Ex-post Monitoring for Completed ODA Loan Projects
Guatemala "Groundwater Development Project"

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Field survey: May 2008

1. Project Profile

Location of the project

Deep well C-10

1.1 Purpose

In the metropolitan area of Guatemala where the shortage of water looms large, a new groundwater source will be developed based upon the Emergency Plan - Phase I of the Master Plan on Water Supply, thereby strengthening the capacity to supply water of the Empresa Municipal de Agua Guatemala City Water Corporation (EMPAGUA) and contributing to the development of infrastructure for social and economic activities in the target region.

1.2 Outline of the project (Summary of loan agreement, etc.)

Loan Amount Loan Disbursed Amount	¥4,711,000,000 ¥4,465,000,000
Loan Agreement Date of (Disbursement)Completion	December 1990 June 1992
Ex-post evaluation	FY 2002[1]
Executing agency	Empresa Municipal de Agua Guatemala City Water Corporation (EMPAGUA)
Main Contractors	Konoike Construction Company, Ltd.
Consultant Services	Chuo Kaihatsu Corporation

[1] Ex-post evaluation report on the ODA loan projects (FY2003):
http://www.jbic.go.jp/japanese/oec/post/2003/pdf/project37_full.pdf

In order to meet an ever-increasing demand for water in the Guatemalan municipal area, in 1982 EMPAGUA formulated a phased plan consisting of two short-term programs and three long-term programs by 2010 in the Master Plan on Water Supply. This project comes under the first short-term plan and is called the "Emergency Plan – Phase I." Its initial purpose was to achieve the production capacity of 1.0m^3 per second by using groundwater that does not need advanced water treatment and connecting it to the existing water distribution networks, thereby alleviating the water shortage by 1992.

For this project, JICA carried out a feasibility study in 1986. The construction work was completed in December 2000 with Japanese ODA loans. Under this project, deep wells were constructed in the total number of 34 in the eastern and northern areas of Guatemala City. At the same time, nineteen of the existing deep wells were rehabilitated. In order to conserve the groundwater resource, eight monitoring wells were built to monitor the level of groundwater.

1.3 Background

According to the ex-post evaluation report, the project achieved an adequate level of effectiveness. At the same time, it pointed out that four out of 34 wells had not been in operation and that the improvement of water supply service was limited to only some parts of Guatemala City because the project had not included the sector of water distribution/water supply. Furthermore, there was concern over sustainability in that there were no regulations to control the pumping of groundwater, which would eventually lead to the depletion of groundwater. Also, there were some doubts about the capacity of the implementing agency to ensure a budget for the operation and maintenance of the wells.

As a result, this ex-post monitoring was carried out with the primary purposes of validating the effectiveness of this project in specifics and confirming the present state of groundwater conservation and the operation and maintenance of the wells.

2. Results of monitoring

2.1 Effectiveness (effect)

Summary of the effect

The deep wells constructed under this project contribute to the maintenance and improvement of water supply service in the benefiting areas despite the fact that there are frequent occurrences of troubles with motors and pumps caused by voltage fluctuations and the fact that water production is significantly lower than the planned capacity.

2.1.1 Operation and production of wells

The new 34 wells built under the project achieved the water production capacity (or equipment capacity) of 1.4m^3 per second vis-à-vis 1.0m^3 per second in the plan at the time of appraisal.[2] In the ex-post evaluation, factual data concerning water production were not analyzed. As can be seen in Table 1, the past water production is very much below the planned volume.

Table 1: Water production and the number in operation of new wells and rehabilitated wells

		Plan	2000	2001	2002	2003	2004	2005	2006	2007
New wells	Annual water production (in million m^3)	31.54	0.20	17.70	20.98	20.79	19.43	18.29	17.53	17.37
	Mean production capacity (m^3/second)	1.00	0.01	0.56	0.67	0.66	0.62	0.58	0.56	0.55
	The number of wells in operation	34	5	20	23	28	28	30	29	30
Rehabilitated wells	Annual water production (in million m^3)	Not known	Not known	21.91	21.50	20.64	20.04	19.23	18.36	18.09
	Mean production capacity (m^3/second)	Not known	Not known	0.69	0.68	0.65	0.64	0.61	0.58	0.57

Source: EMPAGUA

Note: The plan of new wells is a plan at the time of appraisal. The number of wells in operation is the number of the wells of which production is not zero. The water production and planned productivity of rehabilitated wells are not known, but it is assumed from the feasibility study report that it is approximately 25 million m^3 per year (or 0.8 m^3/second).

[2] At the time of appraisal, the production capacity was set based upon the result of groundwater exploration. However, the result of the pumping test carried out after a well had been built, the volume of water that could be pumped up continually was projected, thereby deciding the equipment capacity of each well. The actual water production depends upon not only equipment capacity but also operating ratio and productivity.

(1) New wells

There are many new wells that are delayed in the start of operation for various reasons: residents' opposition; postponement in the distribution of electricity; execution of other construction works and inappropriate water quality. As of May 2008, three wells in one district are not yet in operation because residents have not approved their operation.[3]

It was planned that wells would be in operation around the clock, but the operating ratio in recent years remains about 70%. In the year 2007, absolutely no production was recorded for 14.2% of the year on the average (that is, for 52 days out of 365 days). There are also many wells of which operation is suspended for a long period of time. For instance, fifteen wells out of 30 have not been operated for more than 30 days on end. In the last three years, the number of non-produced days has increased from 34 days to 52 days on the average. Thus, the operating ratio has been on the decrease. EMPAGUA explains that the main reason for the low operating ratio is due to frequent occurrences of troubles with the motor caused by voltage fluctuations. (Refer to the section of sustainability.)

This field study found that the productivity of the wells had dropped to approximately two-thirds of the equipment capacity. The total maximum daily production capacity (i.e. the maximum production when water is pumped continuously) was merely 64% of the plan. It is believed that the lowering level of groundwater as well as deterioration in the wells and pumps is responsible for the less capacity of some wells.[4]

The water production of the new wells is much lower than the plan due to the facts that there are some wells which are not in operation and that the operating ratio and productivity of the wells in operation are lower. The annual water production of the new wells peaked to 20,980,000m^3 (0.67m^3/second) in 2002 and dropped to 17,370,000m^3 (0.55 m^3/second) in fiscal 2007. This is only 55% of the plan at the time of appraisal and 39% of the equipment capacity (1.4 m^3/second).

[3] The construction work of the wells was started after approval of residents. However, some residents began to insist, "If groundwater of this area is distributed to people in other areas, it will be depleted in the future, thereby depriving the local residents of their water source." In particular, older people support this opinion. Hence, even after the completion of the wells, EMPAGUA is unable to start their operation due to strong opposition from the residents. Legally there are no problems for operating them, but EMPAGUA has been negotiating with the residents to have their approval through mediation of the court.

[4] Refer to the section of sustainability as for the lowered levels of groundwater. Given that the capacity of the pump and the motor is constant, water production (m^3/second) decreases when the level of groundwater gets lower. When the production is significantly reduced due to lowered groundwater levels, what is done first is to reduce operating hours per day of the well (24 hours per day in a normal case). When production has decreased to a level that the well does not produce water to meet its operation costs, the well is closed. Or, the well is dug deeper to secure its production. So far, several wells of the new 34 wells had been dug deeper.

(2) Rehabilitated wells

The annual water production of the rehabilitated wells steeply declined in 2007 to 18,090,000m^3 (0.57m^3/second) from 21,910,000m^3 (0.69m^3/second) in 2001. The water production of multiple wells has decreased in seven years by 20~30% presumably because of the lowered levels of groundwater.[5] It is considered that the production of the rehabilitated wells is slightly less than the planned production.

2.1.2 Improvements in water supply service

(1) Amount of water supplied

The ex-post evaluation report states that the population served, the percentage of the population served and water supply equipment capacity in Guatemala City have increased after the project (since 1997) (per table 2). It is also reported that the duration of water supply has been prolonged to a great degree in the target areas of this project.

Table 2: Change in the population and population served in Guatemala Department

	1990	1997	2001
Total population (1,000 persons)	NA	1,741	1,960
Population served (1,000 persons)	NA	1,335	1,586
Percentage of the population served	54%	77%	81%
Water supply equipment capacity (m/second)	NA	3.4	4.5

Source: Ex-post evaluation report

Guatemala Department including Guatemala metropolitan area has a population of 2,980,000 (estimated by the Statistics Bureau). It is conjectured that demand for water is approximately 258,000,000m^3. In 2002 about 80% of the population in the metropolitan area received water supply service by individual connection. As of 2007, EMPAGUA serves approximately 200,000 households in metropolitan area, that is, about 40% of the population of Guatemala Department and some 50% of water demand.[6] The amount of water supplied per year by EMPAGUA in 2007 was 127,500,000m^3 (4.04m^3/second), 13.6% of which comes from the new

[5] EMPAGUA claims that two wells of the rehabilitated 19 wells are unable to produce water because of lowered levels of groundwater.

[6] The water supply service in Guatemala City is also delivered by private water companies, state-owned housing bank and private developers besides EMPAGUA. The data cited in the ex-post evaluation report are obviously derived from PCR, and it is assumed that the figures of the population served and the percentage of population served include those served by other water suppliers besides EMPAGUA. It was not possible to obtain new reliable statistics concerning the population served for this study.

wells built under this project and 14.2% from the rehabilitation wells.

Table 3: Water production and the number of households connected of EMPAGUA and this project

			1997	2001	2007
Water production	All EMPAGUA	In million m^3	106.6	121.0	127.5
	New wells under this project	In million m^3	NA	17.7	17.4
	Rehabilitated wells under this project	In million m^3	NA	21.9	18.1
Number of households connected (All EMPAGUA)		In thousand	150	182	198
Annual production per household		m^3	712	666	644

Source: EMPAGUA

In the past decade the number of the households connected to water supply service increased by 32.2%, whereas water production increased only by 19.6% and the amount of water supplied per household decreased by 9.5%. After this project, there is neither a substantial improvement in the water distribution networks nor have new sources of water supply been developed. As a whole, there are no large improvements in the water supply service by EMPAGUA. On the contrary, the quality of its service has declined in some districts where the population has greatly grown (increased in the number of households connected).[7] It is a matter of increasing urgency to develop new sources of water supply in proportion with the expanding demand for water in the Guatemala metropolitan area,. However, the financial and legal issues to solve this problem still

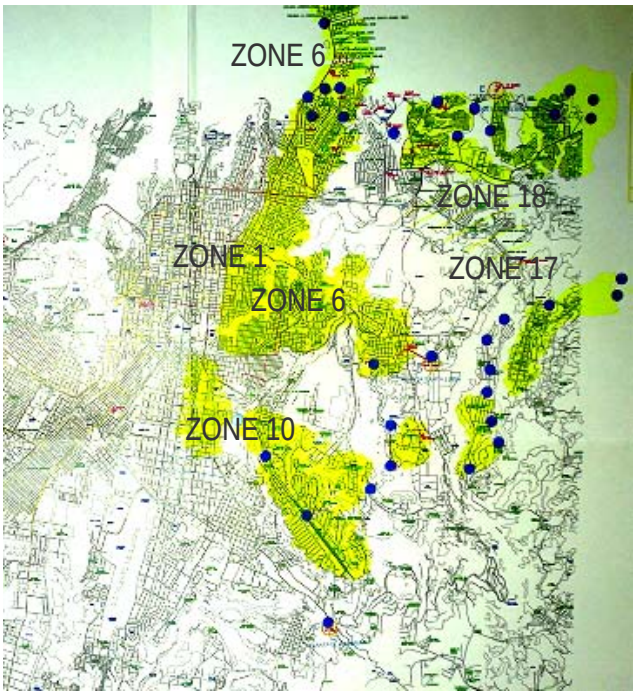


Figure 1: New wells and benefiting areas

[7] Data to directly compare the level of service before the project and at the time of ex-post evaluation were not available. However, according to the questionnaire survey carried out in the areas benefiting from new wells, 20% of households (zones 6, 16 and 18) responded that water pressure (water volume) and the duration of water supply have decreased in the past five years.

remain unsolved.[8]

The water produced by the wells constructed under this project is supplied alone or is used to make up the deficiency of water supplied by the existing water supply systems that use river water or well water. It is difficult to identify clearly the range of water supply from the new wells, but in general it covers the northeastern area of the city. In some districts the population connected has greatly increased in number in the past decade. This fact demonstrates that this project has indeed played an important role in maintaining the level of the service through supplying water from the wells built under the project.

About 60% of water from the new wells is supplied to the northeastern districts of the city (zones 6, 17 and 18), thereby presumably making an important contribution to meeting an expanding demand for water generated by increases in the populations of these districts.

In particular, zones 17 and 18 did not have an adequate water supply. That is, the annual amount of water supply per connection was only 40% of the mean amount of the whole city. On the other hand, the number of connections in these districts has increased by 54% in the past decade. This project nearly doubled the amount of water supplied, thereby increasing the amount of water supply per connection.

Thirty percent of the water from the new wells is connected to the water supply system at Santa Louisa that uses river water as its water source and has increased the amount of its water supply by 70%. Water is supplied chiefly to the central and eastern districts of the city (zones 1, 5 and 16). In these districts the number of connections has only slightly increased. Hence, it is considered that this project has contributed to improvements in the level of service. At present, households enjoy the water supply service for 20 hours per day on the average in the districts served by the water supply system at Santa Louisa.

On the other hand, some of the new wells were constructed in the southeast area of the city (zone 10 and 15), and they supply water to make up the deficiency of the existing wells.

[8] EMPAGUA dug three wells in 2006 and 2007, but has developed no other water sources in a great scale. It has an idea, but it needs a gigantic amount of money because water must be drawn from the water source in a remote area. Thus, the idea crosses the border of the administrative district of Guatemala City, and it will not be possible to realize the idea unless it is supported by national budgets or donors' financial aid. EMPAGUA planned a new project with private loans, but it was cancelled because it was found that EMPAGUA would not be capable of repaying the debts in its financial situation. EMPAGUA is thinking that it will address the issue of improving its financial situation and procure private funds after it has succeeded in its efforts.

2.1.3 Recognition and water use of beneficiaries

According to the survey at the time of ex-post evaluation, 35% of the residents living in the areas that received water through this project (benefiting areas) replied that the volume of water supply, duration of water supply and water pressure have improved. It is reported that the mean consumption of water per month has increased from 19m^3/month to 34 m^3/month. Besides, 36% of the residents reported that the duration of water supply had been prolonged.

Table 4: Findings of the survey on beneficiaries at the time of ex-post evaluation (200 samples)

Change after the project	Benefiting area	Other areas
Water supply service has improved.	35%	10%
Water supply service has deteriorated.	26%	26%
No change or don't know.	39%	64%

This survey[9] has revealed that nearly 30% of the residents are highly satisfied with the water supply service in general and about 50% of the residents are more or less satisfied. On the other hand, 20% of the residents are not satisfied with the water quality, the duration of water supply, the water rates and water pressure. There were 39% of the residents who felt that the water supply service had improved compared to three years before and 16% who replied that it had got worse.[10]

In Guatemala City water is supplied from different water sources by water distribution networks that are operated more or less separately. Hence, the water supply service varies depending upon the district. This survey confirmed that there were disparities among districts in terms of the duration of water supply, water pressure and water quality.

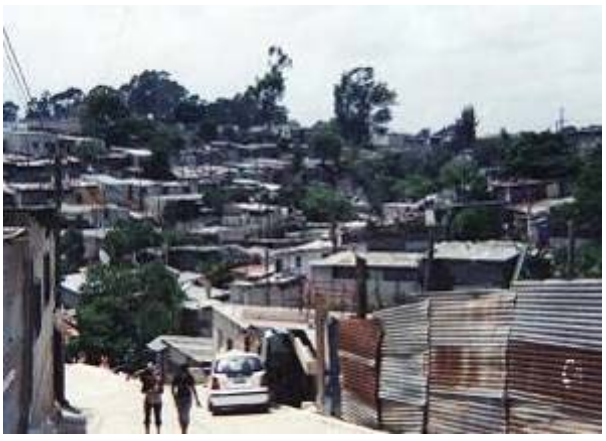
➢The central district of the city (zone 5) has been supplied water from the Santa Louisa Water Supply System that uses river water as its water source for more than 30 years. The new wells constructed under this project were connected to this system. The entire district receives 24-hour water supply. Water pressure (or water volume) has been improved during the past three years, but residents rate the quality of water low. That is, 80% of residents are dissatisfied with the quality because it is not clear or it has an odor sometimes. This is caused by the deteriorating quality of raw water used by the Santa Louisa Water Supply System.

[9] A questionnaire survey was carried out on 140 households in the benefiting areas from the wells constructed under this project.

[10] The project was completed 7 ~ 8 years ago, and the memories of residents are not very clear. Hence, we did not make comparisons with the time before the project.

➢The northern district of the city (zone 6) had a water supply system that used multiple wells as water source. The new wells constructed under this project were connected to those wells. The half of residents receives water supply service for 24 hours. The rest receives about once in the morning or in the evening. The half of its residents is very satisfied with the present water supply service. However, many people in areas adjoining the area that has been recently built for low-income people have a sense of dissatisfaction: they are unable to receive water supply service every day because the amount for water supply becomes scarce, and moreover water is unclear once in a while. Nevertheless, in zone 6 many people feel that the water supply service has improved compared to three years earlier.

➢The northeastern district of the city (zone 18) adjoins a new residential area of the Housing Corporation and an area that low-income people have illegally occupied since the mid-1990s. In this district there are two water supply systems running in parallel: one using surface water and another using the existing wells. This project was connected to the existing well system. There are concurrently three areas: one where people receive the water supply service for 24 hours; one where people receive it once a day; and one where people receives it once or less in two days. At the same time there are an area where water quality is good and an area where it is inferior. As a whole, 90% of the residents are satisfied with the present water supply service. Admittedly, it is the area for low-income people where the duration of water supply is the shortest. However, almost all people there are satisfied with the fact that they can have a legal water supply service.[11] On the other hand, people in the area where water is supplied for 24 hours, people in no small numbers express a sense of dissatisfaction as to the quality of water and the water rates. Furthermore, the deterioration of



Low-income residential area in Zone 18

[11] In the northeastern district of the city (zone 18) there is an extensive area illegally occupied by people from rural areas. That is, people made connections to a water distribution network of EMPAGUA without license and stolen water. EMPAGUA has been expanding its service area successively by constructing a legitimate water supply system through residents' participation to legalize these connections and collect the water rates. Since there is a limit to the duration of water supply due to limited amount for water supply. However, the majority of people in the area express a sense of satisfaction with the current water supply service.

water quality is caused by the instability of its raw water quality at the existing water supply system whose source is river.

2.2 Impacts

(1) Impact on the resident's life

The ex-post evaluation report pointed out that a shortened pumping time might have been caused by the fact that individual hydrants had been installed instead of the joint water supply place in an area inhabited by many poor people and illegal occupants. In this field study we could not confirm this assumption quantitatively because residents' memories were not very clear.

As for improvements in environmental hygiene, it was revealed that the incidence of diarrhea was 22,563 in number in Guatemala City in 2005, which was lower by two-thirds than 2001. However, we could not confirm a cause-effect relationship with this project.

(2) Impact upon industrial and commercial activities

As reported by ex-post evaluation, in many cases industrial and commercial facilities have their own water sources in Guatemala City. That is, EMPAGUA's water is not usually used at such facilities. Therefore, it is assumed that an impact of this project is small.

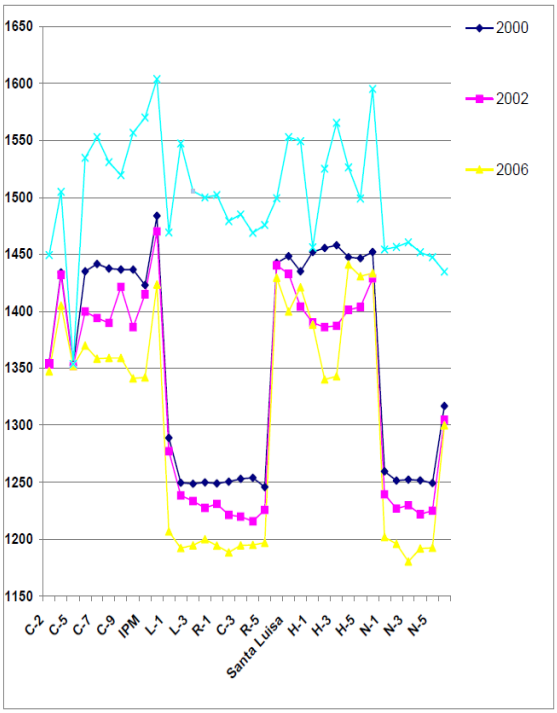


Figure 2: Change in the groundwater level of each well (Source: EMPAGUA)

(3) Impact on environment

The ex-post evaluation report pointed out an extensive decrease in the level of groundwater. In this field survey, it was confirmed that the groundwater level had been on the decrease continually since then. Thus, it is assumed that this project has affected water production. Currently, the groundwater level has declined beyond the extent to which a groundwater monitoring well is able to observe. Therefore, at the time of replacing a pump, the

groundwater level is monitored by using a production well.

However, the declining groundwater level is not caused only by this project. In Guatemala City anyone is allowed to build a deep well and pump up groundwater without license. As a result, many industrial, commercial and residential facilities pump up groundwater, thereby causing the lowering of groundwater level.[12]

2.3 Sustainability

Summary of sustainability:

EMPAGUA makes endeavors for the operation and maintenance of deep wells. However, there is slight concern over repair expenses. Motors frequently break down because of voltage fluctuations. All facilities are well maintained. Issues are the lowered groundwater levels and frequent breakdowns of motor/pump.

2.3.1 Executing agency

2.3.1.1. Structural organizations of operation and maintenance

The organization to operate and maintain facilities of this project remains the same since the time of ex-post evaluation. EMPAGUA was founded in 1972 with the objectives of supplying drinking water and sewerage and hygiene services under agreement with Guatemala City. At present, it is independent from the control of Guatemala City as an independent institution in terms of management, financial affairs and staff composition.

34 new wells are called “Emergencia-I” for which there is an office within the headquarters of EMPAGUA. A storage tank and the pump facility established side by side are under the direct control of EMPAGUA. Other pump facilities are entrusted with two external enterprises for their management. Pumps are basically operated for 24 hours under three-shift system for the EMPAGUA staff and two-shift system for the staff of external companies. The Project Office is responsible for daily commands, monitoring and repairs. The Office prepares a manual and provides training twice a year to the operators of the entrusted companies. Preventive inspection and maintenance are carried out through outsourcing. At present the facilities for which preventive inspection and maintenance are conducted are only Emergencia-I. EMPAGUA intends to introduce the preventive maintenance for other water supply systems including wells based upon this model.

Rehabilitated wells are called “Pozos” (which is a cluster of wells), for which

[12] The legal system is underdeveloped for the conservation of groundwater. In Guatemala Lay General de Agunas (that is, general water law) was discussed for several times since the 1990s. However, it has not been enacted due to opposition from some minority ethnic groups.

there is a separate office from the office for new wells. The EMPAGUA staff is responsible for operating each well, whereas the project office assumes responsibilities for commanding, monitoring and repairs.

2.3.1.2 Technical capacity of operation and maintenance

Like the time of ex-post evaluation, there are three consultants hired, *i.e.* hydrology expert, electrical engineer and water quality expert, for the operation and maintenance of this project. EMPAGUA supervises them. They operate and maintain the facilities properly and make technical improvements to address the issue of voltage fluctuations. Thus, it is believed that they have adequate technical capacity.

2.3.1.3 Financial status in operation and maintenance

At the time of ex-post evaluation, EMPAGUA was financially instable with very small profits. There is doubt as to whether a budget will be ensured for operation and maintenance expenses for the facilities constructed and rehabilitated under this project.

EMPAGUA's revenues come from the water rates and the sewerage rates. It does not receive any subsidies from Guatemala City. That is, it is independently administered in its finance. Its revenue and expenditure are nearly balanced.[13] In the year 2003 it dipped in the red. In the year 2004, however, the water rates were changed, and a black figure was restored. In the future, it is planned to propose a step-by-step price rise so as to be able to collect production costs even in the lowest price zone. At the same time, EMPAGUA has been making efforts to improve its financial state by reducing non-revenue water under a powerful initiative by the mayor of Guatemala City. The non-revenue water rate has decreased from 45.8% in 2004 to 40.3% in 2007.[14] EMPAGUA aims at lowering this rate further to 30% by the year 2010. To that end, it has a wide-ranging plan such as installing or replacing a meter per household, improving the collection of the water rates, taking measures against stolen water, installing a macro-meter, bringing together, rearranging and effectively using the records of water distribution pipe networks, and improving its commercial financing system.

[13] The sewerage rates are collected by adding 20% of the water rates. The annual gross revenue is approximately 4.8 billion yen. The largest portion of expenditure is power supply costs, which account for 40~50% followed by about 22% for personnel costs, 12% for administration costs, and about 5% for chemical costs. The rest is reserved for investments.

[14] It was reported at the time of ex-post evaluation (2002) that the rate of water leak was 40% and the rate of non-collection was 30%. Based upon these rates, it is conjectured that the rate of non-revenue water was approximately 58%.

Table 5: Revenue and expenditure of EMPAGUA (in one million quetzals)

	2002	2003	2004	2005	2006
Revenue	229.4	221.0	268.3	297.8	311.2
Expenditure	227.5	232.3	267.0	292.8	295.6
Operation/maintenance	154.3	152.2	209.6	230.7	242.8
Personnel costs	8.6	13.6	11.9	11.3	12.9
Investment	26.3	9.0	10.6	16.1	6.5
Public debt	38.4	37.4	37.9	34.7	33.4
Balance of payment	1.9	- 11.3	1.3	5.0	15.6

Source: EMPAGUA
Note: One quetzal = $0.135

At the time of ex-post evaluation, it was reported that there would be no particular problems as to the budget because priority would be given to the allocation of budgets to the project's operation and maintenance. Our field study confirmed that a larger amount of budgets for the operation and maintenance of Emergencia-I than the budget for other water supply systems would be apparently secured because preventive inspection/maintenance is conducted. However, a budget for repair expenses is not necessarily sufficient and it is often the case that it runs short towards the end of a fiscal year. The budget of 2008 is indicated below. It should be noted that the repair expense (1.4 million quetzals) is only slightly larger than the actual amount (1.23 million quetzals) of the time of ex-post evaluation (2002).

Judging from the above, although there is no big concern over securing the budget for the operation and maintenance of this project, there is slight concern about repair expenses.

Table 6: Budget for the operation and maintenance of this project (new wells) (2008)

- Outsourcing costs for preventive maintenance: 680,000 quetzals (contract amount)
- Outsourcing costs for repairs: 720,000 quetzals (contract amount)
- Outsourcing costs for operation: 3,510,000 quetzals (the portion for one year out of 1.5-year contract for about 25 wells)
- Electricity – 2,420,000 quetzals: chlorine – 600,000 quetzals
- Personnel costs and administration costs

Source: EMPAGUA

2.3.2 Current operation and maintenance

As stated in the ex-post evaluation report, the facilities constructed or improved under this project have been properly maintained. However, there are a couple of problems: declining levels of groundwater and frequent incidences of troubles of motors/pumps.

(1) Declining levels of groundwater

The levels of groundwater have been continuously declining in some wells. In four wells, the hours of operation per day have been reduced in order to prevent a further decline. There hangs fear of some wells of which water production will be ceased one of these days. Unless any measures are taken to regulate pumping groundwater or recharge the wells artificially, medium or long-term sustainability cannot be maintained.

Replacement work of a motor and a pump

(2) Troubles with motors

The motor frequently breaks down due to voltage fluctuations. It takes a long time to be repaired or to procure parts. Hence, the operating ratio has been on the decline. The motor had to be changed at least once at all wells.

EMPAGUA argues that a motor could be used for about seven years 15 years ago when voltage fluctuated less, but in many cases in recent years it has to be replaced by a new one once in every two or three years. In order to reduce the number of troubles, EMPAGUA has been promoting the measure to improve a device to protect the motor by instantly detecting a voltage fluctuation. When there is an inventory of spare parts, it takes about 1 ~ 2 weeks for repairs or replacement of a motor or a pump. However, a large-size motor or pump is used for the deep wells built under this project. Hence, it is necessary to procure spare parts from outside the country or there is a probability that they may not be kept in inventory. There is a budgetary constraint as well. Thus, in some cases it may be necessary to wait for several months. In fact, last year, two wells had to be closed for three months because of this problem.

3. Conclusions, Lessons learned and Recommendations

3.1 Conclusions

The amount of water production by this project is significantly below the planned quantity. However, the wells are fully utilized as part of the water supply systems of EMPAGUA that suffers from limited sources of water supply and contribute to keeping or raising the level of water supply service in the eastern and northern parts of Guatemala City. EMPAGUA makes endeavors in the operation and maintenance of deep wells, but their operation rates are not very high due to breakdown caused by overheated motor through voltage fluctuations. In Guatemala City there are no regulations as to the pumping of groundwater for residence and commercial/industrial facilities, thereby causing the lowering of groundwater levels and eventually imposing a serious impact on the productivity of deep wells built under this project.

3.2 Recommendations

[For the government of Guatemala and EMPAGUA]

- The Guatemalan government needs to take urgently the measures to develop a legal system and to get water from remote areas to the metropolitan area by negotiating with local governments so as to enable groundwater to be conserved for sustainable use.
- EMPAGUA needs to make further efforts to introduce a motor protection device, to secure an inventory of spare parts, to improve a procurement system and to secure a budget for operation and maintenance in order to raise the operating ratios of wells.
- It is suggested that EMPAGUA carry out an investigation on the past impact and probable impact on water production through the lowered levels of groundwater and study the possibility of rehabilitating wells by, for instance, digging further.

3.3 Lessons Learned

- At the time of ex-post evaluation, it is essential to select accurate effect indicators and collect and analyze data after having fully confirmed the definition and contents. In the ex-post evaluation of this project, the data for the most basic indicators (operating ratio and water production of a well), which EMPAGUA had, were not analyzed. Thus, it was not possible to point out and make recommendations about improving the operation of this project at an early stage.
- In a water supply project that uses groundwater as water resource, it is important to consider the regulation of pumping groundwater and artificial recharge etc., and to carry them into effect as necessary, so as to enable groundwater to be conserved for sustainable use.

Comparison of main plans and achievement

Item	Plans	Plans executed
Output		
Construction of deep wells	38 wells	34 wells
Rehabilitation of wells	22 wells	19 wells
Construction of monitoring wells	5 wells	8 wells
Duration		
Construction of deep wells	March 1991 ~ January 1994	May 1994 ~ August 2000
Rehabilitation of wells	April 1990 ~ February 1992	September 1994 ~ July 1999
Project costs		
Foreign capital	¥3,591,000,000	¥3,898,000,000
Domestic capital	¥1,525,000,000	¥1,316,000,000
	(31,000,000 quetzals)	(94,000,000 quetzals)
Total	¥5,116,000,000	¥5,214,000,000
ODA loans out of the total	¥4,711,000,000	¥4,465,000,000
Exchange rate	$1 = ¥134=2.7 quetzals	$1 = ¥109 = 7.8 quetzals