provide continuing training.

BMG carried out a review of the institutional arrangements for the wastewater sector, and has established the current institutional arrangements after considerable discussion, including with the Bank. With BMG's strong commitment and financial support, these arrangements are sustainable in the medium-term, and assure provision of high quality service at the lowest cost to achieve the desired environmental improvements.

(b) Implementing Agency or Agencies Performance

Rating: Satisfactory

The Beijing Project Management Office (BPMO) provided good coordination, and performed well in project monitoring, and in resolving difficulties as they arose. It provided strong leadership that remained unchanged throughout the project. BPMO has consolidated its position as a strong and permanent agency to provide support to BMG to manage foreign funding and to coordinate implementation.

Beijing Drainage Group (BDG)**.** Consistent with its long experience and stature as a lead wastewater sector agency, BDG performed well in implementing the project components. All activities, including procurement of works, goods and services, were executed in a highly satisfactory manner. Management systems for wastewater facility management were introduced through the GIS-based information management system.

***Beijing Environmental Protection Bureau (EPB*)**.** The EPB's capacity to monitor air quality, analyze data and make projections was enhanced. The EPB manages a number of monitoring

stations covering the entire city, and developed a state-of-the-art air quality monitoring and decision support system (AQMDSS) to enhance its monitoring and analytical capacity. EPB provides daily reports of air quality and health advisories, as necessary.

Shihuan Jietian Energy Technology Corporation (SJET) did not possess the attributes necessary to lead a major commercial activity. SJET staff, drawn mainly from the Beijing Gas Development Company (which was formerly a department of BMG) was not prepared for a commercially-oriented operation, and proactive marketing and competition. In a gradual growth scenario, which was originally envisioned by the Bank and BGDC, SJET might have had a chance to become better at selling gas boilers over time. But the acceleration of boiler conversions soon after the launch of the project quickly stretched SJET's capability. SJET's role in the project diminished due to the reduction in the boiler conversion component, and the transfer of the grant technical assistance to HECC early in the project, during the mid-term review.

Heating Energy Conservation Center (HECC) assumed a greater role in the project when implementation of the grant technical assistance was transferred from SJET. HECC implemented all the technical assistance components satisfactorily, albeit with some delays. HECC has developed into a repository of a wealth of information on boiler conversions, heating energy conservation and new technology for efficient natural gas use for cooling, heating and power generation. HECC has a major future role in natural gas use, energy auditing, heating energy conservation and training.

(c) Justification of Rating for Overall Borrower Performance

Rating: Satisfactory

Despite the weaker performance in implementing the GEF technical assistance component, the overall performance of the Borrower is rated satisfactory.

6. Lessons Learned

Wastewater Sector Institutional Reform. The Bank should adopt a flexible approach to the institutional model for the sector, and in particular consider the country conditions, instead of advocating the traditional utility model as the default option. The arrangements in place in Beijing assure sustainable service provision, which rely on a combination of politically feasible tariffs and regular confirmed resource transfers from the municipal government. However, such an arrangement is only feasible where the city can: (i) ensure service provision at low cost; (ii) take on responsibility for servicing debt; and (iii) provide timely cash transfers to meet shortfalls, especially in relation to new investments.

Water Re-use. Water re-use in water scarce areas is sound policy. Beijing has performed well to achieve a 50% rate of water reuse, by addressing the key issues relating to water re-use: (i) reclaimed water quality and reliability; (ii) price of reclaimed water; and (iii) cost and benefit of using water supplied through the system and reclaimed water. This should serve as an example for other Chinese cities.

Strong Leadership Commitment. The boiler conversion program faced not only major technical, environmental and economic issues, but also significant coordination and political issues. The ambitious targets set for conversion to natural gas-fired boilers were only achieved (albeit mostly outside the project) because of strong leadership, both at central and municipal government levels.

***Participation of International Experts and Sharing of Knowledge*.** The use of international consultants, in the case of gas boiler technology transfer and heating conservation, was highly

valuable and necessary in China, because use of natural gas for heating at the current scale has started only recently. The substantial knowledge gains in efficient design and operations were reflected in heating energy conversion, gas boiler systems, and air quality management. Technologies developed under the project would be very useful to other cities that are contemplating the transition from coal-fired heating to cleaner fuels.

***Intervention in Commercial Operations*.** In areas involving significant commercial operations (such as boiler conversions), newly established municipal entities with no commercial expertise are not likely to succeed. It might have been more appropriate for the government to have partnered with a truly commercial company, or the boiler conversions might have been left entirely to market forces with some incentives to end-users.

7. Comments on Issues Raised by Borrower/Implementing Agencies/Partners

(a) Borrower/implementing agencies

See Summary of Borrower's Implementation Completion & Results Report attached as Annex 7.

(b) Co financiers

Not applicable.

(c) Other partners and stakeholders

Not applicable.

Annex 1. Additional Indicators of Project Outcome

CHINA: Second Beijing Environment Project

Indicator	At Project Start	At Project Close
1. Capacity for air quality monitoring and predictions	None	Daily air quality reports and health advisories now issued
2. Water quality improvements in new rivers* added at project restructuring	Class IV or worse than Class V	Class III and Class IV in most sections of the rivers
3. Improved flood protection in new rivers* added at project restructuring	1: 10 years (average)	1:20 years to 1:50 years in some river sections
4. Improved wastewater collection in catchments of the new rivers* added at project restructuring		15.0 km of interceptor sewers
5. Improved water reuse and conservation in Beijing	40%	50%
6. Introduction of best practices in gas technology, coal-to-gas boiler conversion design, including training;	None	(i) Eight coal-to-gas conversion demonstrations (ii) 29 heating system efficiency improvement demonstrations
7. Comprehensive utilization of energy conservation technologies and equipment	None	(i) Five design institutes trained in boiler conversion designs (ii) Combined heating, cooling and power generation plant demonstration (iii) 140 energy audits for demonstration (iv) HECC capacity enhanced (v) Training center established and functioning
8. Low carbon energy economy development	None	(i) Policy and strategies developed (ii) Project under preparation for IBRD funding.

* Ba River, the Beixiao River, Xiaotaihou River, Xingfeng River and, Liangma River)

2009 Air Quality of Beijing (Published by Beijing EPB)

No	Month of 2009	Number of Days Meeting Class I Standards	Number of Days Meeting Class II Standards	Number of Days Meeting Class III Standards	Number of Days Meeting Class III and Better Standards
1	January	5	19	7	31
2	February	1	23	3	27
3	March	2	23	5	30

4	April	3	20	0	23
5	May	2	23	0	25
6	June	4	21	0	25
7	July	5	20	6	31
8	August	2	26	3	31
9	September	3	19	0	22
10	October	5	19	0	24
11	November	8	10	10	28
12	December	7	15	8	30
	Total	**47**	**238**	**42**	**327**

Annex 2. Project Costs and Financing
CHINA: Second Beijing Environment Project

Project Cost by Component (in USD Million equivalent)

Second Beijing Environment Project - P042109			
Components	**Appraisal Estimate (USD millions)**	**Actual/Latest Estimate (USD millions)**	**Percentage of Appraisal**
AIR POLLUTION REDUCTION	**458.87**	**64.10**	**14%**
Boiler Conversion	417.37	37.36	9%
Air Quality Monitoring and Decision Support System	3.19	3.85	120%
Gas Boiler Market and Technology Development (GEF)	27.14	17.68	65%
Heating Energy Conservation (GEF)	11.17	7.12	64%
WASTEWATER MANAGEMENT	**332.85**	**466.34**	**140%***
Liangshui River Sewers	88.21	142.67.	162%
Liangshui River Wastewater Treatment	185.06	231.00	125%
Qing River Sewers	53.44	86.67	162%
BDC Institutional Development	6.14	6.00	98%
LAND AQUISITION AND RESETTLEMENT	**250.82**	**303.00**	**121%**
Sub-Total Original Components	**1,042.54**	**833.44**	**80%**
ADDITIONAL COMPONENTS*	-	**366.06**	-
River Rehabilitation (by BMWAB)	-	164.50	-
River Rehabilitation in Chaoyang District	-	139.91	-
Xinfeng River rehabilitation in Daxing District	-	23.79	-
Datun Solid Waste Transfer Station Upgrading	-	20.86	-
Reclaimed Water Plant in BDA	-	17.00	-
Total Baseline Cost	**1,042.54**		
Physical Contingencies	132.85		-
Price Contingencies	76.12	-	-
Total Project Costs	**1,251.51**	**1,199.48**	**96%**
Front-end fee IBRD	3.49		
Total Financing Required	**1,255.00**		
Second Beijing Environment Project – GEF Component - P064924			

Components	Appraisal Estimate (USD millions)	Actual/Latest Estimate (USD millions)	Percentage of Appraisal
Gas Boiler Market and Technology Development (including GEF Supported Energy and Environment Study)	27.14	27.68	101%
Heating Energy Conservation (including GEF supported Beijing Low-Carbon Development Study)	11.17	11.17	100%
Total Financing	**38.31**	**38.85**	**101%**

Source of Funds	Type of Financing	Appraisal Estimate (USD millions)	Actual/Latest Estimate (USD millions)	Percentage of Appraisal
Global Environment Facility (GEF)		25.00	24.80	99%
International Bank for Reconstruction and Development		349.00	319.03	91%
Borrower		877.51	894.50	102%
Total Financing		**1,251.51**	**1,238.33**	**99%**

Annex 3. Outputs by Component

CHINA: Second Beijing Environment Project

Overview of Outputs

Loan Project Outputs: Original Components		
Subcomponent	**Planned at Appraisal**	**Actual Achieved**
Wastewater treatment plants	800,000 m3/d capacity	780,000 m3/d capacity
Interceptor and trunk sewers	70 km	71 km
Conversion of coal-fired heating boilers to natural gas boilers	2,000 No.	700 No.
Air quality monitoring stations	10 No.	10 No.
Capacity improvement for air quality monitoring study	To establish an air quality monitoring system for Beijing	Air quality monitoring decision support system (AQMDSS) established with trained personnel
BDC institutional reform	To increase the autonomy of BDC	Recommendations for restructuring BDC as a service provider
Beijing Drainage Operations Management System	To improve operation and management of the entire wastewater service	GIS-based operations management system established and operating,
Beijing Water Environment Management Study	To improve management of the water environment	Recommendations for water environment planning and management
Loan Project Outputs: Additional Components (Water Environment Improvement)		
Rehabilitation of the North Moat and the Liangma River	<u>Rehabilitation of about 11.0 km of North Moat and Liangma River</u> Interceptor sewers Flow regulation structures River bank improvements Landscaping Associated facilities	<u>North Moat (5.927 km)</u> 2 check sluices, 2 navigation locks, 2 diversion sluices, 1 culvert sluice and 5 docks 2 bridges 2 new wharfs <u>Liangma River (5.251 km):</u> 3 new rubber dams 3 bridges 2 docks, 2 wharfs & one escape sluice 575 meters of interceptor sewers
Rehabilitation of Lower Reaches of the Liangshui River	<u>Rehabilitation of about 8 km of Liangma River</u> River channel clean up including dredging Flow regulation structures and equipment River bank improvements, Landscaping Associated facilities	8.4 km of river channel dredging 70 storm water inlets Sluice gate Two bridges 13.85 km of embankment roads 241,300 m^2 of landscaping One artificial wetland (2,800 m^2)
Rehabilitation of the Lower Reaches of the Qing River	<u>Rehabilitation of about 13 km of Qing River</u> River channel clean up including dredging Flow regulation structures and equipment	13.4 km of river channel dredging Three sluice gates Two bridges Two flood retention basins One artificial wetland One flood diversion sluice, one escape

	River bank improvements, Landscaping Associated facilities	sluice and one check sluice Embankment roads 43 storm water and wastewater inlets, Landscaping Automatic monitoring and control system.
Two-lake Connection	Two-lake Connection Connecting canal River bank improvements, Landscaping Associated facilities	1.82 km long connecting canal, New ship lock and new culvert, 10 bridges, 17 storm water inlets, 40,000 m^2 of landscaping 69,000 m2 of improved water surface
Ba River Rehabilitation	Rehabilitation of about 11 km of Ba River River channel clean up including dredging River bank improvements, Landscaping Associated facilities	10.65 km river course rehabilitation: New sluice gate & two new rubber dams 4 bridges 43 storm water inlets 20.3 km of riverside roads 343,000 m^2 of landscaping 1,894,000 m2 of improved water surface
Beixiao River Rehabilitation	Rehabilitation of about 12 km of Beixiao River River channel clean up Flow regulation structures and equipment River bank improvements, Landscaping Associated facilities	3 sluice gates & 2 rubber dams 6 bridges 110 storm water inlets 17.2 km of riverside roads 3.8 km of sewers 210,000 m2 of landscaping 606,000 m2 of improved water surface.
Xiaotaihou River Rehabilitation	Rehabilitation of about 8.0 km of Xiaotaihou River Interceptor sewers Flow regulation structures and equipment River bank improvements, Landscaping Associated facilities	3 sluice gates, & one rubber dam 11 bridges 65 storm water inlets 13.2 km riverside roads 11.2 km of sewers 38,000 m2 landscaping 274,000 m2 of improved water surface
Xinfeng River Rehabilitation	Rehabilitation of about 10 km of Xingfeng River River channel clean up including dredging Flow regulation structures and equipment River bank improvements, Landscaping Associated facilities	River channel dredging and clean up 10,293 m of interceptor sewers Water pump station and pipelines 10.35 km of river bank landscaping Flow diversion structures, and sluice gate with traffic bridge
Solid Waste Management	Improved solid waste transfer operation	A modern solid waste transfer station of 1,800 tons/day capacity, and 40 vehicles of 20 ton capacity
Water Re-use	20,000 m3/d reclaimed water treatment plant (WTP)	20,000 m3/d WTP with double membrane process, and 13 km of distribution network
Grant Project Outputs		
Gas technology transfer and market development	Technical assistance through international consultant services	Eight coal-to-gas boiler house conversion projects completed to support gas technology and market development in Beijing by demonstrating improved conversion design and practices, boiler

		operational management, and environment protection.
Demonstration of comprehensive utilization of energy conservation technologies and equipment	Technical assistance through international consultant services	Twenty nine heating systems renovated to demonstrate comprehensive utilization of energy conservation technologies and equipment.
Heating energy conservation technologies	Technical assistance through international consultant services	140 energy audits done for demonstration, and manual on energy audits, and heating energy conservation technologies developed.
Capacity building for gas technology, heating conservation and training	Technical assistance through international consultant services	HECC capacity as a resource center for all aspects of gas boilers, energy audits and a training center for the boiler industry
Demonstration of a tri-generation combined cooling, heating and power plant	***Added at Grant restructuring*** Technical assistance through international consultant services	Tri-generation combined cooling, heating and power plant constructed in collaboration with the private sector to demonstrate rational and efficient gas utilization
Low-carbon economy development	***Added at Grant restructuring*** Domestic consultant services	Policy, strategies and action plan for Low-carbon Economy Development

Description of Outputs of the Loan Components

(a) Wastewater Management and Water Environment Improvement

Original Component

Wastewater Collection and Treatment. Trunk sewers 71km in length have been laid in the Qing River and Liangshui River basins, and three wastewater treatment plants (Wujiacun WWTP, Lugouqiao WWTP and Xiaohongmen WWTP) have been constructed with a total capacity of 780,000 tons/day. This has significantly lowered the level of pollution in the Liangshui River.

Additional Components of Water Environment Improvement

(a) River Rehabilitation by the BMWAB

The works included the North-ring waterways, the lower reaches of the Liangshui River and the lower reaches of the Qing River. The outputs are as follows:

(i) *Rehabilitation of the North Moat and the Liangma River*. Rehabilitation of 11.6 km of river, including: (a) 5.927 km of the North Moat, the reconstruction of two check sluices, two navigation locks, two diversion sluices (reconstruction), one culvert sluice and five docks, two bridges, (one new and one reconstruction), two new environmental sanitary wharfs and associated facilities; and (b) 5.251 km of the Liangma River, three new rubber dams and three bridges (two new and one reconstruction), one bridge reconstruction, as well as two new docks, two environmental sanitary wharfs, one escape sluice and 575 meters of new interceptors.

(ii) *Rehabilitation of Lower Reaches of the Liangshui River*. Rehabilitation of 8.4 km of river, including dredging river channel, reconstruction of 70 storm water inlets, the Dahongmen sluice gate, fencing, two bridges (reconstruction), 13.85 km of riverside roads, 241,300 m^2 of landscaping, and one artificial wetland of area 2,800 m^2.

(iii) ***Rehabilitation of the Lower Reaches of the Qing River***. Rehabilitation of 13.4 km of river, including channel dredging and rehabilitation, three sluice gates (reconstruction), two bridges, two flood retention basins (Shenjiafen and Shaziying), one artificial wetland, one flood diversion sluice, one escape sluice at Shenjiafen and one check sluice at Shaziying, four management stations, riverside roads, road widening (by 5 meters), 32 storm water and wastewater inlets (reconstruction), 11 new storm water inlets, lighting system and scenery facilities, landscaping along the river, and automatic monitoring and control system.

(iv) ***Technical Assistance Outputs:*** Comprised: (i) policy recommendations to BMWAB on water environment improvement, management of urban rainwater and flood control, and wetlands protection, etc.; and (ii) training, including a six-person study tour to Finland and Sweden to learn about wetland protection and utilization (10 days duration); a six-person study tour to the United States and Canada to learn about water environment improvement and related policies (10 days duration); a 20-day 15-person training tour to the United States for training on project management; and a 20-day, 15-person study tour to Denmark for project management training.

(b) Water Environment Rehabilitation in Chaoyang District

(i) ***Two-lake Connection***. Construction and expansion of a 1.82 km long connecting canal, with a new ship lock, a new culvert, reconstruction and new construction of ten bridges, 17 storm water inlets, 40,000 m^2 of landscaping, and an expanded and improved water surface of 69,000 m^2.

(ii) ***Ba River Rehabilitation***. Rehabilitation of 10.65 km of river including: river course rehabilitation, a new sluice gate, two new rubber dams, four bridges (reconstruction), 43 storm water inlets, 20.3 km of riverside roads, 343,000 m^2 of landscaping,, and an expanded and improved water surface of 1,894,000 m^2.

(iii) ***Beixiao River Rehabilitation***. Rehabilitation of 11.75 km of river including: river course rehabilitation, three new sluice gates, two new rubber dams, six bridges (reconstruction), 110 storm water inlets, 17.2 km of riverside roads, 3.8 km of sewers, 210,000 m2 of landscaping, and an expanded and improved water surface of 606,000 m^2.

(iv) ***Xiaotaihou River Rehabilitation***. Rehabilitation of 7.6 km of river including: rehabilitation of river course, three new sluice gates, one new rubber dam, 11 bridges, 65 storm water inlets, 13.2 km riverside roads, 11.2 km of sewers, 38,000 m2 of landscaping, and an expanded and improved water surface of 274,000 m^2.

(v) ***Technical Assistance Outputs***. Comprised: (i) institutional capacity strengthened through the improved institutional and implementation capacity of the Chaoyang WAB; and establishment of a storm water logging model and early warning system, and outline planning designs for the eight rivers in the Chaoyang District; and (ii) a 10-day six-person study tour to the United States and Canada to learn about water tariffs, water environment improvement, water resources management; a 26-day domestic study tour of 43 people in three groups, visiting Shanghai, Zhengzhou, Wuxi, Xi'an and other cities; and a training seminar of 6 days in Beijing regarding the outputs of the technical assistance services, with 160 people participating in five sessions.

(c) Xinfeng River Rehabilitation in Daxing District

(i) ***River Channel Construction*** consisting of dredging of the river course and cleaning up of the river banks; riverside roads and culverts; hydrophytes plantations; and ecological purification of water through submersible pumps and aerators to reduce COD and BOD concentrations and to improve water quality.

(ii) ***Wastewater Interception*** consisting of 10,293 meters of interceptor sewers.

(iii) ***Environmental water resource*** consisting of a water pump station and pipelines.

(iv) ***Ecological landscaping*** consisting of landscaping along 10.35 km of riverbanks.

(v) ***Flow diversion*** consisting of wastewater from the upper reaches of the Xinfeng River being diverted to municipal sewers, and eventually to the WWTP.

(vi) ***Sluice gate and traffic bridge*** consisting of reconstructed sluice gate and traffic bridge at Suncun.

Solid Waste Management. The Datun Solid Waste Transfer Station has been renovated and reconstructed as a station with relatively advanced technologies compared with other stations in China, and with a daily treatment capacity of 1,800 tons, reaching a maximum of 2,400 tons. The component also included 40 transfer vehicles each with a loading capacity of 20 tons.

Water Re-use. A reclaimed Water Treatment Plant of 20,000 m^3/d capacity has been constructed and put into operation, including 13 km of distribution network. This plant uses the effluent of secondary treatment from the BDA WWTP as the source water and applies the "double membrane" technology (Micro Filtration + Reverse Osmosis) to produce high quality reclaimed water to supply industries in the BDA.

Beijing Water Environment Management Study. This provides recommendations on technologies, policies, and water environment improvement.

Water Environment Improvement Study for the Xinfeng River in Daxing District. This provides recommendations for overall planning, rehabilitation planning, and water environmental impacts.

Beijing Wastewater Sector Reform Study. Recommendations for restructuring BDC.

Water Environment Management Institutional Study. Recommendations for capacity building in Chaoyang District.

Beijing Drainage Operations Management System. This comprises a state-of-the-art online monitoring of drainage facilities including a GIS-based sewer network monitoring, customer service hotline, emergency response, video conferencing, comprehensive database, and an information network platform and data storage management platform that connects all the core business units of BDG.

(b) Air Pollution Reduction

(i) Air quality monitoring equipment in 10 (out of 27) air quality monitoring stations.

(ii) About 700 new small and medium-range natural gas boilers procured and sold to government agencies and private boiler houses.

(iii) Development and operation of an Air Quality Monitoring Decision Support System (AQMDSS). The AQMDSS is a Multimedia Integrated Modeling System (MIMS), incorporating the following: (a) Models-3/Community Multi-scale Air Quality (CMAQ) model (to simulate chemical interactions of PM, NO^2 and O_3); (b) Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System (to process emissions from a number of regional air quality modeling applications); (c) AQMDSS emissions Database (RDBMS); (d) AMS/EPA Regulatory Model (AERMOD) Modeling System (incorporates the state-of-the-art technologies of the EPA's air quality models); and (e) Package for Analysis and Visualization for Environmental (PAVE) (to visualize multivariate gridded environmental datasets, suitable to display simulation results of the models to the public).

Description of Outputs of GEF Grant Component

(a) Expanded use of natural gas, and reduction in the use of coal-fired boilers.

(b) Eight coal-to-gas boiler house conversion projects to support gas technology and market development and demonstrate improved conversion design and practices, boiler operational management, and environment protection.

(c) Twenty nine heating systems renovations to demonstrate comprehensive utilization of energy conservation technologies and equipment.

(d) Beijing Energy and Environment Study recommendations on clean energy, heat tariff, renewable energy, transportation management, etc.

(e) Demonstration, through physical construction of a tri-generation combined cooling, heating and power plant, in collaboration with the private sector.

(f) A strengthened Heating Energy Conservation Center, and a training center.

(g) Energy auditing methodologies, over 140 energy audits for demonstration, manual on energy audits, and heating energy conservation technologies.

(h) Policy, strategic options and action plan for Low-carbon Economy Development in Beijing.

Annex 4. Economic and Financial Analysis

CHINA: Second Beijing Environment Project

Economic Analysis

The development objectives of the project were to improve the ambient air quality of the Beijing area; decrease carbon emissions to the global environment; and protect surface and ground water quality in Beijing and downstream. There were no changes in the PDO since appraisal. Economic benefits identified at appraisal included energy saving, land saving, environmental health improvement and medical cost saving, groundwater saving, and agricultural benefits. These also remained unchanged. At appraisal, the global environmental benefits were not included.

Beijing has improved air and water quality and reduced carbon and air emissions intensity since project appraisal. For example, the ambient concentration of SO_2 has been significantly lowered from 120 $\mu g/m^3$ in 1998 to 47 $\mu g/m^3$ by the end of the project, i.e. 2009, while the number of days a year with air quality worse than Class II Standard has been reduced from 265 days to 80 days. SO_2 emissions from heating boilers were reduced from 21,634 tons in 1998 to 10,800 tons in 2007. The wastewater treatment rate in the Liangshui River increased from 0% to 100% during the same period. The overall rate of wastewater treatment in Beijing has reached 94% from 33% at project appraisal, with 50% of treated wastewater reused.

Cost-benefit analysis was conducted at appraisal on both boiler conversion and wastewater components. However, a comparison of projections at appraisal and at the end of the project was not possible due to the following reasons.

(i) Due to major restructuring undertaken during project implementation (i.e., significant reduction in the investment of the boiler conversion component and addition of a number of new investments in river rehabilitation and wastewater treatment), the actual project composition and impacts are significantly different from those detailed in the PAD.

(ii) It is difficult to quantitatively separate and assess the contribution of the project to the significant economic and environmental benefits achieved in Beijing from other environmental improvement efforts undertaken by the Beijing Municipal Government itself (for the purpose of hosting 2008 Summer Olympic Games) during the project period.

The ICR stage analysis showed that a comparison of the EIRR for the wastewater component would not have been possible because of a computing error. The net present value of wastewater investments, in the PAD, was incorrectly converted, i.e., the negative (RMB -1,032 million, was converted to positive US$ 123 million, and an EIRR of 8.7% was projected, instead of a negative value (paragraph 22 on page 68). There was no document trail of the detailed calculations available for review at the ICR stage.

Although the recent significant environmental improvement in Beijing may be largely attributable to other investments driven by the government and the public sector as a result of the selection of Beijing as the venue of the 2008 Summer Olympic Games, the Bank-financed project has contributed significantly to the remarkable achievements. The Bank project helped to improve the wastewater collection and treatment situation, river and water environmental conditions, and sanitation and amenity in its specific project areas through its investment in wastewater collection and treatment and river rehabilitation along the Liangshui River, the Qing River, the Xiaotaihou River, and the Xinfeng River. Although the amount of the project investment in boiler conversion was scaled down, the project, together with the GEF technical assistance, provided technology transfer, market development, and capacity building for boiler conversion, the introduction of

energy audits, heating conservation, and the demonstration of the largest CCHP generation. Clearly, it contributed to the air emissions reduction and air quality improvement in Beijing.

However, as indicated above, it is not possible to quantify and assess the contribution of the project to economic and environmental improvements made in Beijing, and compare them with estimated values at appraisal. Economic benefits at completion have been analyzed through two case studies (one for boiler and one for river rehabilitation) to illustrate the economic achievement quantitatively.

Boiler Conversion. Beijing successfully converted from coal to gas all the boilers (about 16,000 sets) with a capacity under 20 tons in its central urban districts by the end of 2007. The percentage of natural gas in the total energy consumption has increased from 0.4 to 7% over the same time frame. As a result, Beijing was able to reduce coal consumption by 6 million tons per year and help reduce air pollution emissions and achieve the air quality improvement target of the city. From the perspective of emission reduction per ton of coal consumed, the conversion has proved to be successful. For example, Beijing Lishida Pharmaceutical Company upgraded its boiler house by replacing the old ones with two new gas boilers (2t and 4t each). The project directly saved land of 1,000 m^2 and reduced SO_2 and PM10 emissions by 589 kg and 846 kg per year, respectively. While fuel costs for coal or gas are almost the same, operating cost saving and other direct benefits are estimated at RMB 69,000 per year, excluding environmental and health benefits, which are difficult to quantify. Economic benefits of boiler conversion are obvious. As already noted above, the GEF TA contributed significantly to technology transfer and market development of clean gas boilers which in turn contributed to air quality improvement of the city.

Wastewater Treatment and River Rehabilitation. This group of investments has provided the following economic benefits: flood control, environment and health improvement, and amenity and land value increase. For example, the river rehabilitation investment in the Ba River and the Beixiao River in Chaoyang District significantly improved the water quality (as shown in the table below) by intercepting and collecting three million m^3 of sewerage water each year. It raised the flood control standard from one in ten years to one in 20 to 50 years depending on river sections, protected 270,000 local residents, and avoided potential flood damage up to RMB 50 billion. The project improved amenities along the rivers and increased land and property values. For example, the sales price of real estate in Dongba Jiayuan (a residential neighborhood) increased from RMB 2,800/m^2 before the project to RMB 8,500/m^2 after the completion of the river rehabilitation project. Excluding the price impact of other factors, it is estimated that the river rehabilitation contributed to an increase of property value of RMB 2,000/m^2. Environmental improvement also helped attract investment and boosted local economic development in these areas. Since the completion of the Ba River project in 2007, the high-tech park along the river has successfully attracted over 400 international companies (such as Motorola, Ericsson, Sony, and Samsung), as well as domestic companies. Foreign investments totaled US$ 86 million in 2007, with an annual increase of 79% in 2007. The project also helped preserve several historical relic sites, enhanced the historical and cultural identity and pride of the areas and promoted the concept of integrated river basin management.

River Rehabilitation in Chaoyang District

	Lianghu Lake		Ba River		Beixiao River		Xiaotaihou River	
	2004	2007	2004	2008	2004	2008	2004	2008
PH	7.86	8.6	7.2	7.8	7.6	7.8	7.3	7.9
COD_{Cr}	97	67.2	103.5	47.6	198.5	45.3	187.5	118.8
BOD_5	32.4	6.9	38.6	11	61.4	10.1	80.5	25.3
DO	10.0	13.0	4.6	3.9	4.2	2.6	2.4	2.8
NH_3-N	7.9	1.43	24.5	16	17	28.1	44.4	23.6
TP	0.93	0.47	3.62	1.93	5.74	2.4	4.72	2.16
Visibility	0.25	0.35	0.08	0.2	0.12	0.3	0.05	0.15
Odor*	2	0	3	1	4	1	5	2
Note*: 0 - no smell; 5 - very bad smell. The measurement unit for COD, BOD, NH_3-N and TP is mg/L.								

In summary, the project objectives have been largely achieved and project implementation is satisfactory.

Financial Analysis

Institutional Development. Beijing Drainage Company (BDC) was established in December 1999 during the implementation of the Beijing Environmental Project and was restructured in April 2002 as Beijing Drainage Group Co. Ltd. (BDG). BDG currently operates 11 medium- and large-size wastewater treatment plants with a total capacity of 2.8 million m^3 per day. 95% of wastewater generated in the downtown area of Beijing is treated by BDG. In addition to the wastewater treatment plants, BDG also operates 70 pumping stations and about 4,000 km of sewer networks in the urban area of Beijing. However, BDG is not an autonomous enterprise since it has no powers to receive and manage wastewater revenues or to manage its debt service obligations. According to the terms of restructuring, all wastewater systems (assets) have been transferred to BDG. BMG provides funds to BDG for operation and maintenance of treatment plants and sewer networks, based on a fee determined by the volume of wastewater treated and BMG assumes responsibility for debt service obligations of BDG. These institutional arrangements are different from the institutional model envisaged at project appraisal, which required BMG to constitute BDG as an autonomous enterprise with the full autonomy to retain and dispose of all sewerage tariffs and ownership of and responsibility for all sewerage and drainage facilities in the Beijing urban districts.

Wastewater Tariff. To meet the cost of operating and maintaining wastewater facilities in Beijing, BMG increased the wastewater tariff from RMB 0.30/m^3 in 1999 to RMB 1.04/m^3 in 2009. The following table lists the changes in wastewater tariffs in Beijing from 1999 to 2009.

Wastewater Tariff in Beijing from 1999 to 2009 (RMB/m3)

	Before	1999	2001	2002	2003	2004	2009
		Nov.1	-	Feb.1	Jan.20	Aug.1	Dec.22
Resident	0.10	0.30	0.40	0.50	0.60	0.90	1.04
Non-resident	0.30	0.50	0.80	1.00	1.20	1.50	1.68

Unlike water tariffs, the wastewater tariff in Beijing is treated as an administrative charge and is placed under the administration of BMFB. Currently the wastewater tariff in Beijing is collected by the Beijing Waterworks Group Co. Ltd. and then transferred to BMFB as one of its off-budget revenues. BMFB allocates funds to BDG as a treatment fee to cover the cost of O&M of network and wastewater treatment, based on the volume of wastewater treated. BMFB also subsidies the difference between the treatment fee and the operating cost. However, the debt service obligations of BDG, including loans from the World Bank, JBIC, and foreign governments, are paid by BMFB. These financial arrangements do not comply with the financial covenant for BDG agreed at appraisal which required BMG to cause BDG to generate revenues from wastewater and drainage operations sufficient to cover current operational expenses and depreciation charges or debt service payments, whichever is greater, even though the Bank agreed to BMG's request to delete the requirement for transferring wastewater tariff revenues to BDG.

Financial Performance. Financial statements from 2005 to 2008 were provided by BDG. The following table summarizes the operating revenues and costs relating to wastewater treatment.

Summary of BDG's Operating Revenues and Costs
(RMB million)

	2005	2006	2007	2008
Operating Revenue	318	339	365	445
Operating Cost	273	438	537	608
Cost of Sales	-	3	1	1
Administrative Expenses	42	45	59	102
Financial Charges	3	3	-32	-7
Operating profit	0	-150	-200	-259
Other profits (net)	251	95	32	96
Subsidy from BMFB	0	0	126	165
Total Profit	251	-55	42	2

The financial covenant for BDG agreed at appraisal required BDC to generate total revenues each fiscal year equivalent to not less than the sum of its total operating expenses and the amount by which debt service requirements exceeds the provision for depreciation. The status of compliance with the financial covenant as calculated is illustrated in the table below:

(RMB million)

	2005	2006	2007	2008	2009
Total Wastewater Tariff Collected by Beijing Waterworks Group and transferred to BMFB	-	-	-	-	-
Total Wastewater Collection and Treatment Fee Allocated by BMFB to BDG	318	339	365	445	600
Subsidies from BMFB	-	-	126	165	165
Operating Cost of Wastewater Collection and Treatment by BDC	273	438	537	608	715
Payments of Debt Service	-	-	-	-	-
Cost Recovery Ratio (Including Subsidies)	1.16	0.77	0.86	1.00	1.07

Annex 5. Bank Lending and Implementation Support/Supervision Processes

CHINA: Second Beijing Environment Project

(a) Task Team members

Names	Title	Unit	Responsibility/Specialty
Lending			
Songsu Choi	Senior Economist	EAP Urban Unit	TTL/Economic Analysis
Roger Heath	Sr. Environmental Specialist	EAP Urban Unit	Industry Pollution Control
Dawn Vermilia	Financial Analyst	EAP Urban Unit	Financial Analysis
Bertrand L. Ah-Sue	Procurement Coordinator	WBOB	Procurement
Chongwu Sun	Sr. Environmental Specialist	WBOB	Environment
Zhentu Liu	Sr. Procurement Specialist	WBOB	Procurement
Youlan Zou	Sr. Resettlement Specialist	WBOB	Resettlement
Shunong Hu	Sr. Water Engineer	WBOB	Water Engineering
Margaret Png	Legal Counsel	WBOB	Legal
Jae Hyang So	Financial Analyst	EAP Urban Unit	Financial Analyst
Nancy Chen	Financial Management Specialist	WBOB	Financial Management Specialist
Youhua Yu	Financial Management Specialist	WBOB	Financial Management Specialist
Louisa Huang	Team Assistant/ Financial Analyst	WBOB	Team Assistant/ Financial Analyst
L. Kathleen Stephenson	Financial Analyst/ Peer Reviewer	-	Financial Analyst/ Peer Reviewer
Jack Fritz	Sr. Environmental Specialist/ Peer Reviewer	-	Environmental Specialist/ Peer Reviewer
George P. Taylor	Water Treatment Specialist	Consultant	Wastewater Treatment
Eduard Motte	Sr. Municipal Engineer	EAP Urban Unit	Wastewater Treatment
Martin O'Dell	Municipal Engineer	Consultant	Municipal Engineering
Eddie K S Hum	Sanitary Engineer	Consultant	Sanitary Engineering
Supervision/ICR			
Songsu Choi	Lead Urban Economist	EAP Urban Unit	TTL/Economic Analysis
Raja Iyer	Lead Management Specialist	EAP Urban Unit	TTL/Institutional Analysis
Chongwu Sun	Sr. Environmental	WBOB	TTL/Environment

	Specialist		
Zhentu Liu	Sr. Procurement Specialist	WBOB	Procurement
Youlan Zou	Sr. Social Development Specialist	WBOB/Consultant	Resettlement
David I	Sr. Financial Management Specialist	WBOB	Financial Management
Xiaowei Guo	Sr. Procurement Specialist	WBOB	Sociology
Feng Liu	Sr. Energy Specialist	Headquarters	Energy Specialist
Jian Xie	Sr. Environmental Specialist	Headquarters	Economic Analysis
Shunong Hu	Sr. Water Engineer	WBOB	Water Resources Engineer
Zhang Hao	Sanitary Engineer	WBOB	Sanitary Engineer
Yi Geng	Sr. Financial Management Specialist	WBOB	Financial Management
Margaret Png	Legal Counsel	EAP Legal	Legal
Xuemei Guo	Program Assistant	EACCF	Project Support
Hongwei Zhao	Program Assistant	EACCF	Project support
Xin Chen	Program Assistant	EACCF	Project Support
Chandra Godavitarne	Municipal Engineer	Consultant	Municipal Engineering
Ning Wu	Financial Analyst	Consultant	Financial Analyst
Eddie K S Hum	Municipal Engineer	Consultant	Municipal Engineering

(b) Staff Time and Cost

Stage of Project Cycle	Staff Time and Cost (Bank Budget Only)	
	No. of staff weeks	USD Thousands (including travel and consultant costs)
Lending		
FY98	N/A	151.63
FY99	N/A	145.21
FY00	77	255.94
Total:	77	552.78
Supervision/ICR		
FY00	0	0.00
FY01	21	59.21
FY02	18	55.56
FY03	19	81.10
FY04	17	85.48
FY05	29	119.55
FY06	17	50.35
FY07	17	0.43
FY08	11	26.63

FY09	7	32.37
FY10	3	18.38
FY11	0	0
Total:	153	529.06

Annex 6. Resettlement Implementation

CHINA: Second Beijing Environment Project

1. Resettlement Implementation

All land acquisition and resettlement in the project was related to the wastewater component. A Resettlement Action Plan (RAP) was prepared by the Borrower in accordance with the national laws, regulations and standards as well as the Bank's policy. During implementation of the original component and the new components added in the project restructuring, the resettlement activities were carried out in line with the RAP.

The rehabilitation of the Qing and Liangma Rivers was part of the original components. In 2004, seven additional rehabilitation subcomponents were included for financing using loan savings. They consisted of further works in downstream sections of the Qing and Liangma Rivers. All resettlement activities were fully completed by loan closure in 2009. The key indicators during the planning and implementation stages are summarized in the table below.

Indicators	Original Components	Additional Works (Loan savings)	Total
1. Land acquisition (ha)			
Planned	83.7	106.7	190.4
Actual	112.2	28.7	140.9
Changes	+34%	-73%	-26%
2. House demolition (m^2)			
Planned	229,334	67,681	297,015
Actual	226,421	25,666	252,087
Changes	-1%	-62%	-15%
3. Affected Households and Non-residential units (number)			
Planned: (a) Households (b) Non-residential units	1,839 345	183 165	2,022 510
Actual: (a) Households (b) Non-residential units	733 375	70 171	803 546
Changes: (a) Households (b) Non-residential units	-60% +9%	-62% +4%	-60% +7%
4. Resettlement cost (RMB million)			
Planned	2,066	658	2,724
Actual	1,660	392	2,052
Changes	-20%	-40%	-25%
Total project cost	*3,520*	*1886*	*5406*
Resettlement cost	1,654	396	2,051
Resettlement cost as proportion of total project cost (%)	47%	21%	38%

Details of the resettlement impacts

No.	Index	Unit	Two-lake Connection Canal Project	Ba River Project	Beixiao River Project	Xiaotaihou River Project	Total
1	Land Acquired	Ha	6.05	20.92	29.38	8.27	64.62
2	Houses Demolished	m^2	0	3,654	13,179.3	6,660.7	23,494.0
3	Trees Removed	No.	0	10,037	8,550	2,846	21,433
4	Graves Removed	No.	0	333	462	39	834

Summary Resettlement Information

Indicators	**Original Components**	**New Components** (added at project restructuring)	**Total**
1. Land acquisition (ha)	112.2	28.7	140.9
2. House demolition (m^2)	226,421	25,666	252,087
3. Affected households/non-residential units (number)	733/375	70/171	803/546
4. Resettlement cost (RMB million)	1,660	392	2,052
Total project cost	3,520	1,886	5,406
% of resettlement cost to total project cost	47%	21%	38%

2. Comparison between Planning and Implementation

For the original components, the quantity of land acquisition for roads and land around the three new wastewater treatment plants was increased by 34% from original estimates. However, since the number of houses to be demolished was significantly reduced, the total resettlement cost decreased by 20%. For the new subcomponents added following project restructuring, both land acquisition and house demolitions were greatly reduced, but the resettlement cost did not decrease correspondently, illustrating that resettlement has become increasingly costly and difficult. The high cost of resettlement is due to the increase in compensation rates for land expropriated and houses demolished. Difficulties were caused by prolonged negotiations between the project entities and affected people. Land compensation included not only the loss of income from the land, but also rehabilitation of the land owners, including their employment and social security. Compensation for houses included not only the cost of the demolished houses, but also acceptable replacement houses, the costs of which fluctuate due to the rapidly growing housing market in Beijing.

During project implementation, the project entities continuously searched for ways to consider how to increase the resettlement budget and reduce the scale of resettlement. To reduce the scale of resettlement, viable alternative designs were developed in the project, such as reducing the management area of the river course from 12 meters to 5 meters or 8 meters along both sides of

the rivers in Chaoyang District. Two flood detention basins were not built and instead a wetland was opened by making use of the barren low-lying land, and an embankment was established for flood control at the lower reaches of the Qing River.

3. Experience and Lessons

Resettlement preparation was adequately carried out. However the resettlement difficulties were not adequately foreseen and no analysis of resettlement risks was undertaken during the planning stage. Resettlement implementation took longer than expected for the negotiation of compensation rates and finding additional funds for the largely increased resettlement budget. The civil works of an open channel at the beginning of the Liangma River were delayed due to the slow progress of resettlement implementation. Overall, however, resettlement implementation for all the subprojects was completed successfully within the project period.

Resettlement capacity was well developed in implementing agencies. All resettlement staff was trained and familiar with the World Bank and the local resettlement policies. Each executing agency had one or more staff in charge of coordinating resettlement implementation. Companies with extensive and sound experience in resettlement implementation were contracted for physical work at the locations. A few complaints were received relating to non-restoration of the affected enterprises on temporarily used land, insufficient house compensation, and inadequate participation in land compensation. These complaints were resolved satisfactorily.

BMG revised its resettlement policies and compensation rates twice in the nine years from 2000 to 2008, but barely managed to meet the fast growing needs of the affected people. Local governments devoted more efforts to coordination and funding during resettlement implementation. However, it was more important to work on policy issues to guide resettlement implementation, with respect to timely updating of the compensation principles and rates, taking the initiative in providing suitable apartments for the relocated households, as well as paying favorable and appropriate compensation to the enterprises demolished on temporarily used land which faced difficulties in restoration due to the modern urban planning requirements in Beijing.

4. Internal and External Monitoring

Professors from Beijing University were entrusted with the external monitoring work. Reports were received in a timely manner. The monitors were satisfied, with the resettlement activities and especially, with the actions taken for livelihood restoration. Their reports were used as models for other urban and transport projects. The internal monitoring system which was established and improved was of significant assistance for the Bank's supervision missions.

Major findings through external monitoring are summarized below.

- Resettlement implementation followed all the requirements set out in the RAPs and was successful;
- Relocation of the households improved the livelihood of the affected people. However, some elderly people needed more time to become accustomed to their new living environment, while some young people required more time to reach their work places from their new houses. Also, a few people who were able to lease their houses before relocation needed to use a portion of their compensation funds to cover their income losses;
- By project closure, production and businesses of the relocated enterprises had been restored, although it took about two years for some enterprises to achieve full restoration. It has been difficult to provide or find other jobs for those working in enterprises that

were closed due to the relocation and which could not be reconstructed due to the updated urban planning requirements. The external monitor proposed strengthening of professional training or job training for those affected by the project;

- Even though some affected persons were not satisfied with the relocation itself, they were satisfied with the resettlement staff who acted in a professional and diligent manner; and
- The government should update resettlement policies to guide physical implementation in the field in a timely manner.

5. Conclusions

The outcome of the resettlement assessment illustrated that the resettlement implementation was successfully completed with the full participation of the affected persons whose livelihoods and standards of living were all subsequently restored or improved. No unresolved resettlement issues remained at project closure.

Annex 7. Summary of Borrower's ICR and/or Comments on Draft ICR

CHINA: Second Beijing Environment Project

I. OBJECTIVES AND DESIGN

***Original Project Objective*:** The development objective was to improve the ambient air quality of the Beijing area; decrease the amount of carbon emissions in the global environment; and protect surface and ground water quality in Beijing as well as in areas downstream.

***Amended Project Objective*:** The project development objective remained unchanged during the implementation period.

***Original Components*:** The original components are described in the main text of the World Bank ICR and the PAD.

II. PROJECT RESTRUCTURING

A number of changes were made during project implementation including the addition of new components; changes in project management organization; changes in component numbers and scope; the implementation period; and loan disbursement ratio. All these adjustments were confirmed in the three amendments to the Legal Agreements.

(a) Adjustments to Loan Components

(i) ***Project Restructuring and Loan Cancellations***. In July 2001, during the project implementation, Beijing won the bid to host the 2008 Summer Olympic Games. To expedite the process of meeting air quality targets for the Games, BMG strengthened the policy support to the coal-to-gas boiler conversion program, which in turn spurred the rapid development of Beijing's gas-fired boiler market by non-project vendors. At the same time, the competitive bidding procedures introduced by the Bank had also led to loan savings in the project. Thus restructuring of the project loan was agreed in 2006 and the Legal Agreements were amended on November 2, 2006 to include additional components for river rehabilitation, a reclaimed water plant, sludge section in the Xiaohongmen WWTP, and O&M and GIS construction for drainage facilities. These additional components were financed using loan savings.

Five new implementing agencies were added for the new components. These were the Beijing Municipal Water Affairs Bureau (BMWAB); Chaoyang District Water Affairs Bureau (Chaoyang WAB); Daxing District Water Affairs Bureau (Daxing WAB); Beijing Economic-Technological Investment and Development Corporation; and Beijing Siqing Sanitation Engineering Group Co., Ltd.

The World Bank loans of US$ 26,512,600 and US$ 1,509,784 were cancelled on April 14, 2006 and November 20, 2007, respectively, and the total loan amount was reduced from the original US$ 349,000,000 to US$ 320,977,616.

(ii) ***Extension of the Loan and Grant Closing Date***. The loan and grant closing date was extended from December 31, 2006 to March 31, 2009, by an amendment dated November 2, 2006. The grant closing date was finally extended to January 31, 2011 to enable completion of the combined cooling, heating and power plant demonstration contract.

(iii) ***Adjustment of Disbursement Percentage*.** The 2006 amendment increased the disbursement percentage for the civil works from 40% to 75%. In a second amendment on February 4, 2008, the disbursement percentage for all remaining civil works was increased to 100%.

(iv) ***Adjustment of Procurement Methods***. To provide more flexibility to SJET to deal with the boiler market changes, the World Bank agreed, in 2004, to adopt National Shopping Procedures for boiler procurement. Additionally, International Shopping Procedures were added, and the total allowance for Shopping was increased in the 2006 amendment.

(v) ***Revision of Conditions of the Subsidiary Loan Agreement with BDC***. As the original arrangement of transferring the sewerage tariff revenue to BDC was not a practical option for Beijing's wastewater sector reform, BMG decided to pay BDC for the services it provided to Beijing to cover its operational costs. Since 2006, based on the actual amount of services provided by BDC and the reviewed and agreed rate, BMG has paid BDC the operational costs. The source of funds is mainly from sewerage tariff and supplementary government subsidies. After these arrangements were implemented, the financial situation of BDC substantially improved, as BDC has achieved sustainability both in institutional development and financial balance. As a result, the second legal agreement amendments in 2008, deleted item (ii) "financial independence to retain and use revenues from sewerage tariffs" of Article 9, Section II, Schedule 3 of the Project Agreement.

(b) GEF Grant Financed Components Restructuring

(i) ***Adjustments to the Contents of the Components.*** Two changes to the scope of the grant of technical assistance were made during implementation, as described below, and incorporated in the amendments to the legal agreements in 2006:

In 2004 and 2005, the BMG and the World Bank agreed on the amended implementation plan and adjustment of the focuses of the Gas Boiler Market and Technology Development component, which was divided into three packages: the *Technical model and capacity development of coal-to-gas conversion*; the *Energy efficient gas-based technologies promotion*; and the *Marketing and sales support of coal-to-gas conversion.*

(ii) ***Revised Energy Efficient Gas-based Technologies Promotion.*** This is an extension of the original activities and one focus of GEF financing after restructuring, for which 40% of the total GEF grant was allocated. The objective of this package was to promote combined cooling, heating and power generation (CCHP) and other efficient gas energy technologies through technical assistance and demonstration. This would provide a highly efficient gas utilization mode for Beijing, and facilitate the more efficient and rational use of natural gas resources.

(iii) ***Expanded Scope of the Energy and Environment Study***. To make the outputs of the Study more specific and to combine it with the demands of BMG's work more closely, BMG further expanded the scope of the component through addition of "*Beijing Renewable Energy Development Strategy Study*" and "*Beijing Transportation Demand Management (TDM) Measures Study on the Basis of Sustainable Development*".

(iv) ***Changes to Project Implementing Agencies.*** There were two changes of agencies implementing the grant of technical assistance. These were (a) the *Implementation of the "Energy and Environment Study",* which was originally planned to be implemented jointly by BEPB and HECC, but was transferred to the Beijing Agenda 21 Office which had more experience in policy studies and research; and (b) the transfer in 2005 of the implementation of the Gas Boiler Market and Technology Development to HECC. With the approval of the World Bank, HECC selected a company experienced in World Bank projects to execute the project, which was to assist HECC in specific implementation management of part of the component.

(v) ***Adjustments to Procurement Methods.*** Quality-based selection (QBS) and selection based on consultant's qualifications (LCS) procedures were added for GEF components to meet the implementation requirements of the project.

(vi) ***Extension of the GEF Grant Closing Date***. At the end of 2008, the World Bank officially approved the extension of the Grant closing date to January 31, 2010, to complete construction, monitoring and evaluation of the CCHP demonstration project to fully achieve the project objectives. A further extension of the GEF Grant closing date, to January 31, 2011, was agreed to utilize the Grant savings (of US$ 2.77 million) to prepare a project based on low-carbon economy, for financing by the World Bank, which is not part of this ICR.

III. PROJECT OUTPUTS

Outputs of Original Project Components

(a) Wastewater Management

By the closing date, 18 civil works contracts, 13 goods contracts and 9 consulting service contracts had been completed. All items of the original component were completed.

***Sewers Construction*.** About 71 km of sewers were successfully completed in 2005 consisting of: (i) 26 km along the Qing River, including trunk and secondary sewers along the north bank of the Qing River and the east bank of the Xiaoyue River and (ii) 45 km along the Liangshui River.

Wastewater Treatment Plants (WWTPs). The three WWTPs have been put into service and the total treatment capacity has reached 780,000 m^3/per day. Civil works and equipment for these plants were procured under separate contracts.

***Drainage Operations Monitoring Center & GIS for Sewer Network*.** A GIS-based sewerage network; online monitoring of WWTPs; customer service hotline center; videoconference system; and a comprehensive database, were installed to upgrade the operation and management of the Beijing drainage facilities, and raise customer services and emergency response and decision-making to a higher level.

Sewer O&M and Laboratory Equipment. All the sewer O&M and Laboratory equipment was delivered in 2008 and were put into operation immediately following testing and acceptance.

Consulting Services. The following technical assistance services were satisfactorily completed: (i) Package A – Technical and Technological Assistance; (ii) Package B - Sector Reform and Entity Transformation; and (iii) Package C – Institutional Capacity Strengthening.

(b) Air Pollution Control Component

(b.1) Boiler Conversion and Gas Technology Development

(i) ***Boiler Conversions under the Project.*** During the period 2000 to 2008, SJET satisfactorily converted 591 coal-fired boilers to gas boilers.

(ii) ***Parallel Boiler Conversion outside the Project.*** With BMG support, along with other financing, including private financing, the conversion of all coal-fired boilers under 20 tons/hr in Beijing within the prescribed area was completed by 2008.

(iii) ***Project Contributions to Air Quality Improvement Program***. The project made a significant contribution to the coal-to gas boiler conversion program and subsequent improvement of air quality control in Beijing.

(b.2) Upgrading Air Quality Monitoring

(i) ***Upgrading Monitoring Capacity*****.** The project constructed and upgraded five new and five existing air quality monitoring stations. These 10 monitoring stations measure multi-parameters including SO_2, NOx, CO, O_3, PM_{10}, temperature, humidity, wind direction, wind speed etc. Data from the monitoring stations are provided to the general public via the television media.

Outputs of Additional Project Components

(a) River Rehabilitation by the BMWAB

The works included the North-ring waterways, the lower reaches of the Liangshui River and the lower reaches of the Qing River. The outputs are as follows:

(i) ***Rehabilitation of the North Moat and the Liangma River*****.** River rehabilitation of a total length of 11.6 km, including: (a) 5.927 km of the North Moat, the reconstruction of two check sluices, two navigation locks, two diversion sluices (reconstruction), one culvert sluice and five docks, two bridges, (one new and one reconstruction), two new environmental sanitary wharfs and associated facilities; and (b) 5.251 km of the Liangma River, three new rubber dams and three bridges (two new and one reconstruction), one bridge reconstruction, as well as two new docks, two environmental sanitary wharfs, one escape sluice and 575 meters of new interceptors.

(ii) ***Rehabilitation of Lower Reaches of the Liangshui River*****.** This consisted of dredging the river course of 8.4 km, reconstruction of 70 storm water inlets, Dahongmen sluice gate, fencing, two bridges (reconstruction), 13.85 km of riverside roads, 241,300 m^2 of landscaping, and one artificial wetland of area 2,800 m^2.

(iii) ***Rehabilitation of the Lower Reaches of the Qing River***. 13.4 km of river channel dredging and rehabilitation, thee sluice gates (reconstruction), two bridges, two flood retention basins (Shenjiafen and Shaziying), one artificial wetland, one flood diversion sluice, one escape sluice at Shenjiafen and one check sluice at Shaziying, four management stations, riverside roads, road widening (by 5 meters), 32 storm water and wastewater inlets (reconstruction), 11 new storm water inlets, lighting system and scenery facilities, landscaping along the river and automatic monitoring and control system.

(iv) ***Technical Assistance Outputs***. This involved (a) constructive policy recommendations to BMWAB on water environment improvement, management of urban rainwater and flood control, and wetlands protection, etc., which will serve as a reliable basis for future policy making by BMWAB; and (b) training: a six-person study tour to Finland and Sweden to learn about wetland protection and utilization (10 days duration); a six-person study tour to the United States and Canada to learn about water environment improvement and related policies (10 days duration); a 20-day 15-person training tour to the United States for training on project management; and a 20-day, 15-person study tour to Denmark for project management training.

(b) Water Environment Rehabilitation in Chaoyang District

This component included four sub-components and technical assistance. All of the sub-components were graded as "good quality" when completed in 2008, and the Ba River rehabilitation project was awarded the "Great Wall Cup" of Beijing and the honorary title of "High Quality Project" in Beijing water affairs system. Outputs of the component include:

(i) ***Two-lake Connection***. Construction and expansion of a 1.82 km long connecting canal, with a new ship lock, a new culvert, reconstruction and new construction of ten bridges, 17 storm water inlets, 40,000 m^2 of landscaping, and an expanded and improved water surface of 69,000 m^2.

(ii) ***Ba River Rehabilitation***. 10.65 km long rehabilitated river course, a new sluice gate, two new rubber dams, four bridges (reconstruction), 43 storm water inlets, 20.3 km of riverside roads, 343,000 m^2 of landscaping, and an expanded and improved water surface of 1,894,000 m^2.

(iii) ***Beixiao River Rehabilitation***. 11.75 km of rehabilitated river course, three new sluice gates, two new rubber dams, six bridges (reconstruction), 110 storm water inlets, 17.2 km of riverside roads, 3.8 km of sewers, landscaping of 210,000 m^2, and an expanded and improved water surface of 606,000 m^2.

(iv) ***Xiaotaihou River Rehabilitation***. 7.6 km of rehabilitated river course, three new sluice gates, one new rubber dam, 11 bridges, 65 storm water inlets, 13.2 km riverside roads, 11.2 km of sewers, landscaping of 38,000 m^2, and an expanded and improved water surface of 274,000 m^2.

(v) ***Technical Assistance Outputs***. (a) institutional capacity strengthened through the improved institutional and implementation capacity of the Chaoyang WAB; and establishment of a storm water logging model and early warning system, and outline planning designs for the eight rivers in the Chaoyang District; and (b) a 10-day six-person study tour to the United States and Canada to learn about water tariffs, water environment improvement, water resources management; a 26-day domestic study tour of 43 people in three groups, visiting Shanghai, Zhengzhou, Wuxi, Xi'an and other cities; and a training seminar of 6 days in Beijing regarding the outputs of the technical assistance services, with 160 people participating in five sessions.

(c) Xinfeng River Rehabilitation in Daxing District

The component included the following outputs:

(i) ***River Channel Construction*** consisting of dredging of the river course and cleaning up of the river banks; riverside roads and culverts; hydrophyte plantations; and ecological purification of water through submersible pumps and aerators to reduce COD and BOD concentrations and to improve water quality.

(ii) ***Wastewater Interception*** consisting of 10,293 meters of interceptor sewers.

(iii) ***Environmental water resource*** consisting of a water pump station and pipelines.

(iv) ***Ecological landscaping*** consisting of landscaping along 10.35 km of riverbanks.

(v) ***Flow diversion*** consisting of wastewater from the upper reaches of the Xinfeng River being diverted to municipal sewers, and eventually to the WWTP.

(vi) ***Sluice gate and traffic bridge*** consisting of reconstructed sluice gate and traffic bridge at Suncun.

(vii) ***Technical Assistance Outputs***: Investigation and studies of the status and problems of the river and lake system and water conservation facilities in Daxing District, the current situation of

the Xinfeng River, and monitoring data of water quality of the Xinfeng River. The consultant completed the following reports: *Final Report of the Water System Master Plan of Daxing District; the Engineering Plan of the Feng River Rehabilitation;* and the *Final Report of the Study on the Environmental Impacts of Water Reuse Project of the Xinfeng River*.

(d) The BDA Reclaimed Water Plant

The plant was put into operation in July 2008. The treated effluent water quality meets the designed effluent quality, and is acceptable to enterprises in BDA. The output is a water re-use plant with capacity of 20,000 m^3/d and has a distribution network of 13 km.

(e) Reconstruction of the Datun Solid Waste Transfer Station

Output of the component is a modern transfer station capable of handling up to 2,400 tons/d of solid waste. Waste is compacted and transferred to the landfill using 40 new compactor vehicles each with a capacity of 20 tons.

IV. PROJECT OUTCOMES

The second BEP improved the air quality of Beijing and the water environment of the Liangshui River, the Wenyu River and the Qing River basins. The project accomplished all the targeted objectives and achieved remarkable overall outcomes. It also played an active role in Beijing's fulfillment of its commitments of "Green Olympics" in 2008.

(a) Outcomes of the Wastewater Management and River Rehabilitation Components

The project boosted further development of Beijing's drainage system and made important contributions to reduce pollution discharges and increase Beijing's wastewater treatment capacity. The treatment ratio increased from 25% in 1999 to 93% in 2008, with the total wastewater treatment capacity increasing from 1.08 million m^3/day to 2.52 million m^3/day, including the capacity of 780,000 m^3/day of three WWTPs funded by the Bank loan under this project.

The rehabilitation of the North Moat and the lower reaches of the Qing, Liangshui, Ba, Beixiao, Xiaotaihou and Xingfeng rivers, along with enhanced flood control and drainage capacity of the rivers, improved the river water quality, served as a demonstration for the overall river environment improvement in Beijing, and provided water environment and water security assurance for the Beijing Olympic Games as well as contributing to economic and social development.

The Beijing Drainage Operations Management System and GIS for sewer network provided BDG with a state-of-the-art, efficient tool to manage the large drainage network and facilities in Beijing.

The upgraded solid waste transfer station improved the efficiency of solid waste management in Beijing. The new waste transfer vehicles solved the secondary pollution problems and completely eliminated surface and groundwater pollution and leachate spills at the transfer station.

The reclaimed water plant conserved water resources, reduced wastewater discharge, and generated energy savings.

(b) Outcomes in Air Pollution Reduction Component

Beijing's air quality has been significantly improved and the coal firing related pollutants have been reduced enormously. This has improved the living environment of the citizens and protected their health. Compared to 1998, the 2006 yearly average concentrations of sulfur dioxide and carbon monoxide have both declined, by 55% and 36%, respectively. Coal consumption is estimated to have been reduced by 6 million tons/year, greenhouse gas and pollutant emissions

have also been reduced, and there has been a corresponding significant improvement in air quality.

The component became the driving force for the coal-to-gas conversion program, which was in its infancy in Beijing. The project helped to improve awareness and promote policies, develop the gas boiler market, introduce and promote efficient gas boilers, reduce boiler prices, and introduce coal-to-gas conversion technology and improve service standards. The component prepared the foundations for the acceleration of the implementation of the clean fuel program that occurred in later years, spurred by the impending Olympic Games—a program that was essential for the air quality improvement of Beijing.

The capacity of BMG for air quality management, including monitoring, analysis and prediction, was enhanced through the increased number of updated monitoring stations, and the development of the state-of-the-art Air Quality Monitoring and Decision Support System (AQMDSS).

The project has greatly raised the awareness of the relevant departments of BMG to alleviate air pollution, leading to the *11th Five-Year Energy Plan* attaching increased importance to clean energy utilization, as well as providing important support for BMG's issuing of the *Regulation for Renewable Energy Utilization Management.*

V. ENVIRONMENTAL, SOCIAL AND ECONOMIC BENEFITS

(a) Environmental Benefits

With the operation of the three WWTPs, the environment of the Liangshui River basin as well as the southern part of Beijing city has been improved significantly. Wastewater interception has significantly reduced the source of pollution to the river, decreased the discharge of wastewater to natural water bodies and to the groundwater in neighboring areas, and greatly abated the organic pollutant load in the water environment. As a result, the water environment and landscapes, especially the surface water environment, have been improved. Pollution in the river has been dramatically reduced, aquatic life has gradually recovered, and the river has again become a habitat of wild birds. Through rehabilitation projects of the eight main river sections in urban districts of Beijing (including the lower reaches of the Liangshui River, lower reaches of the Qing River, North Moat and the Liangma River, the Ba River, the Beixiao River, the Xiaotaihou River, the canal connecting the Honglingjin Lake and the Shuizhui Lake, and the Xinfeng River), the water quality and the regional water environment of the rivers have improved overall, landscaping on the river banks and in surrounding areas have been provided, and the river ecosystems have been effectively restored and improved. The implementation of the coal-to-gas boiler conversion component in turn accelerated the conversion of coal-fired boiler to gas-fired boiler—contributing significantly to cleaner air in Beijing. The newly constructed Datun Solid Waste Transfer Station has not only expanded its waste treatment and transfer capacity, but also updated its technology and management by adopting a closed transfer workshop, along with advanced dust and odor control systems and wastewater collecting and treatment facilities, which have eliminated the problems encountered by the affected communities of secondary pollution that previously emanated from the old station caused by leachate, dust, odor and white pollution to the streets.

(b) Social benefits

The dredging and widening of the eight river channels in the city area of Beijing have greatly relieved the pressure of flood control in Beijing.

The completion of the wastewater management and river rehabilitation projects has improved the living environment of the catchment areas, and serves as relaxing and peaceful recreational areas

for people living in the city.

Seven million tons of reclaimed water will be produced and supplied to the enterprises and residents of BDA thus reducing the total water supply of BDA by 40% annually. This component has assisted the BDA to achieve the objective of saving energy, reducing emission and developing a recycling economy.

The wastewater treatment project has played an important role in enhancing water re-use, increasing irrigation efficiency, conserving ground water resources, preventing ground water overexploitation and improving the ecological environment in neighboring areas.

According to available partial statistics, the operation of the three WWTPs and the Reclaimed Water Plant has created up to 284 jobs.

The project outputs have become platforms of environment protection education for the local citizens. Activities such as community education, interaction with the residents and the selection of supervision volunteers have greatly raised the public awareness of water conservation and resources protection.

The ICB procurement activities under the World Bank project have not only facilitated operation and management experience exchange and technological optimization in the gas boiler market of Beijing, but have also promoted price stabilization and the healthy development of the gas boiler market, and citizens have displayed a greater willingness to use clean energy.

The construction and upgrading of the ten air quality monitoring stations has effectively improved Beijing's management capacity of air quality monitoring. The environment monitoring data are released to the public via Beijing Television Station in a timely manner—a development viewed favorably by the local citizens.

The AQMDSS developed and established under the project has enhanced BMG's capacity for air quality projection and assessment and has provided crucial technical assistance to enhance the government's capability of strategic decision-making on air pollution control measures. As part of the data integration system of air quality forecast, the AQMDSS played an important role in air quality forecasting during the Olympic Games in 2008. The system is operated efficiently by BEPB's computing cluster, and provides a daily service of air quality forecast to the public.

(c) Economic benefits

With smooth implementation and completion of the project, the social and the environmental benefits have been emerging gradually, resulting in the following indirect regional economic benefits:

(i) The improvement of the basin area environment of the eight rivers resulting from the rehabilitation works and wastewater management under the project has promoted economic development in these areas. This has attracted more investment, both domestic and foreign, and has especially spurred the development of the real estate industry. The environmental improvement of the project has stimulated regional economic growth, increased local governments' revenues, and brought significant indirect economic benefits to local people and organizations.

(ii) The river rehabilitation projects have provided clean water for agricultural irrigation, which has reduced groundwater exploitation and the waste of clean water resources, leading to an indirect increase in farmers' incomes. For example, the Liangfeng irrigation channel with a total length of 1.91 km has been built to carry treated water to the Nanhongmen agricultural irrigation area in Daxing District, while about 300,000 m^3 of secondary effluent from the Xiaohongmen WWTP (annually 100,000,000 m^3) can be delivered to the area for agricultural irrigation of

13,333 ha (200,000 mu). The actual water delivered was about 5,200,000 m^3 in 2008, which means irrigation costs of RMB 54,600,000 [RMB 1.1/m^3–RMB 0.05/ m^3)×52,000,000 m^3, RMB 1.10/m^3 for ground water and RMB0.05/ m^3 for secondary effluent]. The channel can also reduce the exploitation of ground water by 60,000,000 m^3 annually, which yields enormous economic benefits.

(iii) The Xiaohongmen Sludge Digestion System can save electricity energy of 27,000 kwh/day, equivalent to RMB 6,696,500/year [RMB 0.6795/kwh (the electric power price for industrial use)×27,000 kwh/day×365 days]. The system can also save 2,000 m^3 of gas each day, and conserve 300,000 m^3 of gas in each heating season, which will save about RMB 1,534,000 each year. The calculation is as follows: RMB 1.95/m^3×[2,000 m^3×365 days×(12－4)/12 + 300,000 m^3]. RMB 1.95/m^3 is the current gas price for industrial use, and a four-month heating season is considered. In total, the Xiaohongmen WWTP can directly save energy costs of approximately RMB 8,230,500 per year.

VI. MAJOR FACTORS AFFECTING PROJECT IMPLEMENTATION AND OUTCOMES

(a) Factors outside the Control of Government or Implementing Agencies

(i) Boiler procurement was adversely affected by the SARS outbreak in 2003, and implementation was delayed by about six months.

(ii) The depreciation of the U.S. dollar imposed difficulties due the increased counterpart funding requirements.

(iii) The global financial crisis caused a sharp drop in the demands for the re-use water from the BDA Reclaimed Water Plant.

(iv) The selection of Beijing as the venue for the 2008 Olympic Games had a major impact on the implementation of the boiler conversion component. To achieve acceptable air quality during the Games, BMG issued a series of preferential policies, designed to accelerate the overall boiler conversion program, which resulted in the scaling down of the boiler conversion component of the project.

(v) In 2004 and 2005, Beijing temporarily experienced a shortage of natural gas which affected the gas boiler sales, and the boiler conversion component was forced to slow down.

(b) Factors under the Control of the Government

There were both positive and negative impacts of historical events to this project. These included:

(i) Fluctuation of prices and supplies affected project implementation costs as various supporting policies issued by the government facilitated the progress of resettlement under the project and thus expedited the construction works in general, while some of the civil works had to be suspended due to some special requirements of the government.

(ii) The dramatic surge in real estate development of Beijing since 2005 caused a significant increase in the compensation rates for resettlement. The lack of a revised policy for compensation standards of resettlement in the downtown area created difficulties for project implementation.

(iii) Some of the related public facilities were not constructed according to plan. This meant that the pollution control effects of the project were affected. For example the Dongba and Fatou WWTPs were not constructed, and as a result the planned improvement in water quality in the Ba River and Xiaotaihou River under the project was not fully realized.

(iv) During the project implementation period (2001–2008) Beijing experienced rapid economic growth, making it difficult to accurately estimate project costs at appraisal, which led to adjustments to the overall cost estimation of the project and the need for amendments to the project. As the rapid growth of the clean energy and gas boiler market could not be projected, the appraisal cost estimates for gas boilers were significantly over estimated. Additionally, the target to finance 2,000 gas boiler was overly optimistic and varied markedly from the actual achievement (591 sets), which resulted in a large amount of loan savings.

(c) Factors under the Control of Implementing Agencies

(i) The additional river rehabilitation works were implemented under a very tight schedule that required bidding before designs were fully completed, resulting in a number of contract variations.

(ii) Removal or relocation of municipal infrastructure facilities, and coordination with agencies responsible for traffic and power caused delays in construction.

(iii) There were difficulties in implementation because new agencies included in the additional works lacked experience in World Bank procedures and also lacked adequate project management experience.

VII. SUSTAINABILITY OF THE PROJECT

The Second Beijing Environment Project is sustainable, according to the evaluations of this project, in the following three aspects:

(i) There are adequately experienced staff and organizational arrangements;

(ii) Management systems and sufficient capacity exist for operation and maintenance of the constructed facilities.

(iii) Adequate financial resources and commitment are available.

In addition, the operation costs of the sewerage network, pumping stations and WWTPs are covered by the sewerage tariff and government subsidies. The rate of the wastewater treatment fee agreed by the BDG, BMWAB and BMFB is RMB 0.743 m^3 and the rate for sewerage network is RMB 98.34 per meter. This mechanism ensures that BDG's fund demands for business operation and equipment maintenance can be satisfied. The funds for repayment of the World Bank loan are appropriated by the BFB. Thus, the financial sustainability of this component is satisfactory.

Beijing Economic & Technological Investment Development Corporation (BETIDC) is responsible for the operation and maintenance costs of the BDA Reclaimed Water Plant, and the World Bank loan repayment is guaranteed by the BDA Finance Bureau. The global financial crisis has caused the market to shrink and subsequently adversely affected the source water quality. As a result it is predicted that the Plant will be in deficit from 2009 to 2011. BETIDC and the Boda Water Affair Co. Ltd. are actively taking measures to achieve normal operating as soon as possible.

VIII. PERFORMANCE OF THE BANK AND THE BORROWER

(a) ***The Bank's Performance***. The Bank's performance was rated satisfactory for the following reasons:

(i) The project was well prepared and addressed two key environmental issues of Beijing: water pollution and air pollution. The outputs of the project have met the urgent needs of Beijing to

improve the air and water quality. The Second Beijing Environment Project component package has expedited the recent improvement of Beijing's environment.

(ii) The World Bank has been flexible, pragmatic and cooperative, giving patient guidance and effective assistance to the Borrower throughout the project cycle, and has provided policy assurance for smooth project implementation.

(iii) During project appraisal, the World Bank fully respected BMG's actual needs, assisted in establishing project objectives, and in making implementation plans. In addition the Project Appraisal Document was completed promptly.

(iv) During project implementation, the World Bank provided timely and adequate guidance and assistance in procurement and implementation. With regard to issues that arose during project implementation, the World Bank task team conducted deep and detailed investigations in a timely manner and actively sought practical solutions and measures, so as to resolve the issues smoothly.

(v) In the later stage of project implementation, the World Bank further enhanced the management by local experts in the project task team and granted more authority to the Beijing office. Following the appointment of a staff member from the World Bank Beijing Office as task team leader, the efficiency of communication and project management improved due to her understanding of China's situation and government policies.

(vi) The World Bank is highly attentive to the integrated outcomes and benefits of the project. For example, the World Bank loan supported not only the construction of WWTPs, but also the development and construction of associated facilities such as sewerage networks, sludge disposal systems, river rehabilitation and wastewater reuse facilities, and the Bank also emphasized and suggested reforms and innovation of related management institutions. This has advanced the integrated economic benefits of water environment improvement project and realized the maximum environmental and social benefits of the project.

(vii) The World Bank projects focus on not only the investment in hardware, but also the enhancement and improvement of technical, financial and management capacities of the project implementing agencies and the optimization of the sector system design. Under this project the World Bank loan has been utilized to procure a significant amount of advanced equipment and facilities. Meanwhile, the technical and management capacities of all the implementing agencies and the whole project team have been strengthened through technical assistance, training and management consulting services.

Suggestions. The following suggestions could be considered for improvements to future projects:

(i) The World Bank projects could combine the overall design and management mode with specific local situations and needs.

(ii) The World Bank headquarters could grant more authority to country offices and provide more favorable conditions for project implementation. The Bank should confer more power to the implementing agencies when they have the adequate capacity of project management and implementation. This could lead to the achievement of improved project management results and effects in procurement and disbursement. For example, changes could be made in terms of the disbursement ratio for the category "Civil Works," the thresholds for the procurement methods "ICB" and "NCB" and prior-review and post-review.

(iii) It is also hoped that the Bank's team be maintained in a more stable and consistent form. This project had a succession of three task team leaders, and the composition of team members also changed several times. This affected the project progress in certain stages to some extent.

(b) Performance of the Borrower

The Borrower's performance was in general satisfactory. A project management team with good management qualities that are adequate to the management requirements has been assembled. Led by the BPMO, the implementation agencies worked rigorously and pragmatically and developed a set of rules and regulations adapted to the project management requirements. Successful completion of the project mainly depended on the following factors:

(i) In the initial stage of the project, BMG set up a leading group specifically for this project, headed by the relevant mayors. Under this group was a project management office (BPMO) with proper staffing and ensured financial support. Based on stable organization and staff with a strong sense of responsibility, the BPMO has established a set of rules and institutions suitable for professional management of World Bank projects.

(ii) According to the needs of the components, the implementation agencies set up different departments such as the project operation department, the procurement management department, the construction engineering department, the resettlement department, financial department, the archives department, etc. The departments of most implementing agencies have properly designed positions and professional and stable teams, which allowed communication with the BPMO and the World Bank to be conducted in a timely and effective way and ensured smooth project implementation.

(iii) The counterpart funds were appropriated in time. The World Bank fully understood and supported the project restructuring as well as some contract variations, all of which contributed to the final completion of the project.

(iv) Through bidding procedures the implementation agencies selected and hired qualified professional design institutes and supervision companies to be responsible for engineering design and construction supervision. This ensured high quality technical services for the project.

(v) Foreign and domestic experts provided effective technical assistance and consulting services through international consultancy projects.

(vi) BPMO organized many project management training sessions regarding bidding and procurement, disbursement, contract management and other subjects to improve the professional capabilities of all the PMO staff, to enable them to solve problems in a timely fashion. This has provided a comprehensive operational basis to ensure smooth project implementation.

(vii) The engineering documents and materials have been collected and filed in time with the progression of the project and they reflect the actual construction situations and project progress. Each stage and section of the construction has undergone appropriate examination and checking procedures.

Issues of concern

(i) Due to the fact that the time for the project preparation was limited, especially for the loan saving components, many projects used preliminary design drawings in the bidding. This caused some of the bidding documents to be not specific or sufficiently complete, and in some cases items were missing or were of unreasonable design. This led to many contract variations and noticeable changes in the contract amounts during project implementation. This occurred to the civil works contracts such as the Qing River, the Ba River and the Xiaotaihou River.

(ii) During project preparation, the resettlement risks analysis was not adequate and the difficulties in land acquisition were underestimated. This resulted in a delay of about one year of the completion of the civil works of the 435 meter section in the Liangma River.

IX. EXPERIENCES, LESSONS LEARNED AND SUGGESTIONS

The Second Beijing Environment Project, which was implemented over 10 years, made important contributions to the water and air pollution abatement and prevention in Beijing, as well as institutional reform and enhancement of knowledge and skill. The Beijing PMO and the PIUs has gained valuable experiences and learned lessons as discussed below:

(i) Set-up project management office with all staff trained for the project preparation and implementation.

(ii) Avoid underestimating project risks. China is a developing country and its capital city, Beijing has been experiencing tremendously rapid development. The scaling-down of the boiler conversion component was to a large extent the result of external changes outside the project. The Second Beijing Environment Project commenced at a time when Beijing's economy and society was developing very rapidly with various systems and mechanisms being reformed. The project appraisal underestimated the speed of development of the clean energy promotion and gas boiler market in Beijing and also overestimated the potential market for SJET. This illustrates that when a large-scale project with a long time-span is to be carried out in a fast growing city like Beijing, risks caused by potential changes in policy, market, technology and society must be fully anticipated, and only with flexible implementation modes in project organization, procurement management and other aspects, which can rapidly be adapted to external changes, can damages or loss be mitigated.

In the initial stage of project implementation, due to very limited experience of the implementing agency in World Bank loan project management, there was a noticeable deficiency in overall progress planning and risk assessment. For example, risk analysis was inadequate for the land acquisition and resettlement at the 435 meter section of the Liangma River, causing the civil works to fall behind schedule. As a result, the actual implementation period was one year longer than originally planned.

Due to insufficient analysis on related conditions and project risks during the initial stage of the project, both the quality and quantity of the source water for the BDA Reclaimed Water Plant are problematic. This has affected the achievement of expected project outcomes. Although the implementing agency is remedying the situation, the project costs have been increased.

In addition, the risks associated with fluctuating exchange rates over the course of the long project implementation period have also been underestimated.

(iii) Adequate solutions to complaint issues should be implemented as early as possible. It is unavoidable that complaints will occur during project implementation due to various reasons, but they must be addressed as early as possible. For example, a complaint was received during the bidding process of vehicle procurement under the component of the Datun Solid Waste Transfer Station reconstruction and the implementing agency, lacking the necessary experience, did not respond in an adequate or timely manner. Consequently, the vehicle procurement was prolonged and the component completion was delayed to some extent.

(iv) Ensuring that local counterpart funds are made available in time. For certain components, management levels and the procedures of local counterpart funds were so complicated that the funds failed to be in place promptly, which to some degree affected the smooth progress of the project.

Suggestions

(i) More prudent design of market-oriented approaches.

During the project design of the Second Beijing Environment Project, it was recommended that both the components of boiler conversion and wastewater management were to be aimed at fully market-oriented modes of sector management. However, over the last eight years, it is evident that the good progress of boiler coal-to-gas conversion in Beijing can be mainly attributed to the assistance of the government. Therefore, the implementation arrangements of the boiler conversion component have vacillated between administrative and market-oriented approaches. The inherent inner contradiction in the institutional setting-up of SJET has become increasingly apparent. Inevitably, many specific problems occurred in aspects of coordination between the government and the Beijing Gas Group, and SJET's operation and project implementation, which has hindered the smooth progress of the component. Meanwhile, although the reform of Beijing's drainage sector has made significant progress, the current BDG operation mode differs from how it was originally conceived, and the facts have proved that this mode is effective and suitable for the specific situation of Beijing.

This shows that environment protection projects for development of public utilities are essentially inherently for the public interest, and the characteristics unique to China have determined that the development approaches in all sectors would inevitably differ from those in western countries. Therefore, for future World Bank designs projects in different countries, it is likely to be beneficial to ascertain the optimal arrangements for project implementation, how to fit the specific local conditions and what kind of market-oriented approach should be selected.

(ii) More authority and flexibility granted to the implementing agencies.

As the Chinese economy is developing rapidly, it is difficult to make at the time of project appraisal an accurate estimate of project costs. Therefore, it is likely that the overall project budget will require noticeable adjustments, often undertaken through complicated procedures. Furthermore, some important historical events (such as the Beijing Olympic Games) are likely to influence market prices and supplies, and this will in turn have a direct impact on the costs of project implementation.

As a result it is suggested that (a) implementing agencies be granted more authority and flexibility to deal with necessary adjustments during project restructuring, and (b) the period for price adjustment (180 days) in Special Conditional of Contract (SCC) should be shortened moderately.

(iii) More communication and coordination between the World Bank and local government regulators of bidding and procurement.

In order to ensure a smooth bidding process (especially the ICB), it is necessary for the World Bank to further coordinate with the Ministry of Commerce and other related agencies to make the World Bank's "Procurement Guidelines" more practical in China and reduce difficulties for the implementation agencies.

(iv) More effective measures needed for handling complaints from unsuccessful bidders

More pro-active and effective measures would be of assistance in solving issues of complaints from unsuccessful ICB bidders. Otherwise, should a complainer intend to cause delay, the current process may lead to tremendous risks of bidding failure and result in severe delay of project progress. It may be beneficial if the World Bank set up or coordinated with concerned domestic agencies to co-establish an arbitration agency for complaint issues.

(v) International consulting companies expected to promote localization.

The World Bank attaches great importance to contributions made by international consulting companies in providing technical assistance. However, due to differences in culture and management styles between countries, problems sometimes occur when the international company's working mode is not compatible with the client's requirements or in cases where the outputs are not as satisfactory as expected. In such cases the World Bank could encourage international consultants enhance localization to better meet the clients' demands.

(vi) More local employees in the World Bank teams.

The experiences with the Second Beijing Environment Project have shown that it is very important to have excellent local experts in the World Bank project teams to improve project management efficiency, in particular for solving complex problems. To further enhance the World Bank management it may be useful to consider using more local staff to achieve more effective communication and higher efficiency in project management.

(vii) More authority granted to the World Bank Office in Beijing (WBOB).

The project progress of the Second Beijing Environment Project has been more efficient since 2004 when the World Bank began to gradually transfer more power to the WBOB. If the World Bank continues to simplify review procedures and shorten processing time the efficiency of project management is likely to further improve.

Annex 8. List of Supporting Documents

CHINA: Second Beijing Environment Project

1. Project feasibility studies and project proposal
2. Project Appraisal Document
3. Loan Agreement
4. Project Agreement
5. Mission Aide Memoires and Back-to- Office reports
6. Project Status Reports and Implementation Status Reports
7. Semi-annual Project Progress Reports

IBRD 30782R1

CHINA

SECOND BEIJING ENVIRONMENT PROJECT

FUTURE | PROJECT RESTRUCTURING COMPONENTS | ORIGINAL PROJECT COMPONENTS | EXISTING

WASTEWATER FACILITIES:

WASTEWATER INTERCEPTION AND RIVER IMPROVEMENTS

TREATMENT PLANTS

AIR POLLUTION CONTROL AREAS (BOILER CONVERSIONS: PLANNED 2000, ACTUAL 700)

MAIN ROADS

MAIN ROADS UNDER CONSTRUCTION

RAILROADS

COUNTY/DISTRICT BOUNDARIES

0 2 4 6 8 KILOMETERS

To Changping

CHANGPING COUNTY

SHUNYI COUNTY

Beijing Capital Airport

LOWER REACHES OF QING RIVER

QINGHE WWTP

Qing R.

Wenyu R.

HAIDIAN DISTRICT

Jing Zhang Rd.

BEIXIAOHE WWTP

DATUN SOLID WASTE TRANSFER STATION

Beixiao R.

BEIXIAO RIVER

MENTOUGOU DISTRICT

4th Ring Rd.

Kunming L.

Airport Expy.

3rd Ring Rd.

BA RIVER

Ba R.

JIUXIANQIAO WWTP

SHIJINGSHAN DISTRICT

Jing Chang R.

NORTH MOAT AND LIANGMA RIVER

2nd Ring Rd.

Liangma R.

CHAOYANG DISTRICT

DONG CHENG DISTRICT

XI CHENG DISTRICT

Tiananmen Square

Shijingshan Rd.

Fuxing Rd.

Dong Chang'an Ave.

Tonghui R.

To Tongxian

Xinkai Ditch

4th Ring Rd.

3rd Ring Rd.

2nd Ring Rd.

XUANWU DISTRICT

Qianmen Rd.

CHONGWEN DISTRICT

TWO-LAKE CONNECTION CANAL

GAOBEIDIAN WWTP

WUJIACUN WWTP

Yongding R.

FENGTAI DISTRICT

Fengcao R.

3rd Ring Rd.

FANGZHUANG WWTP

XIAOTAIHOU RIVER

Liangshui R.

4th Ring Rd.

LUGOUQIAO WWTP

Macao R.

XIAOHONGMEN WWTP

LOWER REACHES OF LIANGSHUI RIVER

Xiao Long R.

RECLAIMED WATER TREATMENT PLANT

Liangshui R.

DAXING COUNTY

To Baoding

XINFENG RIVER

To Tianjin

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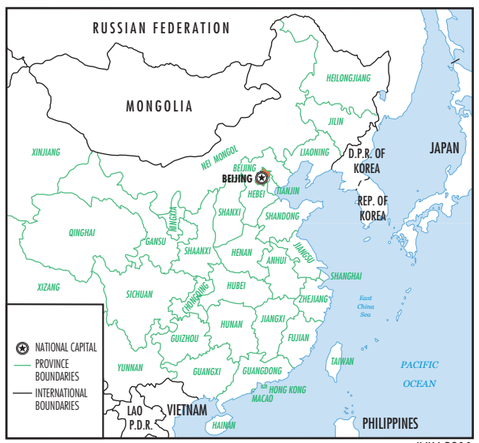

JULY 2011