Republic of Peru

Southern Lima Metropolitan Sewerage Improvement Project

External Evaluator : Global Group 21 Japan, Inc.
Hajime Sonoda

1. Project Description

Project Location

San Bartolo Sewage Treatment Plant

1.1 Background

In the mid-1980's, sewage generated in the Lima Metropolitan Area was almost entirely discharged untreated to the sea. Some one-third of the total sewage went through the La Chira Outfall located in southern Lima and this untreated sewage was one cause of the serious pollution of coastal waters, including the declining water quality at nearby bathing beaches. Meanwhile, untreated sewage was used for irrigation at some suburban farmland in southern Lima and it was pointed out that such use of untreated sewage could be a health hazard for farmers as well as consumers of agricultural products. To rectify the situation, the Government of Peru recognised the importance of improving sewage treatment plants (STPs) in the Lima Metropolitan Area and called for an urgent action at a cabinet meeting[1].

A study conducted in 1985 with the assistance of the Inter-American Development Bank proposed a plan whereby the sewage discharged from the La Chira Outfall would be conveyed, instead of being discharged to the sea, to a suburban treatment plant and reused for the irrigation of 5,000 ha of San Bartolo Plain, a dry area in southern Lima.

[1] As stated in the reference materials at the time of project appraisal and the Final Report for “the Feasibility Study on the Improvement of Sewerage System in Southern Part of Lima (JICA, 1990)”.

In 1988, the Government of Peru submitted an official request to the Government of Japan regarding an improvement of the sewerage system in southern Lima. In response, the JICA conducted the Feasibility Study on the Improvement of Sewerage System in Southern Part of Lima from 1988 to 1990. The sewerage improvement project proposed by this study would develop the sewage treatment capacity of 4.0 m^3/sec in two phases by the year 2000. The expected effects included the retrenchment of the prohibited bathing area by 3.0 km and the conversion of some 4,800 ha of land into green land or farmland through the use of the treated sewage.

In 1995, the Peru-Lima Waste Water Management and Coastal Pollution Control Project (of which the Spanish abbreviation is the PROMAR), a body established at the Peruvian President's Office, made a study of the "Project on Waste Water Management and Coastal Pollution Control" with the assistance of the World Bank[2]. It also prepared a proposal for the Southern Lima Metropolitan Sewerage Improvement Project (the Project) which corresponded to the phase 1 of the project proposed by the said feasibility study[3].

With such background, a request for a yen loan for the Project was made by the Government of Peru in 1995 to the Government of Japan. The Loan Agreement was signed in 1996 and the Project was implemented from 1996 through 2006.[4]

1.2 Project Outline

To alleviate the pollution of sea water and improve the quality of irrigation water from hitherto used untreated sewage in southern Lima by means of developing additional sewage treatment capacity of 3.25 m^3/sec through the construction of two new STPs, the expansion of one existing STP and the construction of new sewer lines, thereby contributing to an improvement of environmental hygiene in the area.

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[2] The study included the Project, the construction of two more treatment plants, and the extension of two deepwater outfall pipelines and anticipated investment by the World Bank and the OECF. However, investment by the World Bank did not materialise.

[3] Project proposal for "Improvement of Sewerage in the Southern Part of Lima": Immediate Action Plan (PROMAR, 1995)

[4] While the loan disbursement for the Project was completed in January, 2006, the San Bartolo STP, the last facility constructed under the Project, commenced operation in December, 2007. For analysis of the efficiency, the project period was considered to be up to the commencement of operation of the San Bartolo STP.

Approved Amount/ Disbursed Amount	¥12,660 million / ¥12,076 million
Exchange of Notes Date/ Loan Agreement Signing Date	August 1996 / September 1996
Terms and Conditions	Interest Rate : 2.5% (Consulting service : 2.1%) Repayment Period (Grace Period) : 25 years (7 years) Procurement : General Untied
Borrower / Executing Agency	Government of the Republic of Peru / Ministry of Presidency, later changed to Lima Water and Sewerage Service Company (SEDAPAL) / Ministry of Housing, Construction and Sanitation
Final Disbursement Date	January 2006
Main Contractor (Over 1 billion yen)	SADE(France)・COSAPI S.A.(Peru)(JV) / Companhia Brasileira de Projetos e Obras(Brazil)・Consorcio Odebrecht- CBPO(Peru)(JV) / Companhia Brasileira de Projetos e Obras(Brazil)・Construtora Norberto Odebrecht(Brazil)(JV) /Consorcio Odebrecht - CBPO(Peru)
Main Consultant (Over 100 million yen)	NJS
Feasibility Studies, etc.	The Feasibility Study on the Improvement of Sewerage System in Southern Part of Lima (1990, JICA), Project Proposal for "Improvement of the Sewerage in the Southern Part of Lima" Immediate Action Plan (Ministry of the Presidency, Republic of Peru, 1995)

2. Outline of the Evaluation Study

2.1 External Evaluator

Hajime Sonoda, Senior Consultant, Global Group 21 Japan, Inc.

2.2 Duration of Evaluation Study

The ex-post evaluation study of the Project was conducted over the following period.

Duration of the Study: September, 2008 to July, 2010

Duration of the Field Study: 14th November to 24th December, 2009

21st February to 16th March, 2010

2.3 Constraints during the Evaluation Study

Data and information was collected through a series of interviews with the project implementing body and other stakeholder organizations, the gathering of relevant documents, observation of the project-related facilities and the situation of the reuse of treated sewage, interviews and workshops with farmers using the treated sewage for irrigation and a questionnaire survey with swimmers at bathing beaches. No major constraints were encountered in the process of information gathering.

3. Results of the Evaluation (Overall Rating: C)

3.1 Relevance (Rating: a)

3.1.1 Relevance with the Development Plan of Peru

The Government of Peru already recognised in the mid-1980's that there was an urgent need to improve the sewage treatment facilities in the Lima Metropolitan Area. The current government has adopted the "Agua para Todos" (Water for Everyone) policy which aims at ensuring access to clean water by the entire population by the end of its term in 2011, identifying the water supply and sewerage sector as a priority sector for national development. The Project has been given the status of one of three mega projects forming the General Clean Water Plan (Plan General de Aguas Limpias) which is being implemented by the government in the Lima Metropolitan Area[5].

In view of such status, the Project designed to improve the sewerage system in the Lima Metropolitan Area is judged to be compatible with the development policies in Peru at the time of appraisal and also at the time of ex-post evaluation. However, it must be noted that no clear policy currently exists to promote the reuse of treated sewage for agricultural irrigation in southern Lima.

3.1.2 Relevance with Development Needs of Peru

At the time of appraisal, sewage generated in the Lima Metropolitan Area was almost entirely discharged untreated to the sea, making the introduction of sewage treatment facilities highly necessary. As of 2008 after the completion of the Project, the sewage treatment rate in the Lima Metropolitan Area is still as low as 14.6%, failing to arrest either the continual deterioration of environmental hygiene or contamination of the sea. Therefore, Lima Water Supply and Sewerage Service Company (SEDAPAL) had commenced the construction of the new Taboada STP (treatment capacity: 14 m^3/sec) in 2010 and also is planning the construction of a new STP near the La Chira Outfall. These moves illustrate the strong need for an increase of the sewage treatment capacity in the Lima Metropolitan Area.

[5] This Plan stipulates investment of US$ 500 million with a view to improving the sewage treatment rate in the Lima Metropolitan Area to 100% by the end of 2011.

Layout of the Project

3.1.3 Relevance with Japan's ODA Policies

The old ODA Charter adopted in 1992 stipulated that Japan would provide assistance for the development of infrastructure, which is an important precondition for socioeconomic development. Around that time, Japan actively provided assistance to Peru in recognition of the positive reform efforts of the then Fujimori Administration to ensure sustainable economic development and alleviate poverty. In line with the diverse development needs in Peru, Japan decided to provide loans every year, in principle, from 1996 onwards with the qualitative as well as quantitative enhancement of cooperation in mind. In 1999, poverty alleviation and environmental conservation were identified as priority issues for Japan's ODA for Peru and active cooperation was called for to improve the country's water supply and sewerage services and to control water pollution. In these regards, the Project was compatible with Japan's ODA policies at the time of its appraisal.

Based on the above, this project has been highly relevant with the country’s development plan, development needs, as well as Japan’s ODA policy, therefore its relevance is high.

3.2 Efficiency (Rating: b)

3.2.1 Project Outputs

The plan at the time of appraisal consisted of the following two independent sewage treatment systems.

(i) Sewage from areas at an elevation of 130 m ~ 150 m within the Surco Drainage Area, which is discharged untreated through the La Chira Outfall, will be received by two intake points. The sewage will be then conveyed to the San Bartolo STP (treatment capacity: 2.2 m^3/sec) via two pre-treatment facilities to remove garbage and a 32 km transmission line[6]. The treated sewage will be discharged to Rio Lurin and also used for agriculture on the San Bartolo Plain and other areas. Part of the sewage running through the transmission line will be diverted and treated at the new Huascar STP (treatment capacity: 0.05 m^3/sec) that provides treated sewage for irrigation in the nearby area. All of these facilities will be newly constructed. Treatment will be made by the aerated lagoon method.

(ii) The treatment capacity of the existing San Juan STP will be increased from 0.25 m^3/sec to 1.0 m^3/sec. The aerated lagoon method will be introduced for more advanced treatment. The treated sewage will be used for irrigation in the nearby area.

After the signing of the Loan Agreement in September, 1996, the detailed design work was carried out until 1998. The finalised detailed design included such changes as; (i) extension of the discharge pipeline from the San Bartolo STP, (ii) addition of a stabilisation pond at the San Bartolo STP, and (iii) scale reduction of both the San Bartolo STP and San Juan STP in consideration of a likely increase of the project cost due to the weakening of the yen and also the anticipated financial stringency of the government due to damage caused by the El Niño phenomenon. Meanwhile, in consideration of the strong needs of reuse of treated sewage in the nearby area, the scale of the Huascar STP was expanded from the original plan at the time of appraisal. As a result of these changes, the sewage treatment capacity to be added by the Project was reduced to 2.67 m^3/sec or some 82% of the originally planned 3.25 m^3/sec at the time of appraisal.

Moreover, the following changes were made after the commencement of the construction.

- The original plan intended two intake points from the existing sewer lines and the construction of a pre-treatment facility at each intake. However, it was found to be impossible to construct a pre-treatment facility at one of the planned two intake points due to strong opposition by nearby

[6] The Project was based on an unprecedented concept in the world that the raw sewage would be transported for 35 km by a transmission line.

residents and the mayor of the district. Accordingly, one of the new connections with the existing sewer lines was abandoned[7].

- During the detailed design process for the San Bartolo STP, the discharge pipeline of treated sewage to the sea was considered for a time. However, because of the opposition of coastal residents to this plan, the destination for the discharge pipeline was changed to Rio Lurin. The actual discharge point was then moved to downstream of the wells that supply water to local residents because of the opposition of residents living near the originally planned discharge point.
- Respecting the opinions of local resident, the discharge method for the treated sewage from the San Juan STP was changed from coastal discharge to deep-sea discharge.
- The original plan for the Huascar STP was to treat part of the sewage diverted from the main transmission line to the San Bartolo STP. However, because of a major delay of the commencement of operation of this transmission line and the San Bartolo STP, it was decided not to receive sewage from this sewer line. The Huascar STP was then remodelled to operate as an independent sewage treatment system receiving sewage from existing sewer lines in the nearby area.

Connection between an existing Sewer and the transmission line

Pre-Treatment Plant (Punto A)

San Bartolo STP : Control Room(left), Discharge to Lurin River(right)

[7] The San Bartolo STP cannot receive more sewage due to an increase of the Biochemical Oxygen Demand (BOD) concentration of the sewage and no new connection with a sewer line is currently planned.

Table-1 Comparison of Planned and Actual Project Outputs

(a) Construction of Sewers (49.95km) San Bartolo Transmission Line : 31.55km Discharge Pipe for San Bartolo STP : 5.5km Discharge Pipe for San Juan STP : 5.4km Discharge Pipe for Huascar STP : 5.0km (b) Expansion of Sewerage Treatment Plants Expansion of San Juan STP : 0.25→1.0 m^3/sec. Collector for San Juan STP : 0.2km (c) Construction of Sewerage Treatment Plant Construction of San Bartolo STP : 2.20 m^3/sec. Construction of Huascar STP : 0.05 m^3/sec. (d) Consulting Services : Detailed Design, Construction Supervision	(a) Construction of Sewers (53.1km) San Bartolo Transmission Line : 32.5km Discharge Pipe for San Bartolo STP : 9.5km Discharge Pipe for San Juan STP : 5.6km Discharge Pipe for Huascar STP : 5.5km (b) Expansion of Sewerage Treatment Plants Expansion of San Juan STP : 0.25→0.8 m^3/sec. Collector for San Juan STP : 0.2km (c) Construction of Sewerage Treatment Plant Construction of San Bartolo STP : 1.7 m^3/sec. Construction of Huascar STP : 0.17 m^3/sec. (d) Consulting Services: (additional scope) supplemental EIA, manual and training for transmission line

Source : Material at the initial appraisal, SEDAPAL

San Juan STP : Pre-Treatment Plant (left), Stabilization Pond (right)

(Left) Laboratory at San Juan STP

(Right) Receptor from the Transmission Line (not in use due to change in plan)

3.2.2 Project Inputs

3.2.2.1 Project Period

The Project was originally planned to be implemented for 56 months from July, 1996 to February, 2001. In reality, it was implemented over a period of 136 months from September, 1996 to December, 2007. The length of the actual project period was 243% of the original plan. The San Bartolo STP, the last facility to be completed under the Project, commenced operation six years and 10 months behind the original schedule. Because of such delay, the time limit for loan disbursement was extended twice. Reasons for the delay will be explained as follows;

After the signing of the Loan Agreement, the project implementing agency was changed from the President's Office to the SEDAPAL as a result of the reorganization of government ministries and agencies. The impacts of this change of the project implementing body were small and the construction work commenced without any major delay. After the commencement of the work, however, the completion of the discharge pipeline from the San Bartolo STP was delayed by more than three years because of opposition by local residents. Moreover, the commencement of operation of the San Bartolo STP and the transmission line was delayed by further three years due to an accident during test operation.

The construction of the discharge pipeline from the San Bartolo STP to Rio Lurin was suspended in August, 2001 due to an opposition by local residents. Subsequent negotiations with local residents and head of the district experienced many difficulties and the work was finally completed in June, 2004. The opposition of local residents originated from their lack of a proper understanding of the project contents but the interference of a local politician made the issue political, delaying settlement of the issue[8]. The construction of the transmission line and San Bartolo STP was almost completed in February, 2002 and the test operation of these facilities could have commenced at that time. Because of the delay of the construction of the discharge pipeline, however, the said test had to wait until June, 2004 when the discharge pipeline was finally completed.

Moreover, the San Bartolo STP suffered from an incident in September, 2004 when part of the partial mixing aerated lagoons collapsed during the filling test. In this incident, part of the concrete plates laid at the bottom of the stabilisation pond collapsed as the soil below was eroded by water seeping through some of the joints. Several possible causes of the collapse were pointed out as listed bellow,

[8] The opposition of local residents began when incorrect information was spread that the untreated sewage but not the treated one will be discharged. Although the SEDAPAL secured all of the necessary permits, etc. legally required for the construction of the discharge line, the opposing residents forcibly halted the work in 2001. The opposition of local residents subsequently became a political issue and the court ordered temporary suspension of the work on the grounds of resident protection.

but no conclusion has been reached as of March, 2010, as the SEDAPAL, the contractor and the consultant are in a dispute over where the responsibility lies and how the repair cost should be met.

- The filling test went ahead although the joint deteriorated during the period from completion of construction to the filling test[9].

- The geological survey prior to the commencement of the construction work failed to detect the localised presence of highly erosive soil.

- Fault in the design and/or execution of the joints.

In October, 2005, two incidents happened one after another during the test operation where the sewer exploded at the bottom part of the inverted siphon of the transmission line. According to the SEDAPAL, these incidents occurred as a result of the generation of a combustible as well as corrosive gas from the sludge accumulated inside the sewer. Even though oxygen was injected to prevent the generation of such gas, insufficiently dissolved oxygen was mixed with the combustible gas. This mixture was eventually ignited by sparks that occurred at the exhaust port. The insufficient performance of the oxygen dissolving device was pointed out as one cause of the explosion along with the generation of a large quantity of combustible gas due to the much accumulation of sludge, which was caused by a much lower sewage flow than the design flow.

The repair work necessitated by these incidents was completed in June, 2006. After the compilation of the manual and the implementation of training for the proper operation of the transmission line by the consultant, the San Bartolo STP and the transmission line finally commenced operation in December, 2007. Meanwhile, the San Juan STP commenced operation in 2002 almost as originally planned and the Huascar STP commenced operation in 2004 after remodelling as an independent system.

3.2.2.2 Project Cost

At the time of appraisal, the project cost was estimated to be approximately ¥16.9 billion. The finalised actual cost was approximately ¥15.0 billion (89% of the originally planned amount)[10]. The factors contributing to this lower spending were the reduction of the scale of the STPs, change of the project scope due to the omission of some pre-treatment facilities, and the reduction project cost owing to competition exceeding the currency exchange losses.

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[9] The original design of the joints assumed filling of the stabilisation pond immediately after the completion of the work but were left exposed to the sun for more than four years without any maintenance.

[10] The cost of the repair work following the collapse incident during the test operation was not included in the project cost as the incident occurred after the completion of the construction work. The cost is to be paid by the SEDAPAL (Ministry of Housing, Construction and Saniatation) using its own funds, the contractor and/or the consultant.

Table 2 Planned and Actual Project Costs

	Planned			Actual		
	Foreign Currency (¥ million)	Local Currency (US$ '000)	Total (¥ million)	Foreign Currency (¥ million)	Local Currency (US$ '000)	Total (¥ million)
Civil Engineering Work	6,660	43,154	11,061	7,161	4,248	11,408
Consulting Service	624	3,364	967	519	648	1,167
Price Escalation	430	4,712	911	-	-	-
Contingency	709	4,937	1,213	12	0	12
Land Acquisition	-	1,500	153	0	142	142
Taxes	-	25,243	2,575	0	2,302	2,302
Total	8,423	82,910	16,880	9,062	5,957	15,032

Source: Prepared by the evaluator using reference materials at the time of appraisal and data provided by the SEDAPAL.

Foreign Exchange Rates: (at the time of appraisal) US$ 1 = S/. 2.31 = ¥102.00
(at the time of evaluation) US$ 1 = S/. 3.28 = ¥112.4
(Weighted average for 1997 through 2005)

Based on the above figures, although the project period was significantly longer than planned, the project cost was lower than planned, therefore efficiency of the project is fair.

3.3 Effectiveness (Rating: b)

3.3.1 Quantitative Effects

3.3.1.1 Results from Operation and Effects Indicators

At the time of appraisal, the Biochemical Oxygen Demand (BOD) concentration of the sewage flowing into each STP was assumed to be 250 mg/L. However, the actual level stands at 400 - 500 mg/L and exceeds the 600 mg/L level in some months. Such a high level is caused by (i) the decline of the water consumption per capita due to the installation of water meters etc. making the sewage denser, and (ii) the increase of industrial waste water with a high BOD concentration from stores, restaurants, factories and others[11].

[11] The amount of industrial waste water in the Lima Metropolitan Area has sharply increased in recent years because of rapid economic growth. But the regime to control the quality of industrial waste water is not functioning effectively. The industrial waste water standards are stipulated by the relevant laws enacted in 1960 and 2002. Under these laws, sewage connection can be terminated for unscrupulous violators. However, this provision has been practically unenforceable because of the unclear criteria for such termination, the insufficient capacity of the SEDAPAL to monitor the waste water quality, and the insufficient authority of SEDAPAL to implement the termination of connection. A new law is scheduled to take effect in November, 2011 to allow the imposition of a fine when the statutory standard is exceeded with certain indices. In preparation for this new legal set-up, the SEDAPAL is now planning to strengthen its capacity for water quality monitoring. The current reality is that it is still difficult to invoke such a strong measure as the forcible termination of sewage connection for waste water of which the BOD concentration exceeds, for example, 1,000mg/L.

Because the BOD concentration of incoming sewage far exceeds the planned level, each STP is trying to achieve a planned level of BOD concentration (30 mg/L) by means of reducing the amount of sewage inflow and thereby increasing the overall treatment efficiency (i.e. reduction rate of BOD concentration) [12]. The actual BOD concentration of treated sewage fluctuates depending on the original BOD concentration of the sewage inflow, water temperature and other conditions. The BOD removal rate has been relatively good achieving the original target level at the San Juan STP and the San Bartolo STP and the average annual BOD concentration of treated sewage at these STPs is around 40 mg/L in 2008. The nominal BOD removal rate and BOD concentration of treated sewage at the Huascar STP is relatively high as the higher ambient temperature at this STP stimulates the growth of green algae at the final treatment stage. The combined BOD removal rate in 2008 was 89.5% exceeding the target level of 88%.

Table 3 Operation and Effects Indicators at Each STP (Planned and Actual)

			San Juan STP	Huascar STP	San Bartolo STP	Total
BOD Concentration of Sewage Inflow	mg/L	Planned	250	250	250	-
		Actual (2008 Average)	458	483	395	-
BOD Concentration of Treated Sewage	mg/L	Planned	30	30	30	-
		Actual (2008 Average)	40	82	43	-
Sewage Treatment Capacity and Actual Treatment Volume	m^3/sec.	Planned	1.00	0.05	2.20	3.25
		Actual Treatment Capacity	0.80	0.17	1.70	2.67
		Actual Treatment Volume (2008)	0.43	0.07	0.73	1.23
BOD Removal Rate	%	Planned	88.0	88.0	88.0	88.0
		Actual (2008)	91.3	83.0	89.1	89.5
BOD Load Removed	g/sec.	Planned	220	11	484	715
		Actual (2008)	179	30	256	465

Source: Prepared by the evaluator using reference materials at the time of appraisal and data provided by the SEDAPAL.

Notes: BOD Removal Rate

= [(BOD concentration of sewage inflow) – (BOD concentration of treated sewage)]
/ (BOD concentration of sewage inflow)

(Total BOD removal rate is a weighted average by volume treated of BOD removal rate at each STP)

BOD Load Removed

= [(BOD concentration of sewage inflow) – (BOD concentration of treated sewage)]
x (Volume of sewage treated)

= (BOD concentration of sewage inflow) x (Volume of sewage treated)
x (BOD removal rate)

[12] If a sewerage treatment plant receives more sewage inflow, treatment efficiency will be lowered and the BOD concentration of treated sewage will increase. It is not possible for SEDAPAL to receive more sewage, as it is obliged to make efforts for retaining the BOD concentration level close to the standard of 30mg/L.

San Bartolo STP : Sewage Inflow before treatment (left), Treated Sewage (right)

Although the combined sewage treatment capacity of these three STPs is 2.67 m^3/sec, the actual treatment volume is restricted to some 50% of the capacity at 1.23 m^3/sec (2008). This figure represents 38% of the planned sewage treatment volume at the time of appraisal. The estimated total amount of the removed BOD load is calculated as 465 g/sec (2008) based on (i) the difference between the BOD concentration of sewage inflow and treated sewage and (ii) the actual treatment volume at each STP. This figure represents 65% of the planned figure at the time of appraisal[13].

At the time of appraisal, the plan was to reduce the BOD load discharged to the sea via the La Chira Outfall by some 31% through the implementation of the Project. The actual reduction rate is inferred to be approximately 14%. Because of the higher BOD concentration of untreated sewage, the BOD load discharged from the La Chira Outfall almost doubled in five years from 2003 to 2008, recording 180% of the planned level at the time of appraisal.

3.3.1.2 Results of Calculations of Internal Rate of Return (IRR)

The internal rate of return of the Project was not calculated at the time of appraisal. Because of the difficulty of measuring the project benefits in monetary terms, no recalculation of the internal rate of return was conducted.

3.3.2 Qualitative Effects

No specific qualitative effects are observed.

[13] Given one of the purpose of the Project is to alleviate ocean pollution by untreated sewage, the reduction of BOD load (i.e. amount of removed pollutants) is more suitable to judge the effectiveness of the Project than the actual sewage treatment volume. BOD load removed is a function of BOD removal rate, BOD concentration of sewage inflow and the volume of sewage treated. It was because the effect of lower treatment volume was greater than the effect of higher-than-planned BOD concentration of inflow that BOD load removed at San Juan and San Bartolo STP did not reach target level while BOD removal rate achieved the same,

Based on the above analysis, this project has somewhat achieved its objectives, therefore its effectiveness is fair.

3.4 Impacts

3.4.1 Intended Impacts

The anticipated impacts of the Project were (i) alleviation of ocean pollution, (ii) improvement of the quality of irrigation water for agriculture and greening of arid areas with the reuse of treated sewage and (iii) improvement of the environmental hygiene in southern Lima. The actual manifestation of these impacts is described next.

(1) Impact on Alleviation of Ocean Pollution

As shown in Table 4, according to the data of the Ministry of Public Health, the number of coli forms at swimming beaches at the south of the La Chira Outfall that are affected by the quality of discharged water from this outfall slightly reduced in the summer of 2008 (March), immediately after the commencement of operation of the San Bartolo STP. The level of the coli forms, however, returned to the pre-operation level in 2009. No significant positive impacts have been observed there, presumably because of the low treatment level (1.23 m^3/sec in 2008) compared to the overall discharge from the La Chira Outfall (4.69 m^3/sec in 2008).

Beach at Lima South (Agua Dulce)

Water Truck receiving Water at San Juan STP

Table 4 Change in Water Quality at the Beaches near La Chira Outfall

(1 − 4 weeks in March)

	March 2007				March 2008				March 2009			
Agua Dulce Norte	R	G	G	G	G	G	R	R	G	G	G	R
Agua Dulce Sur	G	G	G	G	R	R	R	R	G	G	G	G
Pescadores	B	G	R	R	B	G	B	B	G	R	R	R
Club Regatas 1	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG	B
Club Regatas 2	G	G	G	G	VG	VG	VG	VG	VG	VG	VG	VG
Club Regatas 3	VG	VG	VG	G	VG	VG	VG	VG	VG	R	R	R
La Caplina	R	R	G	R	R	R	B	B	B	B	B	R
La Herradura	B	B	B	B	B	R	R	R	G	B	B	R
La Chira Outfall												
Playa Villa	G	R	B	B	B	VG	B	B	B	B	B	B
La Encantada	R	B	B	B	B	R	B	B	B	B	B	B
Cocoteros	R	B	B	B	R	R	R	R	B	R	R	B
Country Club de Villa	R	B	B	B	R	R	R	B	B	B	B	B
Venecia	R	B	B	B	R	R	R	R	R	G	G	B

Source : Prepared by the evaluator based on data of the Ministry of Health

Notes : Number of coli forms VG (Very Good : less than 250MPN/100mL), G (Good : 250～500MPN/100mL)
R (Regular : 500～1000MPN/100mL), B (Bad : 1000～4000MPN/100mL)
MPN : Most Probable Number

The questionnaire survey conducted with swimmers at local beaches found that some 40% of the respondents acknowledged pollution of the seawater and sandy beach [14]. It must be pointed out that the primary culprit for pollution as identified by the respondents was rubbish discarded by swimmers and only 17% of the respondents cited untreated sewage as the main reason for pollution. The opinions expressed by the respondents suggested that the pollution of coastal water and beaches may have slightly improved compared to five years ago but no causal relationship with the Project was established.

(2) Impact on the Reuse of Treated Sewage

The treated sewage from the three STPs either newly constructed or expanded under the Project is reused for mainly agricultural irrigation, the greening of parks and streets and the greening of STP premises in the Villa el Salvador District and San Juan de Miraflores District at the north of Rio Lurin and the Lurin District at the south of Rio Lurin. As of March, 2010, approximately half of the treated sewage discharged by these three STPs is reused and it is inferred that some 500 - 600 ha of farmland are irrigated with the treated sewage. Prior to the reuse of the treated sewage, the SEDAPAL determines the amount for reuse and other relevant matters with individual users such as irrigation

[14] 40 swimmers at four beaches located to either the north or south of the La Chira Outfall were interviewed.

committees, district offices and other users. The facilities required to receive and convey the treated sewage are set up by individual users[15].

According to the interview results with the users[16], the treated sewage from each STP is used in the following manner.

(i) San Juan STP: Of the treated sewage produced at a rate of some 0.4 m^3/sec, 0.2 - 0.3 m^3/sec is reused for the irrigation of nearby farmland and also for the greening of parks and streets. In the nearby area, raw sewage was formerly used for irrigation but, since 2001, 62 farming households of two irrigation committees commenced the use of treated sewage from the San Juan STP for the irrigation of their farmland. The quality of the treated sewage has improved due to the higher standard of sewage treatment since 2002 when this STP was expanded under the Project.

(ii) Huascar STP: The entire volume of treated sewage (0.07 m^3/sec) is reused for (i) the greening of an adjacent park and recharging of the pond in this park, (ii) a fish culture project operated by the Ministry of Housing, Construction and Sanitation and (iii) the greening of streets and other parks. Farming households near the Huascar STP formerly used raw sewage for irrigation but the opening of this new STP has enabled 36 farmers of one irrigation committee to use treated sewage. However, these farmers have again begun to use raw sewage as the construction of a pond in the park adjacent to the STP has resulted in an insufficient supply of treated sewage for irrigation.

Agricultural Irrigation using Treated Sewage from the San Bartolo STP :Existing agricultural land at Lurin District (left), Drop irrigation of fig at a new farmland (right)

[15] Under the present legal framework, no user charge can be imposed. In Peru, the Ministry of Environment, Ministry of Housing, Construction and Sanitation, Ministry of Health and Ministry of Agriculture are examining a desirable supervisory system and water quality standards regarding the reuse of treated sewage.

[16] A workshop with irrigation committees using the treated sewage was held seven times while six individual farmers were interviewed. Moreover, study visits were made to irrigated farmland and parks.

A district park using the treated sewage from the Huascar STP

(iii) San Bartolo STP: Of the treated sewage produced at a rate of some 0.7 m^3/sec, 0.2 - 0.3 m^3/sec is reused for agricultural irrigation and the greening of streets and parks. In the Lurin District, river water and groundwater were formerly used for irrigation but 68 farmers of three irrigation committees commenced the use of treated sewage for irrigation along with river water and groundwater at the end of 2008[17]. In addition, some 50 ha of orchards owned by an independent farmer in an area where irrigation water was unavailable before the Project has begun to practice drip irrigation using the treated sewage which undergoes a more advanced treatment process before use. The export of fruits produced in these orchards will begin in 2011 and the farmer plans to expand the irrigated area in the coming years. Several real estate companies also plan to use up to 0.35 m^3/sec of treated sewage for the greening of their development sites.

There has been a decrease of the farmland to the north of Rio Lurin where both the San Juan STP and Huascar STP are located due to a shortage of irrigation water and the pressure of urbanisation. At those farmlands using treated sewage from the San Juan STP, the quality of the irrigation water has improved. There are, however, still farmlands where raw sewage is used for irrigation.

In the south of Rio Lurin where the San Bartolo STP is located, both river water and groundwater have been used for irrigation since the 1970's. Local farmers using treated sewage consider the quality of the treated sewage is superior to that of river water which is contaminated by household waste, etc. In this area, the use of treated sewage appears to have slightly increased the area of cultivation as well as the overall production volume. The use of treated sewage has also reduced the production cost as a saving has been made on the cost of pumping up groundwater. The farmer who has started to cultivate fruits by means of drip irrigation using treated sewage from the San Bartolo STP believes that the high level of nutrients (nitrogen, etc.) in the treated sewage is effective for the positive growth of his fruit trees.

[17] Because of the change of the discharge route due to the opposition of local residents, 30 farming households other than these 68 households were unable to use the reused treated sewage.

The use of either raw sewage or treated sewage for the cultivation of crops with short stalks is prohibited by the Ministry of Agriculture on the ground that the irrigation water is in contact with the edible part of such crops. At the farmlands using treated sewage from the old San Juan STP since some 10 years ago, production shifted to ornamental foliage plants, flowers and fruit trees around the time of the expansion of this STP under the Project. In comparison, a shift to new crops has not occurred in areas which began to use treated sewage from the San Bartolo STP since the end of 2008, leaving concern in regard to food hygiene. No concrete consultations or adjustments regarding the use of treated sewage for irrigation have been made between the SEDAPAL and the Ministry of Agriculture.

(3) Impact on Improvement of Environmental Hygiene in Southern Lima

In the Lima Metropolitan Area, the sewerage service coverage increased from 75% in 1995 to 90.4% in 2008. The Project did not have any components directly contributing to the increase of this coverage. However, it is fair to say that the Project indirectly contributed to the increase of the sewerage service coverage as the treatment of sewage produced by some 320,000 people and transported to the San Bartolo STP allowed the SEDAPAL to proceed with its work of extending the sewerage service without additional investment to sewage collectors linked to the La Chira Outfall.

3.4.2 Other Impacts

(1) Impacts on the Natural Environment

Using the consulting service under the Project, the SEDAPAL conducted a supplementary EIA in 2000 and confirmed that the treated sewage discharged to a river, etc. was not causing any serious problems.

At the San Bartolo STP, environmental monitoring of not only the quality of the treated sewage but also odour, vibration and noise is conducted. While the BOD concentration level sometimes exceeds the set standard of 30 mg/L for discharge from SPT, it is confirmed that the same of the water at Lurin river does not exceeds the standard for river water due to dilution. As for odour, vibration and noise no complaints have been made regarding the operation of this STP as no private homes are located in the vicinity. In the case of the other two STPs, only monitoring of the water quality is conducted. No special complaints have been made, presumably because of conscious efforts to alleviate any negative impacts on nearby private homes through the installation of a deodorisation unit and greening of the premises.

(2) Land Acquisition and Resettlement

No resettlement of residents was necessary under the Project. At the San Bartolo STP, the land expropriation procedure has not yet been completed and the SEDAPAL is currently engaged in this procedure.

3.5 Sustainability (Rating: b)

3.5.1 Structural Aspects of Operation and Maintenance

SEDAPAL has been undertaking a reform over a broad area[18]. While the sewerage section of the SEDAPAL is responsible for the operation and maintenance of the facilities newly constructed or expanded under the Project, some of the operation and maintenance work for the STPs and the transmission line is entrusted to private companies. While one full-time SEDAPAL engineer is stationed at the San Bartolo STP, most of the operation and maintenance work at this STP is entrusted to a private company. In fact, one private company is in charge of the operation and maintenance of three STPs and transmission line. The SEDAPAL evaluates the performance of the current contractor as "fair". There is another contract featuring the cleaning and greening of the three STP premises. In view of the above, it is judge that the organizational setup of SEDAPAL is well established and no problems are observed.

In order to swiftly achieve the improvement and effective operation of STPs in an appropriate manner, the SEDAPAL is now examining the possibility of entrusting the operation of 16 STPs, including those involved in the Project but excluding three STPs; La Chira STP, the STP currently being planned, etc., to a private company under a blanket contract and preparations are in progress to select a contractor some time in 2011[19].

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[18] The SEDAPAL has been conducting a series of reforms, including improvement of the human resource policies, introduction of an operation and financial management system, formulation of a short-term plan and long-term strategy and concession of some of the maintenance work and meter reading work. The SEDAPAL also has an annual management agreement with the Ministry of Housing, Construction and Sanitation with a view to achieving the agreed annual performance targets regarding quality, operation and finance.

[19] The terms of the contract under consideration will leave facility ownership to the SEDAPAL. The contractor will prepare a plan to utilise the treatment capacity of each STP to the full, making the necessary additional investment and operate the contracted facilities for 30 years. While this contractor will receive a fee corresponding to the amount of treated sewage from the SEDAPAL, it is liable to the payment of a penalty if the treatment standard (degree of water quality improvement after treatment) fails to meet the set criteria.

3.5.2 Technical Aspects of Operation and Maintenance

Although the SEDAPAL lacked experience of operating a large-scale STP before the Project, in view of the existence of a well-established training regime, acquisition of ISO certifications and history of awards received, it is inferred to have basic technical capacity to operate STPs[20].

The transmission line constructed under the Project extends for a total of 35 km. As they have several inverted siphon sections, they are rare facilities in the world. It must be said that the operation technique of these facilities has not yet been fully established even since the explosion incidents. According to the SEDAPAL, the technical manual on the operation of the San Bartolo transmission line which was provided by the consultant for the Project after the explosion incidents was insufficient as it lacks detailed technical information. The SEDAPAL is examining viable measures to reduce the risk of a similar incident. These measures include more advanced pre-treatment and a more effective method to inject oxygen to contain the generation of combustible gas. However, no definitive measures have so far been found, partly because of the difficulty of accurately assessing the degree of risk and possible causes based on amount of accumulated sludge and amount of gas generated.

3.5.3 Financial Aspects of Operation and Maintenance

Since 2004, the SEDAPAL has been steadily growing in terms of its sales and operating profit as a successful outcome of a higher water charge, reduction of non-revenue water and improved operational efficiency[21] Although the expenditure for facility maintenance and repair has also increased, it has been properly funded by the increased sales. It is, therefore, judged that the SEDAPAL should not encounter any serious problems regarding the financial sustainability of its operation.

The STPs constructed or expanded under the Project incur a large electricity bill as electricity is used for the aeration of sewage. The past expenditure for the operation and maintenance of the project-related facilities is shown in Table 6.

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[20] Almost all of the 2,200 employees of the SEDAPAL undergo some kind of training every year. The training hours per person are as many as 66 hours for administrative staff and 32 hours on average. It has also received a number of awards, including Peruvian Company of the Year 1999 and Best Water and Sewerage Management 1998.

[21] With the approval of the regulatory body (SUNASS), a system is in place to raise the water charge in accordance with SEDAPAL's water production cost and financial performance. SEDAPAL's operational efficiency as reflected in its working ratio (annual cost/annual turnover) shows a trend of annual improvement, and such indicators as the Current Ratio (current assets/current liabilities) and the Debt Ratio (liabilities/capital) are within an acceptable range.

Table 5 Financial Performance of the SEDAPAL

(Unit: S/. million)

	2004	2005	2006	2007	2008
Sales	624.0	660.8	748.1	827.4	959.1
Operating Profit	53.7	56.0	110.0	117.7	204.5
Net Profit	96.9	9.0	93.2	125.8	4.1
Maintenance/Repair Expenditure		52.6	54.0	66.5	82.0

Source: SEDAPAL

Table 6 Operation and Maintenance Expenditure for Project-Related Facilities (3 STPs and Transmission Line)(Unit: S/. '000)

	2001	2002	2003	2004	2005	2006	2007	2008
Operation	1,212	1,739	2,778	3,829	3,976	4,181	4,358	5,230
Maintenance	674	1,929	1,978	2,544	2,582	3,232	3,680	2,484

Source: SEDAPAL

3.5.4 Current Status of Operation and Maintenance

Because of the explosion incidents caused by gas generated from accumulated sludge in the transmission line, the contractor visually inspects nine sludge removal ports and gas exhaust ports on a daily basis to detect any signs of a problem. The current flow velocity of the sewage is far below the design rate due to the restriction on the receivable amount of raw sewage in view of the substantially higher BOD concentration level of the raw sewage than originally planned. This slow flow velocity creates an environment in which the sludge is liable to deposit itself. Moreover, the limited number of sludge removal ports means lengthy operation to remove the sludge accumulated at the bottom of the siphon. At some sections, it is impossible to remove the entire accumulated sludge. It is necessary to suspend the operation of the transmission line for approximately 10 days a year for sludge removal purposes.

At the San Bartolo STP, the SEDAPAL has set up observation wells (monitoring holes) to continually observe the seepage of sewage into the ground as this will eventually cause caving-in of the ground. In 2009, such seepage was detected at the same section where the collapse incident occurred in the past and the operation of this section was suspended. Even though no actual collapse occurred, as cracks were observed with some concrete panels, the SEDAPAL conducted a soil engineering study to examine how to improve the situation. Because of the fear of the recurrence of collapse, the SEDAPAL plans to continue the suspension of the operation of this section for the foreseeable future. This suspension has not significantly affected the overall sewage treatment volume of the San Bartolo STP. All other areas of the sewage treatment system centring on the San Bartolo STP have been

operating without any problems. In the case of the San Juan STP and Huascar STP, no special operational problems have been encountered so far.

Gas exhaust port at the transmission line

Oxygen tank for the transmission line

Based on the above evaluation, some problems have been observed in terms of technical aspects of the operation and maintenance; therefore sustainability of the project is fair.

4. Conclusion, Recommendations and Lessons Learned

4.1 Conclusion

At the time of its appraisal, the Project was considered to be urgent in the Lima Metropolitan Area where most sewage was discharged virtually untreated. Even today, there is a strong need to not only maintain but also reinforce the sewage treatment capacity in this area. As it also matched Japan's ODA policies, the relevance of the Project is high. While the overall project cost ended almost as planned, the commencement of operation at the San Bartolo STP was delayed by six years and 10 months from the originally planned date due to the delayed execution of the work caused by opposition by local residents and also due to a series of accidents during the test operation. Accordingly, the efficiency of the Project is rated as medium. Because of the much higher BOD concentration of the raw sewage than originally planned, the three project-related STPs have reduced the amount of raw sewage for treatment to less than half of the originally planned amount to maintain an acceptable quality level of the treated sewage. As the amount of BOD removed by the three STPs is 65% of the planned amount, the Project is found to have produced some positive effects and its effectiveness is judged to be medium. The amount of pollutants discharged to the sea from the La Chira Outfall (BOD load) is inferred to have decreased by 14% as a result of the Project but no clear

impacts on improving the water quality have been observed at nearby swimming beaches. Almost half of the treated sewage is now used, contributing to the promotion of irrigated farming and greening of the area. Some local farmlands are still marred by a problem from the viewpoint of food hygiene because of the use of raw sewage for irrigation. The SEDAPAL which assumes overall responsibility for operation and maintenance is believed to possess an appropriate operation and maintenance system, technical expertise and financial capability. The sustainability of the Project is judged to be medium because of the suspension of a part of the sections in the San Bartolo STP and absence of well-established operation and maintenance techniques for the transmission line. In conclusion, the Project is judged to be generally high.

4.2 Recommendations

4.2.1 Recommendations for the Government of Peru and Project Implementing Body

- It is necessary for the SEDAPAL to promptly conduct a technical review for the safe and efficient operation of the transmission line and San Bartolo STP with a view to further improving the existing facilities. While it is not a bad idea for the SEDAPAL to introduce the broad experience and technical expertise of the private sector through a contract with a private company, preparatory work for which is currently in progress, the SEDAPAL should also improve its facilities in stages, starting with the improvement of the pre-treatment facilities (introduction of finer screen mesh to remove more garbage from the raw sewage) and other types of work which can be quickly started.

- The SEDAPAL need to strengthen its capacity to monitor the quality industrial waste water to ensure the effectiveness of the regulatory regime for industrial waste water for which new standards have been introduced.

- To facilitate the safe and efficient reuse of treated sewage, the Government of Peru should promote consultations between stakeholders (Ministry of Housing, Construction and Sanitation, Ministry of Environment, Ministry of Agriculture and others) with a view to determining the responsibility of each ministry, management framework, standards for water quality and method of use (watering or irrigation method) by purpose of use of treated sewage and cost sharing system.

- The SEDAPAL and Ministry of Agriculture should cooperate and coordinate with each other to achieve the safe and efficient reuse of treated sewage, and should also discuss with irrigation committees in the Lurin District which use treated sewage from the San Bartolo STP on the supply and distribution of treated sewage, shift to the crops suitable for treated sewage.

4.2.2 Recommendations to the JICA : None

4.3 Lessons Learned

- For any STP project, it is imperative to eliminate any anxiety and/or misunderstandings on the part of residents who will be affected by the project so that any unnecessary delay of the project implementation can be prevented. For this reason, it is extremely important to conduct public relations and educational activities aimed at local residents by the time of commencing the construction work at the latest. These activities are designed to convey accurate information on the purposes, benefits and environmental impacts of the project to local residents. In the case of the project in question, the opposition of local residents to the Project originated from the fact that wrong information on the project was spread among the residents. Once the matter developed into a political issue, the completion of the San Bartolo STP was substantially delayed. In turn, this delay caused modification of the original plan for the Huascar STP. This delay may also have been a remote cause of the caving-in incident at the San Bartolo STP.

- For projection of the future sewage quality for the planning of a STP, it is important to increase accuracy by means of thoroughly examining the quality of the sewage by sources, an increase of the quantities of the pollutants as a result of economic growth, changes in amount of water consumption and other relevant matters. In the case of the Project, such projection was conducted while referring to the World Bank and Japanese standards for general sewage. However, this projection exercise did not examine the likely sewage discharge volume by different sources (such as ordinary households and industrial premises), possible changes of the quantities of the pollutants to be discharged as a result of economic growth and possibility of reducing the overall amount of sewage through water saving by end users. Consequently, the projected future sewage quality was widely off the mark, necessitating restriction of the inflow volume of raw sewage to approximately half of that originally planned. In turn, this has made the operation of the transmission line difficult.

- The Project was based on an unprecedented concept that the raw sewage would be transported for 35 km by a transmission line so that sewage produced in the city centre could be treated and reused for irrigation and greening of the San Bartolo Plain. Several new technologies of which the application had been rare throughout the world were employed, including oxygen injection to restrict the generation of combustible gas and sludge removal from long distance transmission line using inverted siphons. The overall plan for the Project was found to be quite vulnerable to unexpected situations, such as changes of the BOD concentration of the sewage and the delayed completion of some of the facilities. These experiences suggest the importance of formulating a project based on not only thorough technical analysis but also vital assumptions regarding the potential risks of changes of the demand, delayed work and others when the planned contents (technologies) of a project do not have many precedents.

Comparison Between the Original Plan and Actual Results

Item	Original	Actual
1. Outputs	(a) Construction of Sewers (49.95km) San Bartolo Transmission Line : 31.55km Discharge Pipe for San Bartolo STP : 5.5km Discharge Pipe for San Juan STP : 5.4km Discharge Pipe for Huascar STP : 5.0km (b) Expansion of Sewerage Treatment Plants Expansion of San Juan STP : 0.25→1.0 m^3/sec. Collector for San Juan STP : 0.2km (c) Construction of Sewerage Treatment Plant San Bartolo STP : 2.20 m^3/sec. Huascar STP : 0.05 m^3/sec. (d) Consulting Services : Detailed Design, Construction Supervision	(a) Construction of Sewers (53.1km) San Bartolo Transmission Line : 32.5km Discharge Pipe for San Bartolo STP : 9.5km Discharge Pipe for San Juan STP : 5.6km Discharge Pipe for Huascar STP : 5.5km (b) Expansion of Sewerage Treatment Plants Expansion of San Juan STP : 0.25→0.8 m^3/sec. Collector for San Juan STP : 0.2km (c) Construction of Sewerage Treatment Plant San Bartolo STP : 1.7 m^3/sec. Huascar STP : 0.17 m^3/sec. (d) Consulting Services: (additional scope) supplemental EIA, manual and training for transmission line
2. Project Period	July 1996 – February 2001 (56 months)	September 1996 – December 2007 (136 month)
3. Project Cost		
Foreign Currency	¥8,423 million	¥9,062 million
Local Currency	¥8,457 million (S/.192 million)	¥5,957 million (S/.174 million)
Total	¥16,880 million	¥15,032 million
Japanese ODA Loan Portion	¥12,660 million	¥12,076 million
Exchange Rate	US$1=S/.2.31=¥102円 (September 1996)	US$1=S/.3.28=¥112.4 (Weighted average during 1997 – 2005)