ECONOMIC EVALUATION OF MATANZA-RIACHUELO BASIN SUSTAINABLE DEVELOPMENT PROJECT

September 2008

This report was written by Luz Maria Gonzalez and Irina Klytchnikova and summarizes the results of other studies carried out by several consultants during preparation

Executive Summary

The Matanza-Riachuelo Basin Sustainable Development Project is economically feasible with economic profit of US$ 0.6 billion and internal rate of return of 28%. Detailed financial, economic, and distributive analyses is presented in this report, and complemented by sensitivity and risk assessments.

The economic analysis was carried out for the following activities: (i) sewerage expansion; (ii) improvement of water quality in MR River; and (iii) improvement of water quality in MR River as well as in the Rio de la Plata. Economic benefits were estimated based on a combination of revealed and stated preference approaches. The revealed preference technique, which uses market information indirectly, was used to estimate: (a) benefits for sewerage expansion through avoided costs method and hedonic price approach; and (b) benefits of water quality improvement in the MR River, through hedonic price approach as well. The stated preference technique, which is based on survey methods asking households how much they are willing to pay for a service or an environmental improvement, was used to estimate the benefits of clean-up of the MR River, as well as of clean-up of both rivers: MR and Rio de la Plata. Special attention was paid to not double counting the benefits.

Contingent Valuation Survey. This survey was designed to evaluate the benefits expected from the project based on water modeling results by the Authority of the Matanza Riachuelo Basin (ACUMAR): elimination of bad smell along the entire flow of the Matanza-Riachuelo river, possibility to use Matanza-Riachuelo for recreation without direct contact with water, possibility to use Rio de la Plata for recreation without direct contact with water (but for a wider range of water-related sports, including rowing, than in the case of Matanza-Riachuelo), and lastly the protection of the water intakes for the public water supply. Benefits from the provision of sewerage network to households in the Matanza-Riachuelo basin were not evaluated in this survey or mentioned as one of the outcomes of the project. Survey respondents were given detailed information about the contamination of the two rivers, the project and its expected benefits. Then the respondents were asked whether they would be willing ty pay a specified amount for the clean-up of MR alone and another amount for the cleanup of both rivers. The payment would be on a recurring bi-monthly basis as an increment to the water bill and it would be used to finance the maintenance of the infrastructure and public works once they are put in place through the project.

The following results were obtained for the willingness to pay for the clean-up of both rivers (MR+RP) or for the clean-up of only the MR river:

Project	*WTP*	
	Ar$/hh/every 2 months	*US$/hh/month*
MR+RP	19.71	3.12
MR	16.65	2.63

The WTP for the clean-up of the MR River is expected to vary depending on the distance to the river, since households that live closer to the river are directly affected by the contamination and the bad smell of the river. In that sense, the WTP of these households reflects their “use value.” Households that live far away from the river and that do not have direct contact with the river and its surrounding areas are not directly affected by the contamination but they may still derive benefits from the clean-up of the river for altruistic reasons. Furthermore, the MR river may have a symbolically important value for the population of Greater Buenos Aires, since there is great awareness of contamination in the basin as one of the most severe environmental contamination problems in the country. In that sense, the clean-up of the MR river can benefit households that do not use the river or frequent the surroundings of the river. The WTP of those

households reflects their "non-use" value of the river, or value that is based on households' satisfaction from knowing that the water quality of the river improves and smell is eliminated even though will not use the river or directly benefit from this improvement through an increase in the value of their property.

The average WTP for households in the proximity of the MR river is shown separately from the WTP for the other households. To compare the use and non-use values, the WTP is shown by distance from the MR River. Results of the contingent valuation survey reveal a substantially higher average WTP by households living less than 20 blocks away from the river than the households living further away:

WTP by distance to the MR River

Project		*Location*	*WTP*	
			Ar$/hh/every 2 months	*US$/hh/ month*
MR+RP	Use value	Less than 20 blocks of MR River	23,24	3.68
	Non-use value	More than 20 block of the MR River	15,15	2.40
MR	Use value	Less than 20 blocks of MR River	23,08	3.65
	Non-use value	More than 20 block of the MR River	9,07	1.44

MR+RP= Río Matanza - Riachuelo and Río de la Plata. *MR* = Río Matanza-Riachuelo

Hedonic Pricing Approach was used to estimate benefits for: (i) provision of sewerage connections; and (ii) clean-up of the MR River. The hedonic price function was estimated as a function of a series of attributes of the property and the area where the property is located. For sewerage connection, results of the 2008 Real Estate Survey conducted as part of this economic evaluation reveal a statistically significant difference between the average prices of houses, apartments and lots with and without a sewerage connection from the survey sample. Results show that the price increase of a property with sewerage connection is 31% for empty lots, 24% for houses, and 8.5% for apartments. For cleaning-up the MR river, which would eliminate bad smell, the difference between the average prices of properties affected and not affected by the smell is also significant, particularly for smell from any source of contamination (MR River, factories etc.). Distance from the MR river was used as a proxy for the smell after controlling for other variables that are also correlated with distance in the hedonic price regression. Sensitivity analysis confirms the robustness of this result. Descriptive statistics from the survey data show that property prices fall with the distance to MR River from an average of 662 to 591 US$/m2 for houses, from 889 to 757 US$/m2 for apartments and from 415 to 259 US$/m2 for empty lots.

Avoided Costs method was used to estimate the benefits of: (i) sewerage connections; and (ii) protection of water intakes. Avoided costs for sewerage connection were estimated based on current costs of different on-site sewage disposal systems. At present 54% of households located in the MR basin do not have access to a sewerage connection, and use the following sewage disposal solutions: septic tanks (30%), holes with no septic chamber (17%), and other solutions (8%). Avoided costs for protection of water intakes were provided by the water and sewerage utility AySA.

Health Benefits Expansion of sewerage and protection of water intakes results in substantial health benefits through the reduction of diarrheal mortality and morbidity as well as reduction of the risk of other water-borne diseases. For this project, the value of risk reduction from diarrheal morbidity and mortality was estimated using the benefit transfer approach to the value of statistical life. The health benefits analysis provides two estimates of cost savings: health benefits resulting from the provision of sewerage to households that will obtain connection through the project (taking into account the fact that averting expenditures already help to partially mitigate the health risks), and health benefits from the protection of drinking water quality. The value of health benefits has been added to the averting expenditures to obtain an

estimate of total benefits from the provision of sewerage connections. The estimated benefits from the reduction of diarrheal morbidity and mortality in children under 5 and the rest of the population are USD 29 per person for sewerage expansion and USD 6 per person for the protection of water the Bernales water intake in NPV terms:

The project's total expected benefits were estimated using more than one valuation approach. In order to obtain the total expected benefits of the project, some of the estimated benefits can be summed up, while adding others would result in double-counting. The following table shows which methods can be used to evaluate different benefit components of the project:

Benefits	***Methodology***
Sewerage connection for households in the MR basin	(1) Avoided costs; (2) Hedonic pricing; (3) Cost of illness.
M-R: Elimination of odor and suitability for recreation without direct contact	(1) Hedonic pricing; (2) Contingent valuation.
Rio de la Plata: Suitability for recreational activities without direct contact; and protection of water quality at water intakes for drinking water	(1) Contingent valuation; (2) Avoided costs.

Different combinations of these approaches were used to calculate total economic benefit of the project:

Benefit	*Choice of the valuation method*
Access to sewerage	- Hedonic pricing OR - Avoided costs for having sewerage connection plus health benefits
Elimination of odor and recreation possibilities in the M-R river	- Hedonic pricing for households within 20 blocks of M-R, AND contingent valuation for the households farther than 20 in Greater Buenos Aires OR - Contingent valuation for the whole population of GBA (within and outside the M-R basin)
Elimination of odor in the M-R river, recreation possibilities in the M-R river and Rio de la Plata, and protection of water intakes	- Avoided costs (extending the Bernales water intake) AND Contingent valuation for M-R OR - Contingent valuation for M-R + Rio de la Plata. OR - Hedonic pricing for households within 20 blocks of M-R, AND contingent valuation for the households located farther than 20 in Greater Buenos Aires

A combination of hedonic pricing and contingent valuation is deemed to be the most robust estimate of the total project benefits: (i) hedonic for sewerage connection; (ii) hedonic for households <20 blocks from MR river, and (iii) contingent valuation for household in GBA >20 blocks. The results show a net profit of US$ 0.6 billion, and an economic rate of return of 28%. Sensitivity and risk analyses confirm the robustness of the project's estimated benefits, which has a 67 percent probability of having positive returns.

Financial Analysis of the Project

The financial viability of the project was assessed from the perspective of the entity implementing the project (AySA). It is based on the actual prices that AySA will pay for the project and receive from it. A 100% subsidy on investment is included in the evaluation in the form of a grant from the Federal Government. Taxes are also included. The results show that the project is not financially viable, with a net loss of US$ 455 million. These negative returns result from the low sewerage tariffs than are not high

enough to cover operating costs. A sewerage tariff increase of at least 140% is required to make the project financially viable.

TABLE OF CONTENTS

1.Introduction

For many years, the Matanza-Riachuelo (MR) watershed has been the recipient of sewage and industrial discharges from the city of Buenos Aires and some others municipalities of the Province of Buenos Aires. Currently, it is the most contaminated river basin in Argentina and one of the country's most visible environmental problems. It is estimated that around five million people live in the basin, of which 39% live without proper drinking water, and 67% are not connected to the sewerage system. Ten percent of population lives in informal settlements, often in food-prone areas and/or near open garbage dumps. The poorest households live along the river and are in constant contact with contaminants ranging from untreated organic waste to industrial toxic chemicals. More than 3,000 industries are located in the watershed, with the majority discharging untreated effluents in the storm drainage system or directly into the river. Pollution control is weak and compliance is low. The MR river also floods frequently, due to high flows in the rainy season or high water levels in Rio de la Plata. This flooding spreads highly polluted waters into informal settlements, exposing the inhabitants to further contamination.

The Government of Argentina has given a high priority to the environmental and social recovery of the MR basin. It has designed the Matanza-Riachuelo Basin Sustainable Project as a comprehensive urban-environmental recovery project with several components aimed at upgrading social conditions and urban infrastructure in the basin.

The proposed project is an integrated approach to the clean-up of the MR basin, which consists of three components: industrial pollution control, sanitation, and urban rehabilitation. The estimated cost of the project in all three areas of intervention is about US$ 2.5 billion, with financing mostly from the federal government, and the World Bank. The *industrial pollution abatement component* ($250 mln) is designed to eliminate most of the polluted effluent discharges into the environment, as well as most of toxic waste that enters the sewerage system. The *sanitation component* ($2,250 mln) is designed to eliminate most of sewage discharges into the MR River through investment in sewage collectors, interceptors, and construction of two treatment plants, two pumping stations, and two outfalls into the de la Plata River. The *urban rehabilitation component* ($65 mln) is designed to address urban land use, flood and groundwater management, storm drainage, slum upgrading, solid waste management, and economic growth issues.

This economic evaluation is carried out here for the industrial pollution and sanitation components of the project. These two components are expected to result in a significant improvement of water quality in the MR river, an improvement of water quality in Rio de la Plata, and provision of sewerage to 40% percent of households in the MR basin that are currently not connected. Total sewerage coverage in the concession area of the water and sewerage utility (AySA) will increase from current 58% to 80% by 2012.

This evaluation was performed by a team led by Luz Maria Gonzalez, Economic Consultant and comprising Irina Klytchnikova, World Bank Economist; Diomira Faria, Economic Consultant, Aydet, Argentine Consulting Firm, and Opinion Autenticada, Argentine public opinion survey firm.

2. Methodology

The objective of the project is the clean-up of the MR basin through a comprehensive urban-environment project with several components aimed at upgrading social conditions and urban infrastructure in the basin. On the basis of this objective the cost benefit analysis was carried out to determine the financial and economic feasibility of two components of the project: (i) industrial pollution abatement; and (ii) sanitation. The evaluation was carried out to evaluate the following benefits obtained with those two project components: (a) sewerage expansion; (b) clean-up of the MR River; and (c) clean-up of the MR River and improvement of water quality of Rio de la Plata.

The analysis was carried out from three perspectives: financial, economic, and distributional. From a financial perspective, each activity was appraised measuring its costs and benefits at market prices. From an economic perspective each activity was evaluated converting financial cash flows into economic cash flows through the use of: (i) conversion factors to be applied to the investment and operating costs so as to eliminate market distortions; and (ii) measurement of the welfare impact on households within the influence area of the project. The fiscal impact was estimated measuring the taxes and subsidies that occur in the transactions associated with the project and its financing. The distributional analysis was conducted based on the results of the economic and financial evaluation. This analysis assesses the impact of each activity on specific groups of stakeholders such as the Government, customers, employees, and suppliers. Finally, the results of the economic and financial analyses were tested against real world uncertainties by conducting a sensitivity and risk analysis.

The net benefit of each activity equals the difference between the incremental benefits and the incremental costs of two scenarios: "with" and "without" project. The "with" project scenario considers the proposed investment program is implemented, and hence, the environmental recovery of the MR river is achieved as well as the associated benefits for the La Plata River; sewerage expansion is also attained, with some complementary investments. The "without" project scenario assumes that pollution and sewerage coverage remain at the current level. The activities were appraised measuring the flow of costs and benefits for the lifetime of the project, estimated at 30 years. Costs and benefits were expressed in constant prices as of October 2007[1]. The discount rate corresponded to the opportunity cost of capital of Argentina estimated at 11%[2].

Benefits expected from the project consist of: (i) a significant improvement of water quality in the MR River; (ii) an improvement of water quality in Rio de la Plata; and (iii) provision of sewerage to about 700 thousand households that are currently not connected.

Economic benefits were estimated based on a combination of revealed and stated preference approaches. The revealed preference approach, which relies on data from observed transactions in the market or on expenditures by households or other agents, was used to estimate: (i) the benefits from sewerage expansion through the avoided costs and hedonic pricing methods; and (ii) benefits of water quality improvement in the MR River through the hedonic pricing approach. The stated preference technique, which is based on survey methods—in this case, asking households how much they are willing to pay for an improvement in water quality—was used to estimate the benefits of the clean-up of the MR River, as well as the benefits of the clean-up of

[1] The exchange rate used was Ar$ 3.16: 1US$

[2] Glenn P. Jenkins. *Buenos Aires-Colonia Bridge Project, Financial and Economic Appraisal. International Institute for Advanced Studies*. Cambridge, MA, July 30, 1998.

both rivers: MR and Rio de la Plata. Estimates of the benefits from different components of the project obtained using different environmental valuation methods were aggregated to yield the total project benefits in such a way as to avoid double-counting any of the project's benefits, as explained in detail further on in this annex.

Financial benefits were estimated based on current sewerage tariffs charged by the water and sewerage utility (AySA), number of households connected to the sewerage network, and volume of sewage discharged. Financial benefits were projected for two scenarios: with and without the project. The "with project scenario" assumes that sewerage coverage will increase from the current level of 58% to 80% by 2012 for the entire AySA concession area, it is also assumed that municipalities in the upper basin will be incorporated in AySA's concession area (without including the city of BsAs the coverage will increase from 39% to 75%. Within the basin, the coverage will rise from the current level of 33% to 71%; and outside the basin, the coverage will rise from 48% to 81%). The "without project scenario" assumed that current sewerage levels remain constant. Average bill per household every two months is about Ar$13 for the sewerage service.

3. Financial and Economic Costs

The flow of costs consists of investment and operating costs. Investment costs include all the required works needed to attain the benefits expected with the project, and hence include the works to be financed by WB, and the works to be financed by AySA. Operating costs were projected for two scenarios: with and without project. The without project scenario assumed that current unitary costs remain constant; while with project scenario included all operating costs incurred when the project is implemented. The financial flow of costs includes taxes and excludes subsidies. Financial costs were transformed into economic costs using conversion factors to eliminate market distortions created by taxes, tariffs and subsidies. Conversion factors for the main inputs of the investment and operating costs were estimated according to the guidelines of the *Direccion Nacional de Inversion Publica*. Financial costs included a 100% subsidy on investment costs to be funded by the Federal Government. A VAT of 21% was added to financial costs.

Investment costs. As table 1 shows, total investment required for cleaning up the MR River and the Rio de la Plata costs US$ 2.5 billion, including US$ 840 million for sewerage expansion. The investment will be implemented in two phases which are expected to be completed by 2016.

Table 1. Investment costs for cleaning up the MR river and Rio de la Plata (without VAT)

	Million US$
MR RIVER	
Collector left bank of MR river	206
Collector right bank of MR river	274
Treatment Plant Capital	142
Pump Stations Capital (entrada y salida)	122
Outfall Capital	215
Subtotal MR Basin	*959*
Industrial pollution abatament	250
Total MR Basin	*1,209*
COSTANERO AND BERAZATEGUI	

Collector Costanero	88
Pump Station Berazategui	85
Outfall Berazategui	115
Treatment Plant Berazategui	183
Total Costanero and Berazategui	*471*
Total MR River and RLP	*1,680*
SEWERAGE EXPANSION	
To increase coverage from current 39% to 75% in all municipalities served by AySA (excluding city of BsAs whose coverage is 100%).	840
TOTAL INVESTMENT COST	2,520

For the financial analysis all costs incurred by the entity in charge of the project, AySA, are included. If a subsidy is given to AySA, the financial cost will be reduced accordingly; at the same time if a tax is charge, AySA will have a cost increase and the financial cost will be higher. The financing plan for the investment consists of a subsidy from the Government of Argentina of the total cost, and hence the cost for AySA will be zero and so the financial cost considered for this evaluation.

To estimate the economic costs, all investment and operating costs were broken down in its components and then applied the conversion factor, as follows.

	Sewerage			*MR yRLP*		
	Participation %	*Conversion Factors*	*Compound factor*	*Participation %*	*Conversion Factors*	*Compound factor*
Investment by components						
Skill labor	10%	0.72	0.07	10%	0.72	0.07
Unskill labor	5%	0.72	0.04	5%	0.72	0.04
Total labor	15%		-	15%	-	-
Equipment	25%	0.79	0.20	40%	0.79	0.32
Material	30%	1.00	0.30	30%	1.00	0.30
Land	20%	1.00	0.20	5%	1.00	0.05
Others	10%	0.77	0.08	10%	0.77	0.08
Total	100%		0.88	100%		0.85

Operating Costs

The financial operating costs were estimated for both situation "with" and "without" project scenario. For the without project situation is assumed that current operating costs remain. For the with project situation, operating costs are based on actual costs to be incurred by AySA with the project.

4. Economic Benefits

4.1 Benefits for Rio de la Plata.

Rio de la Plata is an estuary formed by the combination of Uruguay and Parana Rivers. It forms part of the border between Argentina and Uruguay, with the major ports and capital cities of Buenos Aires in the southwest and Montevideo in the northeast. Rio de la Plata is a funnel-shaped indentation, extending 290 km from the rivers' confluence to the Atlantic Ocean. It is 48 km wide where the rivers join, widening to 220 km where it enters to the Atlantic Ocean, making it the widest estuary in the world (Figure 1).

Figure 1. De la Plata River

The total population around the Rio de la Plata is about 17 million, including the densely populated centers of Buenos Aires and Montevideo. This region comprises the main industrial centers, ports, and economic activities for both countries.

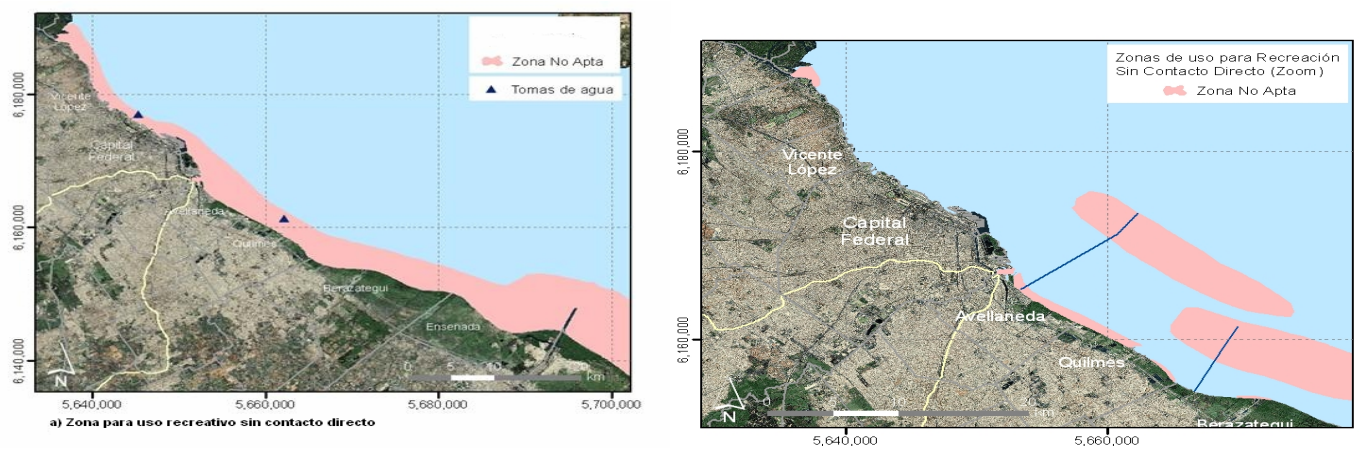
The urban centers discharge large quantities of domestic and industrial wastewaters to the de la Plata River. Buenos Aires generates about 60 m^3/seg of domestic wastewater. Of this, about 30m^3/seg is currently conveyed to the Berazategui site where it is discharged without treatment through an outfall that discharges from an essentially point source 2.5 km offshore[3]. Other 3m^3/seg are treated at the treatment plant Sudeste and then discharge at MR River; the remaining 27m^3/seg discharge at many points at tributaries of different rivers, including the MR River; as well as at de la Plata River.

Currently the river de la Plata has a pollution level defined as moderate, that is, water is not suitable for drinking supply without treatment; and it can be used for recreational purposes with no direct contact. Through works proposed in the project (construction of a coastal collector along the banks of Rio de la Plata, primary treatment at two new treatment plants and discharge of treated wastewater further away from the river banks), the project is expected to improve water quality in Rio de la Plata. According to the results of water quality modeling by the Authority of the MR basin (ACUMAR), the project will protect water quality at the intakes of drinking water (marked by triangles in figure 1) and it will make a large stretch of Rio de la Plata suitable for recreational activities without direct contact with water that are currently not possible due to water pollution. Figure 1 shows the contaminated areas along the coast of Rio de la Plata before and after the project.

Figure 1. Water Quality along the Coast of de la Plata River

Before the Project **After the Project**

[3] Robert, Phillips and Beatriz Villegas. *Review of the Capital and Berazategui Wastewater Outfalls Buenos Aires*. January 2008



4.2 Benefits for the Matanza-Riachuelo River.

The MR basin is contaminated by sewage disposal from households with no sewerage connection and by discharge of untreated wastewater by the water utility's (AySA's) sewerage system. The MR River is a huge open sewer with sewage flows that frequently exceed natural flows, particularly in the dry season. Industrial discharge is also a major problem in the basin. Approximately 3,000 industries are located in the MR basin of which about 766 discharge effluents into the sewerage network or into the river with inadequate or no treatment at all. Samples taken in the MR River indicate that a significant percentage of these effluents contain heavy metals and other toxins. It is estimated that 99 of the 766 industries are responsible for about 91% if the total discharges into the MR basin[4]. The main contaminating industries include tanneries (50% of the industries in the basin), meat processing facilities, and petrochemical plants. The industrial and domestic sectors are the major sources of organic contamination, each contributing with about 20 thousand ton per year of BOD_5, which corresponds to 90% of total contamination (Table 2).

Table 2 . Discharges and contamination in BOD_5 and SS in MR river per year

Concepto	*Wastewater discharges (million m^3/year)*	*BOD_5 (ton/year)*	*SS (ton/year)*
Sewerage system discharges	75	7.100	11.950
Diffuse domestic sewage discharges	61	13.030	17.290
Industries	32	20.800	20.800
Open waste dumps	0,2	26	-
Drainage	108	760 – 2.380	2.270 – 278.900
Total	*276*	*41.716 – 43.336*	*52.310 – 328.940*

According to the data collected by the newly created basin authority, ACUMAR, to measure the contamination of surface water from the MR River and its tributaries, the pollution was graded based on two indicators: Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD). The contamination was categorized according to the following water quality standards:

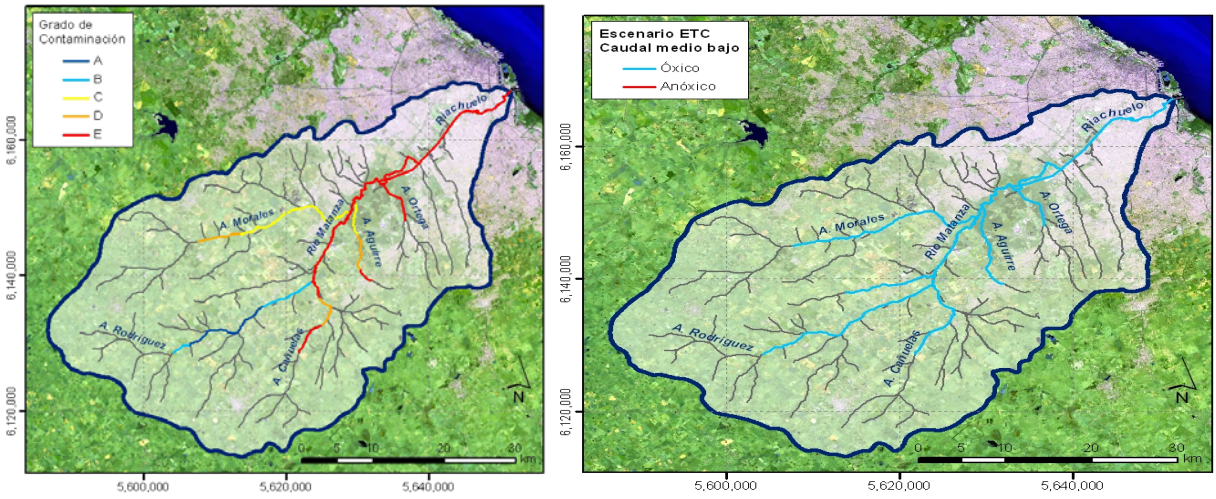
[4] Boll, Jorge. *Se require una solucion integral para resolver los problemas de contaminacion de la cuenca hidrica Matanza-Riachuelo.* Ingenieria Sanitaria y Ambiental AIDES 87. Julio/Agosto 2006. Buenos Aires.

- *Class A. Acceptable water quality.* Designated uses: potential drinking water supply; fish and wildlife habitat, scenic view, recreational use; other legitimate uses including navigation.
- *Class B. Moderate water quality.* Designated uses: fish and wildlife habitat, scenic panorama, recreational use; other legitimate uses including navigation.
- *Class C. Low water quality.* scenic view, recreational use with no direct contact with water.
- *Class D. Unacceptable quality.* Severe contamination. It allows some esthetic appearance, limited recreational use with no direct contact
- *Class E. Unacceptable quality with extreme contamination.* It can not have any use. It presents anoxic conditions, with levels of dissolved oxygen (DO) lower than 2, odor is persistent.

ACUMAR concludes that water quality along the MR River and its tributaries is extremely polluted along 50 km out of 60 km of its total extension (Figure 2).[5] A similar situation occurs in some of its tributaries such as Arroyo Ortega, and Arroyo Cañuelas. The project is expected to bring about a significant improvement of water quality of the MR River. Water modeling by ACUMAR shows that the project would result in the elimination of anoxic conditions and recuperation of oxygen in the water body (Figure 2). The river's bad smell will be eliminated along the entire course of the river and the river will become suitable for recreational activities with no direct contact with water (i.e., navigation, various activities at the banks of the river, but no swimming or rowing).

Figure 2. Water Quality on MR River and its Tributaries

Before the Project **After the Project**



Note: The extent of contamination depending on current levels of dissolved oxygen (DO) along the extension of the river (from the lowest, A, to the highest, E). The river is currently in a persistent anoxic condition due to oxygen depletion especially in the proximity to the delta where MR flows into the de la Plata River. Stretches of the river with anoxic conditions are denoted in red.

4.3 Benefits from provision of sewerage connections.

[5] Menendez Angel. *Insumos para la Evaluacion de los Beneficios Economicos del Plan de Saneamiento de la Cuenca del Matanza-Riachuelo.* ACUMAR. Marzo 2008

The big provider of the sewerage system is AySA (Agua y Saneamientos Argentinos), the water and sewerage utility. The concession area consists of the city of Buenos Aires and seventeen municipalities in the Province of Buenos Aires. Water coverage is 79% , and sewerage coverage is 58%. The concession area is comprised for 9 million people, out of 17 million people in the city of Buenos Aires and the whole Province of Buenos Aires. AySA provides water connection to 7 million people out of the 9 million in the concession area; and sewerage connection to 5.6 million. Even though billing data of AySA shows universal coverage for the city of Buenos Aires, there are some informal settlements (locally known as villas) with no access to either of the services. About 0.4% of total population lives in those *villas*, according to 2001 Census data.

Sewerage coverage in AySA's concession area at MR basin is currently 33%. The remaining 64% of unconnected households have their own on-site solutions: septic tanks 30%; pits 17%; other 18%, such as direct discharge to the streets, streams nearby, or drainage systems (Table 3).

Table 3. Percentage of Households inside the basin classified according to sewage disposal system.

Municipalities in MR basin within AySA's concession area	*Sewage Disposal types*				
	Sewerage connections	*Septic tank*	*Pit*	*Other*	*Total*
Almirante Brown	17%	42%	20%	21%	100%
Avellaneda	58%	18%	17%	7%	100%
Esteban Echeverría	14%	43%	18%	26%	100%
Ezeiza	11%	39%	15%	35%	100%
La Matanza	47%	22%	9%	21%	100%
Lanús	29%	29%	33%	9%	100%
Lomas de Zamora	27%	30%	24%	18%	100%
Merlo	19%	39%	14%	28%	100%
Morón	50%	36%	9%	5%	100%
Total	36%	30%	17%	18%	100%

Lack of a sewerage connection causes serious problems to the population and to the environment. They include the costs and the inconvenience of maintaining on-site systems, flooding, and health problems. Apart from the costs of investing in an on-site system, households with on-site solutions for sewage disposal have to maintain them in order to ensure adequate operation. Maintaining a *septic tank* or a *pit* (a hole in the ground without a septic chamber) requires periodical cleaning. Sludge and floating scum have to be removed from time to time in order to avoid overflow. The cleaning service is generally provided by operators of vacuum pumping trucks. Non-regulated wastewater discharge to drainage system or the streets is done with a manual pump, which also requires maintenance. Furthermore, on-site sewage systems discharge wastewater into the aquifer, increasing its water level and contaminating it. In some parts of the basin, that increases the frequency of floods, causing damage to people's homes. Lastly, the lack of access to sewerage increases the incidence of diarrhea and other water-borne illnesses, even though the relationship between the incidence of illness and sewerage connections is complex, and it is important to take into account the effect of drinking water quality on prevalence of water-borne diseases.

The project aims to connect about 2 million people currently without service. Out of these 2 million, 1.2 is located within the MR basin, the remaining 0.8 is located along the coastal collector along the banks of Rio de la Plata. Coverage for the whole concession area will increase from the current level of 58% to 80% by 2013. Within the basin coverage will increase from 33% to 71% (Table 4).

Table 4. Sewerage Coverage in AySA's concession area

	Total Population 2007	AySA's concession area		
		Population in concession area	Sewerage coverage	
			2007	2013
Municipalities at MR Basin	4,826			
Currently at AySA's concession area		4,075	33%	71%
To be included at AySA's concession area		751	14%	40%
Municpalities along coast Rio de la Plata	2,596	2,596	49%	82%
Subtotal	*7,423*	*6,661*	*35%*	*76%*
Capital Federal	3,034	3,034	100%	100%
Total	*10,457*	*9,706*	*58%*	*80%*

5. Methods used to measure economic benefits and data sources

The methodology to assess project benefits includes a combination of revealed and stated preference approaches. The revealed preference approach comprises methods that use data indicating expenditures on market goods associated with the service in question (e.g., costs of cleaning septic tanks, or so-called "avoided costs"). Another approach—"hedonic pricing"—uses data on property values and a series of amenities, including environmental quality. The avoided costs and hedonic pricing approaches permit the estimation of an implicit value of welfare improvements due to a change in coverage of an infrastructure service (e.g., sewerage) and welfare improvements due to a change in environmental quality (e.g., elimination of bad smell in the MR basin).

The term "stated preferences" refers to survey-based methods that rely on information about households' willingness to pay for an improvement in service quality or about their stated hypothetical choices. In the case of this project, contingent valuation—one of the stated preference methods—has been used to elicit respondents' willingness to pay for an improvement of water quality of the MR and Rio de la Plata rivers.

Some components of the benefits can be evaluated only using the hedonic approach, while others can be captured only through contingent valuation. The following data sources have been used in the evaluation of project benefits:

- The *Real Estate Survey* of 1,200 properties for sale (apartments, houses and empty lots) has generated data on sale prices and attributes of the properties included in the survey. These data have been used to estimate the hedonic price function and evaluate the following benefits of the project: elimination of smell of the MR river and provision of sewerage.
- The *Contingent Valuation Survey* of 1,001 households residing in the MR and Rio de la Plata basin has generated data on willingness to pay for the elimination of smell in the MR river, recreational possibilities in the MR river, new recreation possibilities in Rio de la Plata and protection of water quality at drinking water intakes. The contingent valuation survey has separately elicited willingness to pay for the environmental benefits for the MR river alone, and for the combined benefits from an environmental improvement in Rio de la Plata and MR rivers.
- Data on *avoided costs* of sewerage connection was collected from: (i) ACUMAR, which provided the georeference data for all municipalities in the basin regarding number of households, type of sewage disposal system (sewerage network, septic tank, pit, or other), altitude, and water table level; (ii) a small sample of households that use on-site sewerage

solutions in order to generate data for cost of operating all types of sewage disposal systems; (iii) operators of vacuum pumping trucks to get information of actual costs paid by households; and (iv) experts on hydrology and operators of sewage disposal systems to get accurate information of required maintenance for proper functioning of the disposal systems.

- Data on *avoided costs* of moving the Bernales drinking water intake further out into the river in Rio de la Plata and the additional treatment costs during the contamination spikes at the Bernales water intake that have been provided by AySA.
- Partial data permitting the estimation of the *costs of illness* for households without sewerage connections have been collected through the Contingent Valuation survey (the incidence of diarrheal diseases among children under 5 years of age from the survey sample). Supplementary data from other sources, such as treatment costs for the public healthcare system, have also been collected.

Table 5 describes the combination of approaches that have been used in the project's economic evaluation.

Table 5. Revealed and stated preference approaches to the project's economic evaluation

Benefits	Methodology	Source of data
Sewerage connection for households in the MR basin	(1) Avoided costs; (2) Hedonic pricing; (3) Cost of illness..	**Avoided costs**: Data on the investment and operating costs of each type of on-site sewerage solution from a survey of a small non-representative sample of households in Lomas de Zamora, Lanus, and Almirante Brown carried out as part of this economic evaluation. **Hedonic pricing**: Real Estate Survey of 1,200 properties, carried out as part of this economic evaluation in the MR basin. Sewerage is one of the attributes that affects the price of housing, as estimated in the hedonic price function. **Cost of illness**: The incidence of diarrheal diseases among children under 5 years of age from the Contingent Valuation Survey sample and secondary data, such as treatment costs for the public healthcare system.
Matanza-Riachuelo: Elimination of smell and suitability for recreation without direct contact	(1) Hedonic pricing; (2) Contingent valuation.	**Hedonic pricing**: Real Estate Survey of 1,200 properties, carried out as part of this economic evaluation in the MR basin. Distance to MR and the presence of smell are other attributes that affect the price of housing, as estimated in the hedonic price function. **Contingent valuation:** WTP Survey of 1,001 households in the MR and Rio de la Plata basins. The welfare gains from elimination of smell and recreational possibilities for the MR river are evaluated in the survey.
Rio de la Plata: Suitability for recreational activities without direct contact; and protection of water quality at water intakes	(1)Contingent valuation; (2)Avoided costs (water utility and cost of illness)	**Contingent valuation:** The welfare gains from the new recreational possibilities for the Rio de la Plata river and protection of water quality at drinking water intakes. **Avoided costs**: Investment costs by the water utility

for drinking water		AySA for having to move further the drinking water intakes and the incremental water treatment costs.

5. Summary of Economic Benefits Resulting from different approaches

5.1 Contingent Valuation Survey

Contingent Valuation survey was designed to evaluate the benefits expected from water modeling by ACUMAR: elimination of bad smell along the entire flow of the Matanza-Riachuelo river, possibility to use Matanza-Riachuelo for recreation without direct contact with water, possibility to use Rio de la Plata for recreation without direct contact with water (but for a wider range of water-related sports, including rowing, than in the case of Matanza-Riachuelo), and lastly the protection of the water intakes for the public water supply. Benefits from the provision of sewerage network to households in the Matanza-Riachuelo basin were not evaluated in this survey or mentioned as one of the outcomes of the project (The WTP study is presented in Annex 1).

The survey sample, drawn using geographically stratified random sampling, includes 1,001 households in the Greater Buenos Aires area, distributed as follows: 465 households in the capital (Capital Federal), 129 in the coastal areas Costas (Vicente Lopez, Sarandi-Villa Dominico, and Quilmes), and 199 households in the downstream part of the M-R basin (Cuenca Baja), 201 in the middle part of the M-R basin (Cuenca Media), and 7 in the sparsely populated upstream part of the M-R basin (Cuenca Alta). These areas were selected to represent the population in the area influenced by the project.

The survey separately elicits the WTP for the improvements in the Matanza-Riachuelo river alone and for the improvements in both Matanza-Riachuelo and Rio de la Plata. Respondents were asked whether they would be willing to pay a specified amount, that varies across respondents, as an increment to the bi-monthly water bill that they receive. Each respondent was asked two questions in sequence. Half of the sample was first posed the WTP question for M-R river and then for both rivers (Form A), and for the other half the order of the questions was reversed (Form B). Ordering the questions in different ways for the two subsamples was done so as to reduce the anchoring effect—or the dependence of the answer to the second question on the previous question and the answer given by the respondent. These methodological and sampling issues, the literature review and a detailed exposition of the survey results are discussed in Faria (2008). [6]

The willingness to pay for water quality improvement of MR River (MR), as well as the WTP for the improvement of both Rivers: MR and Rio de la Plata (MR+RP) are shown in table 5. For the MR River the average WTP is about US$ 2.6 per household per month; while for both rivers (MR+RP) it is US$ 3.13 per household per month.

Table 6. WTP per component of the project

Project	*WTP*	
	Ar$/hh/every 2 months	*US$/hh/month*
MR+RP	19.71	3.12
MR	16.65	2.63

[6] Faria, Diomira. *Estudio de Disponibilidad de Pago para la mejora ambiental de los Rios Matanza Riachuelo y Rio de la Plata.* Buenos Aires. August 2008.

The WTP for the clean-up of the MR river is expected to vary depending on the distance to the river, since households that live closer to the river are directly affected by the contamination and the bad smell of the river. In that sense, the WTP of these households reflects their "use value." Households that live far away from the river and that do not have direct contact with the river and its surrounding areas are not directly affected by the contamination but they may still derive benefits from the clean-up of the river for altruistic reasons. Furthermore, the MR river may have a symbolically important value for the population of Greater Buenos Aires, since there is great awareness of contamination in the basin as one of the most severe environmental contamination problems in the country. In that sense, the clean-up of the MR river can benefit households that do not use the river or frequent the surroundings of the river. The WTP of those households reflects their "non-use" value of the river.

The "use value" represents the WTP for an actual use of a good or service, which in this case is having direct impact with the cleaning up of the rivers (for recreational purposes, or for not having the smell at MR). The "non-use value" represents the willingness to pay for perceived benefits not related to its use value; it is an existence value, which is based on the satisfaction of knowing that the water quality of the Rivers will be clean, even without an intent to use the river; it responds more to altruistic motives.

The average WTP for households in the proximity of the MR river is shown separately from the WTP for the other households. To compare the use and non-use values, the WTP is shown by distance from the MR River.[7] It was found that up to 20 blocks from the MR River, the contamination of the MR is perceived in someway by the population through a bad smell, or living close to sewage discharges sites, etc. Farther than 20 blocks, the population does not perceive the odor or other inconveniences that result from the river's contamination. The results are presented in Table 7.

Table7 . WTP by distance to the MR River

Project		*Location*	*WTP*	
			Ar$/hh/every 2 months	*US$/hh/ month*
MR+RP	Use value	Less than 20 blocks of MR River	23,24	3.68
	Non-use value	More than 20 block of the MR River	15,15	2.40
MR	Use value	Less than 20 blocks of MR River	23,08	3.65
	Non-use value	More than 20 block of the MR River	9,07	1.44

MR+RP= Río Matanza - Riachuelo and Río de la Plata. *MR* = Río Matanza-Riachuelo

5.2 Hedonic Pricing Survey

Hedonic property models are used in the hedonic pricing literature to estimate welfare effects of changes in environmental quality and other characteristics of a property. Hedonic models have been used in Buenos Aires to estimate the benefits from access to sewerage. In the literature, several studies have estimated the impact of proximity to a water body (canal, river etc) and the

[7] The results of hedonic pricing analysis, described below, reveal that contamination of the MR River does not have a significant impact on property values beyond 20 blocks from the river. The same threshold is used here to show the WTP that in a sense captures the use (less than 20 blocks away from the river) versus the non-use (more than 20 blocks) value of the river.

view on housing prices, but very few papers have estimated the effect of water quality on property prices (Leggett and Bockstael, 2000).[8]

In the literature, hedonic models are normally estimated in two stages. First, a hedonic price function is estimated where property price is a function of a series of attributes or characteristics of that property, including, in this case, a connection to public sewerage and the presence or absence of smell from Matanza-Riachuelo or one of the streams in the basin. Once a hedonic price function is estimated, the next step in the analysis is estimation of demand functions, and the parameters of the demand functions are used to derive the welfare measures of an improvement in environmental quality (the elimination of smell) or provision of a sewerage connection. However, estimation of the second stage is very complex.

Results from the first stage—the hedonic price function alone—can be used directly for welfare measurement if the environmental quality improvement (or provision of sewerage) does not result in a shift in the hedonic price function. In other words, if few properties are affected compared to the overall size of the property market and the supply and demand conditions do not change, then it can be assumed that the hedonic price function does not shift. With localized externalities—or externalities that affect only those in proximity to the externality—it is only necessary to estimate the hedonic price function (Palmquist, 1992).[9] If the hedonic function shifts, then the bounding result by Bartik shows that the benefits estimated from the first stage (the hedonic price function) are a lower bound of the actual benefits that would be estimated from the demand functions (Bockstael and McConnell).[10] Thus, the approach taken in the hedonic analysis in this project is theoretically valid, and if the externality is not localized and it affects the whole property market, then the estimates are more conservative (lower) compared to what would be obtained form the second stage.

Results of the Hedonic Analysis of the 2008 Real Estate Survey of the project area.[11] Results of the 2008 Real Estate Survey conducted as part of this economic evaluation reveal a statistically significant difference between the average prices of houses, apartments and lots with and without a sewerage connection from the survey sample (Table 8). The difference between the average prices of properties affected and not affected by the smell is also significant, particularly for smell from any source of contamination (MR River, factories etc.). As shown by the descriptive statistics from the survey data, property prices fall with the distance to MR River from an average of 662 to 591 US$/m2 for houses, from 889 to 757 US$/m2 for apartments and from 415 to 259 US$/m2 for empty lots. (The hedonic price study is presented in Annex 2)

Table 8. Land, housing and apartment prices from the Real Estate Survey data ($US/m2)

	Sewerage connection		Smell from MR River		Smell (any source)		Distance to MR River (blocks)				Total
	Yes	No	Yes	No	Yes	No	0 to 5	6 to 10	11 to 20	21 to 25	
Greater Buenos Aires											
Houses	683	502			602	624	389	585	621	634	615
Apartments	827	701	736	815	750	834	618	889	810	803	805
Empty lots	261	108	139	191	141	216	139	222	198	187	183

[8] Leggett, Christopher and Nancy Bockstael (2000). "Evidence of the Effects of Water Quality on Residential Land Prices." *Journal of Environmental Economics and Management* 39: 121-144.

[9] Palmquist, Raymond (1992). "Valuing Localized Externalities." *Journal of Urban Economics* 31: 59-68.

[10] Bockstael, Nancy and Kenneth McConnell (2007). *Environmental and Resource Valuation with Revealed Preferences: a Theoretical Guide to Empirical Models*. Springer Verlag.

[11] Juan, Andres. *Estimacion de Funcion de Precios Hedonicos para la mejora ambiental del rio Matanza Riachuelo y la extension de redes cloacales. Informe Preliminar.* Buenos Aires. Agosto 2008.

City of Buenos Aires											
Houses	792	na			721	810	720	811	843	816	792
Apartments	962	na	660	1029	667	1039	827	980	1033	1012	962
Empty lots	493	na	342	507	316	517	385	391	499	618	493
Total											
Houses	712	502			614	668	591	672	695	662	647
Apartments	873	701	710	876	733	903	757	915	902	889	850
Empty lots	358	108	171	278	156	323	259	292	333	415	263

Note: Mean values for the survey sample of 385 houses, 395 apartments and 362 empty lots. Average prices for properties further than 25 blocks away from the MR River are not reported in this table but these properties are included in the survey.
Source: Juan, Andres and others (2008).

As explained above, the hedonic price approach was used to estimate the benefits for sewerage connection, and for cleaning-up of the MR River. The hedonic price function was estimated as a function of a series of attributes of the property and the area where the property is located. The dependent variable is property value per m2, and the equation is estimated using the semi-logarithmic functional form. First, the model is estimated separately for each sub-sample: empty lots, houses and apartments. Then, in the fourth model run all observations are pooled and dummy variables are included to allow for the different intercept terms for apartment, empty lot and housing prices. The results of the estimation are reported in Table 9.

Table 9. Regression results for the hedonic price function estimation

	Model 1: Empty lots	Model 2: Houses	Model 3: Apartments	Model 4: Pooled
	Coefficient	Coefficient	Coefficient	Coefficient
Constant	2.584	2.997	3.244	1.619
Apartment (dummy)				0.91
House (dummy)				0.833
Distance to center, minutes	-0.002	-0.001	-0.001	-0.001
Distance to bus stop, meters	-0.00021	-7.84E-05		
Number of bus lines within 4 blocks	0.009			0.003
Area (logarithm)	0.708			
Area with structures (logarithm)		0.713	0.708	
Smell from any source (dummy)	**0.071**		**-0.072**	**-0.027**
Geographic location (City of BsAs or not)	0.324	0.139	0.106	0.145
Sewerage connection (dummy)	**0.117**	**0.095**	**0.035**	**0.078**
Gas connection (dummy)				0.14
Geographic location (Lanus district or not)	0.146	0.048		0.059
Index of areas with structures over available area	0.048			0.155
Condition of sidewalk	0.115			0.09
Presence of ditches for water drainage along sidewalks (dummy)		0.108	0.069	0.047
Condition of the house (dummy=1 if good)		0.082		
Age of the house		-0.002	0.001	-0.002
Additional attributes dummy (garden, backyard or swimming pool)		0.036		
Service entrance (dummy)			0.136	

Elevator (dummy)			0.012	
Number of apartments per building			-0.00035	
Index of quality of the area (good lighting, housing conditions in the area, sidewalks, trees, parks, and absence of factories, railroad tracks, dumps, areas prone to inundation)		0.022		
Distance to closest avenue or major street, meters	-0.000108			-7.06E-05
Distance to MR River (category from close (1) to far (4))	**0.073**	**0.019**	**0.045**	**0.028**
Distance to an informal settlement, blocks	0.006	0.001	0.004	0.003
Street lighting quality			0.081	
Area gets inundated (dummy)				-0.049
R-squared	0.75	0.76	0.66	0.80

Distance is included in the hedonic function in Models 1, 2 and 3 as a proxy for the smell variable. While this has been done in some other studies of water quality, omission of important variables that are correlated with distance but cannot be included in the equation would result in upward bias of the estimated parameters and overall benefits. Model 4 that pools all the data includes the distance variable separately from the dummy variable describing whether the property is affected by smell (from any source, not only the MR river). Using the estimated coefficients from Models 1, 2 and 3, the predicted increase in property value with average characteristics for the survey sample is around 15 percent when the bad smell is eliminated and 8.5 to 31 percent when sewerage is provided (Table 10). The results of Model 4 that pools the data for all property types and uses both the distance variable and the dummy variable for the presence of smell in the area—and therefore is not affected by this possible upward bias—corroborates these findings. Using the coefficients from Model 4, an increase in the price of an average property is around 6 percent when the smell is eliminated and around 19 percent when sewerage is provided. For the project evaluation, this means that roughly halving the benefits from an increase in property values associated with the elimination of bad smell from Models 1, 2 and 3 would yield a conservative (and unbiased) measure of this project benefit.

Table 10. Impact of sewerage and the presence of smell on an average property

(predicted prices of an average property)	Empty lots	Houses	Apartments
Affected by smell, US$	54,269		47,080
Unaffected by smell, US$	63,908		55,516
Difference, US$	9,639		8,436
Difference, % per m2	**15%**		**15%**
With a sewerage connection	57,683	76,935	53,151
Without a sewerage connection	44,061	61,872	48,988
Difference, US$	13,622	15,063	4,163
Difference, % per m2	**31%**	**24%**	**8.5%**
<u>Categories by distance to MR</u>			
Over 20 blocks		80,690	
11 - 20 blocks		77,300	
6 – 10 blocks		74,054	

Less than 5 blocks	70,943
Increase in property value as it moves from one distance category to the next	**4%**

As table 10 shows the value increase of the properties due to access to sewerage connection varies from 8.5% when the property is an apartment to 31% when it is an empty lot. For this evaluation it was decided to work with 8.5% for all the properties to be conservative.
The magnitude of the benefits from cleaning up the MR river for specific properties varies. As expected, the results show that once the MR river is cleaned-up, the closer the property is to the river, the higher the value of the benefits. The impact on property values varies with distance, with type of property (house, apartment or empty lot), and with location (properties in the capital BsAs have higher impact than those on the Provinces). These results are also consistent with the WTP results, which indicate that after 20 blocks there is no impact on the property value. Tables 11 and 12 present the results in absolute value as well as in percentage terms.

Table 11. Impact of the clean-up of the MR River on property values. (US$/m2)

Distance to MR River (blocks)		**1 a 5**	**6 a 10**	**11 a 20**
Houses				
Increase in value u$s/$m^2$	City of BsAs	95.67	65.16	33.29
	Province	69.47	47.32	24.18
Apartments				
Increase in value u$s/$m^2$	City of BsAs	83.42	49.91	23.38
	Province	81.15	48.55	22.75
Empty Lots				
Increase in value u$s/$m^2$	City of BsAs	51.06	30.95	14.64
	Province	24.22	14.68	6.94

In percentage terms the results are as follows:

Table 12. Impact on property value when the project of clean-up of the MR River is implemented

Distance to MR River	*Houses*	*Apartments*	*Empty lots*
Up to 5 blocks	14.0%	10.9%	18.3%
Between 6- 10 blocks	9.1%	6.3%	10.3%
Between 11-15 blocks			4.6%
Between 11- 20 blocks	4.5%	2.8%	

The hedonic pricing technique was not used to estimate benefits of an improvement in the Rio de la Plata, given that along the coast where the benefits will occur there is no urban development and so no properties whose prices could be included in the study; and most of the properties are natural reserves owned by the Federal Government. Thus, the recreational benefits from the clean-up of Rio de la Plata can only be assessed using the stated preference data obtained from the Contingent Valuation method.

5.3 Avoided Costs

This technique was used to estimate two types of benefits to be attained with the project: (i) sewerage connection; and (ii) protection of water intakes. The obtained results were used very carefully to avoid double counting of benefits. Access to sewerage was evaluated through hedonic pricing and avoided costs approaches, using the results only for comparison purposes. The results

obtained for the protection of water intake through the avoided cost approach were not added to the results obtained with the willingness to pay method, since they were implicitly included in the WTP; however they were added to the results obtained with the hedonic price for the clean-up of the MR River (tables 15 and 16).

5.3.1 Avoided Costs when connecting to sewerage.

Currently 54% of households located in the MR basin do not have access to a sewerage connection. They use different solutions for sewage disposal: 30% of households have septic tanks, 17% have holes with no septic chambers, 18% have other solutions, such as illegal discharge to the drainage system or direct discharge to the street. The latter solutions require the operation of a manual pump. When households have access to the public sewerage connection, they will not have to operate these on-site systems and this results in cost savings. On the other hand, households will have to pay the bill from the water and sewerage utility. The difference between these two costs is the lower bound on households' benefits.
Apart from this gain (assuming the increase in their bills is lower than the cost savings), households may incur additional health benefits and further benefits from having a more convenient sewerage disposal system when a connection to public sewerage is provided. The additional health benefits may be incurred by households if the private sewerage solutions they use in the absence of sewerage are less optimal from the public health perspective than a public sewerage connection. If the private systems are not maintained and operated in an optimal way, households incur an increased risk of water-borne illnesses compared to the situation when the systems are optimally maintained. The assessment of this residual health risks has been being carried out. Since the averting actions (pumping and maintaining sewerage systems) does not completely eliminate the health risks for all households—particularly with improper system maintenance—the residual health risks remain and the costs of illness (averaged for the population) can be added to the averting costs (on average for the population) to obtain the total benefits of sewerage provision. This will not result in double-counting of project's benefits.

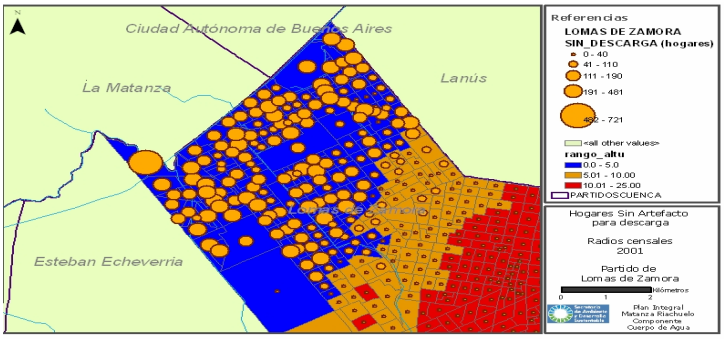
Current costs of on-site sewage disposal systems vary depending on the frequency of cleaning, volume of discharge and very important in this area, the altitude where the house is located. According to the Water National Institute of Argentina (INA), the level of the water table has increased in the Metropolitan Area of Buenos Aires[12] during the past few years, which has caused frequent floods and tanks overflow. The municipalities located in the MR basin are the most affected.

The frequency of the floods is higher due to the increase of the water table, which has increased due to: changes in rainfall frequency and intensity; urban growth; high per capita water consumption; water losses; lack of sewerage service; and expansion of the water service. According to INA, the areas in the MR basin, which have seen greater expansion of the water network than of sewerage coverage as well as improvement of drainage system, have had more problems with the level of phreatic surface. Before the expansion of the water system, these areas used to pump up groundwater with individual wells. When the households were connected to the water system, the water utility has been providing water taken mostly from surface water sources (Rio de la Plata). Individual wells were then closed and the aquifer increased. The problem became more complex when water coverage did come along with neither sewerage expansion nor improvement of drainage system; consequently the on-site sewage systems are discharging wastewater into the aquifer, increasing its water level and also contaminating it.

[12] Instituto Nacional del Agua INA. *Elevación de Napas en el Conurbano Bonaerense: Caracterizacion Integral y Responsabilidades Emergentes.* Ezeiza, Mayo 2007.

Additionally, the metropolitan region of Buenos Aires (which includes some municipalities of the MR basin) is more vulnerable to floods, given that: (a) topographically, the area is characterized for being a plain region: short courses with little permanent flow, irregular routs, and broad flood valleys; (b) it is affected by the strong winds from the southeast, *sudestadas*, which produce a rise of the de la Plata River high above its average; and (c) a considerable part of this area is between 2.8 mt and 5 mt above mean sea level[13].

In order to get a better understanding of the situation in which the population of the Basin is, ACUMAR, used a Geographic Information System (GIS) to prepare, for each municipality, data on number of households with on-site sewage systems arranged according to height above sea level. Figures 2 and 3 show the results obtained for Lomas de Zamora and Northeast region of La Matanza



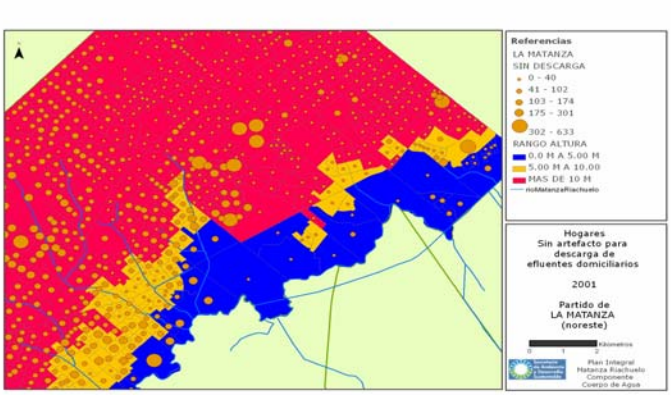


Table 17 shows the number of households distributed according to height above sea level and type of sewage discharge system. Information corresponds to 2001 Census updated by ACUMAR.

Table 17. Number of Households in the MR Basin arranged by type of sewage disposal system and height above sea level.

	Number of	*% Distribution of hh according to height above sea*

[13] AIACC (Assessments of Impact and Adaptations to Climate Change). *Vulnerability to floods in the Metropolitan Region of Buenos Aires Ander Future Climate Change.* Working Paper No. 20. April 2006

	households	level			
		0-5 mt	5-10 mt	Higher than 10 mt	total
hh with sewerage connection	332,707	19.8%	22.6%	57.6%	100%
hh with septic tank	281,773	15.4%	41.9%	42.7%	100%
hh with pit	176,839	25.3%	45.3%	29.4%	100%
hh with other solution	178,369	23.3%	33.8%	42.9%	100%
Total households	*969,688*	*20.2%*	*34.4%*	*45.4%*	*100%*

The estimation of on-site sewage disposal systems' operating costs was made taking into account the water table level for each municipality, the altitude where the houses are located, and the type of on-site sewage disposal system. The costs were calculated for proper maintenance of the systems according to the water table level in a particular location. The information collected from the willingness to pay survey and a small sample of households with on-site systems reveals that many of the households incur lower costs given improper system maintenance. This is the main reason why so many tanks overflow on a regular basis.

Costs of on-site sewage disposal systems. To estimate the current costs of on-site sewage systems, the Secretariat of Environment, as part of preparation of the economic evaluation, hired a Consultant, to carry out a survey in Lomas de Zamora, Lanus, and Almirante Brown, and find out the investment and operating costs for each type of system[14]. The Consultant corroborated the information obtained from the population, with: (a) providers of sewage disposal systems; (b) operators of vacuum pumping trucks; and (c) sanitary engineers. After gathering and analyzing all the information, the following results were obtained (Results are presented in Table 18 and in more detail in Annex 4)

Table 18. Costs of on-site sewage disposal systems

	Septic tank	Pit	Manual pump	No disposal
Investment Cost				
Construction (Ar$)	2,200	1,800	280	280
Lifetime (years)	8	6	5	5
Mantainance (cleaning cost)	120	120	10	6
Frequency required:				
If <10 mt above sea level (times/ year)	4	4	12	12
If >than 10 mt above sea level (times/yr)	2	2	12	12
Cleaning cost per year				
< 10 mt	480	480	120	72
> 10 mt	240	240	120	72
Investment and O&M costs				
Ar$				
Annual cost (Ar $)				
< 10 mt	923	918	198	150
> 10 mt	683	678	198	150
US$				
Annual cost (US $)				
< 10 mt	290	290	63	47
> 10 mt	216	214	63	47

[14] Bergman, Roberto. *Beneficios Asociados por las Obras de Cloacas en Almirante Brown, Lanus, y Lomas de Zamora.* March 2008.

Costs of in-house adjustments. Households that rely on on-site sewerage solutions incur an additional investment cost of making an "in-house adjustment" to be able to connect to their on-site sewerage system. This cost is treated in this analysis as a further economic cost incurred by the customers. Most households that make this in-house adjustment have their septic tank or their pit located in the back yard. A cost ranging from US$ 150 to US$ 250 was assumed depending on the type of adjustment. This cost was applied to about 40% of the households.

5.3.2 *Avoided cost for water intake.*

If the project is not implemented, AySA would have to move the Bernales water intake to a site further out into the Rio de la Plata. With the project, AySA would avoid the cost of having to move the Bernales intake. All sewage discharge will have an appropriate treatment and through the outfalls will dilute into the Rio de la Plata at an adequate distance from the water intake. Currently, the Bernales water intake is close to the point of the untreated sewage discharge, and even though at present the water quality at the intake is deemed to be of adequate quality by AySA, pollution may require moving the water intake further out into the river in the near future. That water intake has been previously moved by AySA to ensure adequate water quality at the intake.

If the project is implemented, AySA will avoid incurring this cost and hence it is a financial benefit generated by the project. This cost was calculated by AySA and it is estimated at US$ 140 M in present value. This cost however is a purely engineering cost estimate that does not provide an estimate or a bound to the welfare impact of protecting water quality at the water intake. This is useful information from the financial point of view, but the cost could theoretically be lower or higher than the benefits to the population.

The actual benefit of protecting water quality has been estimated through estimation of the health cost caused by poor water quality at water intakes, the results are shown in the next section.

5.4. Cost of Illness (Health Benefits)

Expansion of sewerage and protection of water intakes results in substantial health benefits through the reduction of diarrheal mortality and morbidity as well as reduction of the risk of other water-borne diseases. For this project, the value of risk reduction from diarrheal morbidity and mortality was estimated using the benefit transfer approach to the value of statistical life (Strukova 2008).[15] The estimation of the risk reduction uses the data on the value of statistical life estimated for developed countries and adjusted by the income differences between those countries and Argentina; the expected risk reduction in mortality and morbidity from diarrheal diseases in children under 5 and in the rest of the population from meta-analysis of studies of health risk reductions; and data on the incidence and prevalence of diarrheal illness among children under 5 with different types of sanitation generated from the data collected by the Contingent Valuation survey as part of this project.

The health benefits analysis provides two estimates of cost savings: health benefits resulting from the provision of sewerage to households that will obtain connection through the project, and health benefits from the protection of drinking water quality. The latter estimation assumes that if the water intakes are not moved further out into the river, then in the absence of the project, drinking water quality would deteriorate with the incidence and prevalence of diarrheal illnesses rising as a result. The health costs analysis uses the average incidence and prevalence of diarrheal

[15] Strukova, Elena (2008). "Health Benefits of Water-Sanitation-and Water Source Improvements in Matanza-Riachuelo and De la Plata Basins." Background paper for the economic evaluation of the project.

illnesses prevalent at present—taking into account the fact that some households already undertake averting actions and incur averting expenditures to reduce their health risks in the absence of a public sewerage connection. For that reason, the health costs estimated using this approach can be added to the averting expenditures to obtain an estimate of total benefits from the provision of sewerage connections. It is crucial to point out that the averting expenditures incurred by the households do not fully mitigate the risk of diarrheal illnesses either because the non-network sewerage systems are not perfectly maintained (not cleaned frequently enough) or not all households undertake these maintenance measures. The estimated benefits from the reduction of diarrheal morbidity and mortality in children under 5 and the rest of the population are USD 29 per person for sewerage expansion and USD 6 per person for the protection of water the Bernales water intake in NPV terms (Table 19):

Table19 . Estimated benefits of interventions to improve sanitation and water quality at the source in MR Basin

Interventions	Sewerage expansion	Protection of water intake	Total
Population affected, million	2.1	5.7	5.7
Annual diarrheal illness reduction	40%	11%	
Annual diarrheal morbidity reduction, million USD	23	17	38
Annual diarrheal mortality reduction, million USD	38	15	49
Total annual health cost reduction, million USD	61	33	87
Annual health reduction per person (USD)	29	6	15

In addition, Strukova (2008) estimates the value of the time savings associated with the provision of public sewerage. With improved sewerage connection, each adult saves about 5 minutes per day. If those time savings are valued at 75 percent of average wages, i.e. 75 percent of 80 ARS per hour in Argentina, the NPV of the total time savings reaches USD 871 to 1,325 mln with a discount rate of 5 and 10 percent, respectively. However, valuation of time savings is controversial in the literature and detailed site-specific data are preferable for obtaining reasonably robust estimates of the value of time savings. In order not to overestimate the project's expected benefits, the value of time savings has not been added to the total project benefits and it is not part of the calculation of the project's overall rate of return.

6. Financial Benefits

Financial benefits were estimated based on current sewerage tariffs charged by the water and sewerage utility (AySA), number of households connected to the sewerage network, and volume of sewage discharged. Financial benefits were projected for two scenarios: with and without the project. The "with project scenario" assumes that sewerage coverage will increase from the current level of 58% to 80% by 2012 for the entire AySA concession area (without including the city of BsAs the coverage will increase from 39% to 75%. Within the basin, the coverage will rise from the current level of 33% to 71%; and outside the basin, the coverage will rise from 48% to 81%). The "without project scenario" assumed that current sewerage levels remain constant.

AySA charges its customers every two months for water and sewerage services. The bill includes fees for both services, whose charges split equally (50% and 50%). Average sewerage bill per household every two months is about Ar$13 which corresponds to about US$ 4/hh every two months or US$ 2/hh/month. Table shows the coverage currently and in 2013, as well as average

bill charged to customers in all municipalities served by AySA and included in the master plan for sewerage expansion[16].

	Sewerage coverage		*Sewerage bill per household*	
	2007	*2013*	*Ar$/hh/ 2 months*	*US$/hh/ 2 months*
Inside the MR Basin				
Almirante Brown	7%	40%	12	3.94
Avellaneda	57%	70%	14	4.41
Esteban Echeverría	14%	80%	15	4.78
Ezeiza	14%	100%	15	4.85
La Matanza	44%	79%	11	3.35
Lanús	32%	56%	14	4.34
Lomas de Zamora	24%	90%	10	3.08
Morón	47%	54%	12	3.93
Total	33%	71%	12	3.75
Outside the basin				
Quilmes	52%	87%	13	4.09
Vicente Lopez	92%	92%	17	5.23
San isidro	60%	90%	14	4.41
San Fernando	61%	91%	14	4.59
San Martin	70%	100%	11	3.40
Tigre	8%	95%	16	5.18
Tres Febrero	66%	71%	10	3.18
Hurlingham	0%	8%	n.a	n.a
Ituzaingo	0%	9%	n.a	n.a
Subtotal	48%	81%	13	4.24
Total	*39%*	*75%*	*13*	*3.98*

The annual billing for sewerage services is currently close to US$ 20 million. By 2013, the revenue bill will be about US$ 37 million, assuming current tariffs and increase of coverage to 75%.

7. Results of the Evaluation

The results of the evaluation are presented for each component, and for the entire project. The components are: (i) sewerage expansion; (ii) clean-up of the MR River; and (iii) clean-up of both Rivers: MR and the la Plata River (RLP). The benefits of sewerage expansion are gradually included at same pace as investment; however the benefits from the clean-up of the both rivers are included after 10 years of start implementing the project, that is, at 2018.

7.1 Financial Results

Table 20 shows that financially the project is non-viable. The net financial loss is about US$ 455 million. This loss occurs even though 100% subsidy on investment costs was assumed, and hence only operating costs were included in the financial analysis. The negative returns result from the

[16] AySA. Plan de Expansion y Mejoras de los Servicios de Agua Potable y Desague Cloacal 2008/11-2012/17 S/IVA. 2008

low tariffs charged to customers. Sewerage bill per household do not cover operating expenses for the sewerage service[17], let alone wastewater treatment costs.
The required increase in sewerage tariffs would be about 140% to cover at least the operating cost.

Table 20. Financial Results

FINANCIAL RESULTS	NPV OF CASH FLOWS (000 US$)			
	Benefits	*Costs*	*Net benefit*	*IRR*
Sewerage	131,024	188,065	(57,040)	n.a
Clean up of the MR River	-	9,899	(9,899)	n.a
Clean up of the MR River and Rio de la Plata (includes MR river)	-	398,342	(398,342)	n.a
Total MR Project (clean up of MR is not included)	131,024	586,407	(455,382)	n.a

7.2 Economic Results

The project's expected benefits have been estimated using more than one valuation approach. In order to obtain the total expected benefits of the project, some of the estimated benefits can be summed up, while adding others would result in double-counting. Table 21 shows which methods can be used to evaluate the project's economic benefits by component:

Table 21. Choice of valuation methods to account for the project's benefits

Benefit	*Choice of the valuation method*
Access to sewerage	Hedonic pricing OR Avoided costs + health benefits.
Elimination of smell and recreation possibilities in the MR river	Hedonic pricing for households within 20 blocks of MR, AND contingent valuation for the households located farther than 20 in Greater Buenos Aires (WTP for MR) OR Contingent valuation for the whole population of GBA (inside and outside the MR basin): WTP for MR
Elimination of smell in the MR river, recreation possibilities in the MR river and Rio de la Plata, and protection of water intakes	Contingent valuation: WTP for MR + Rio de la Plata

[17] Same happens with water bill which does not cover water service operating costs.

Table 22. A range of estimates of project benefits

	Benefits of Sewerage Access	*Benefits of cleaning up of both rivers: MR and Rio de la Plata*
Estimation 1: Hedonic Price plus CV	Hedonic price	Hedonic price plus CV (> 20 blocks)
Estimation 2a: Avoided Cost sewerage (w/o health benefit) + CV	Avoided cost	CV
Estimation 2b: Avoided Cost sewerage (with health benefit)+ CV	Avoided cost plus COI (cost of illness)	CV
Estimation 3a: Avoided costs sewerage (w/o health benefit) and hedonic price and avoided cost water intake	Avoided cost	Hedonic price (MR) Avoided cost water intake
Estimation 3b: Avoided costs sewerage (with health benefit) and hedonic price of MR and health benefits	Avoided cost and COI due to lack of sewerage connection	Hedonic price (MR) COI of non enough protection of water intake
Estimation 4: Hedonic price sewerage and MR and avoided cost water intake	Hedonic price	Hedonic price (MR) Avoided cost water intake
Evaluation 5: Hedonic price sewerage CV for MR plus RLP	Hedonic price	CV (MR+RLP)

Table 22 shows five alternative ways of calculating the total project benefits without double-counting any of the benefits. Estimation 1 is the most robust, while Estimation 2 through 5 are reported for comparative purposes. Estimation 1 combines the hedonic estimates of the impact of sewerage provision and getting rid of the smell along the Matanza-Riachuelo river for the population within 20 blocks of the river with the contingent valuation estimates for the rest of the population of Greater Buenos Aires. The rationale for combining these two sets of results is the following. The prices of properties in proximity to the river are depressed by the smell and environmental contamination. The adverse effect of the river disappears beyond 20 blocks from the river, according to the analysis of the data from the Real Estate Survey. The WTP estimates for these households—while still higher than the average WTP—are much lower than the estimates of the benefits of getting rid of the bad smell obtained from the hedonic function. The most likely explanation is the fact that the stated WTP is much lower than the actual benefits the households would derive from the project because the respondents compare their WTP to the current water and sewerage bill, which is on average only 20 Argentinean pesos every two months (about US$3.2/hh/month). The hedonic estimates are likely to be closer to the true value of the benefits from removing the river's bad smell.

For the population living further than 20 blocks away from the river, the only way to estimate the value of the benefits from removing the bad smell of the river is through the contingent valuation approach, since housing prices are not affected by the river at such a distance.

Avoided costs for sewerage provision can be added to the estimated cost of illness from the residual risk attributed to lack of a sewerage connection, as discussed earlier (see the summary of

the results of health benefits estimation above). These results are useful for assessing the benefits from sewerage from another revealed preference method in addition to hedonic pricing. They are also useful for assessing the magnitude of the health costs (diarrheal and other illnesses) and for understanding how households cope with the absence of a sewerage connection and how much they have to pay for pumping sewerage. But given the methodological issues and the quality of the available data, this provides only a rough measure of the benefits. The measure of the benefits of sewerage obtained from the hedonic function in this project is more robust.

The results for each component using different approaches are presented in table 23.The results for the whole project are presented in table 24. The estimation yields the total benefits by combining the valuation of partial benefits obtained using different methodologies, without double counting those benefits.

Table 23. Economic results for each component	*NPV OF FLOWS (thousand US$)*			
	Costs	*Benefits*	*Net Benefit*	*IRR*
Sewerage component				
Avoided Costs (without health benefits)	925,660	1,340,975	415,316	18%
Avoided Costs (with health benefits)	925,660	1,802,285	876,625	27%
Hedonic Price for sewerage	925,660	2,019,987	1,094,328	76%
MR River				
WTP	489,896	454,880	(35,016)	10%
Hedonic Prices for MR River	489,896	644,238	154,342	16%
Hedonic prices plus WTP MR (non use value)	489,896	849,236	359,339	20%
MR River AND De La Plata Rivers				
WTP (MR+RLP)	1,415,631	538,480	(877,152)	
Hedonic price plus WTP (MR+RLP) non use	1,415,631	986,654	(428,977)	
Hedonic price plus Water intake	1,415,631	783,889	(631,743)	

Both components: sewerage, and the clean-up of MR River component are profitable. The net gain for sewerage is between US$ 415 million and US$ 1 billion depending on the approach (avoided cost or hedonic prices); the internal rate of return varies from 18% to 76%. The clean up of the MR river is profitable when benefits are measured including the results from hedonic price approach, with returns between US$ 150 and US$ 360 million; and IRR from 16% to 20%. However, the component for cleaning up Rio de la Plata requires the additional benefits for the sewerage component to become economically viable.

When benefits are added to get the benefit of the project, results vary depending on the approach used to add the benefits. Five different estimations were made based on combination of benefits, as shown in table 24. Estimation 1 is the most robust, as explained previously. The net returns are US$ 0.6 billion and economic internal rate of return is 28%.

Table 24. Results for the whole project using different approaches

Approaches for measuring benefits	*Benefits per component*				*Total project*			
	Sewerage		*M-R+RLP*		*Total Benefits*	*Costs*	*Net benefits*	*IRR*
	Approach	*NPV (000US$)*	*Approach*	*NPV (000US$)*	*NPV (000 US$)*			
Combination 1: Hedonic price plus CV	Hedonic price	2,019,987	Hedonic price CV (> 20 blocks) Total	644,238 342,416 986,654	3,006,642	2,341,291	665,350	28%

Combination 2a: Avoided Cost (w/o health benefit) Plus CV	Avoided cost (w/o health benefits)	1,340,975	CV	538,480	1,879,455	2,341,291	(461,836)	
Combination 2b: Avoided Cost (with health benefit)plus CV	Avoided cost Health benefit Total Benefit	1,340,975 461,309 1,340,975	CV	538,480	2,340,765	2,341,291	(526)	11%
Combination 3a: Avoided Cost (without health benefit) Plus Hedonic Price	Avoided cost	1,340,975	Hedonic price M-R Avoided cost water intake Total	644,238 139,651 783,889	2,124,864	2,341,291	(216,427)	
Combination 3b: Avoided Cost (with health benefit) Plus Hedonic Price	Avoided cost Health benefit Total Benefit	1,340,975 461,309 1,802,285	Hedonic price (M-R) Health benefits of protection water intake Total	644,238 185,389 829,627	2,631,912	2,341,291	290,621	14%
Combination 4: Hedonic Price plus avoided cost	Hedonic price (sewerage)	2,019,987	Hedonic price (M-R) Avoided cost water intake Total	644,238 139,651 783,889	2,803,876	2,341,291	462,585	31%
Combination 5: Hedonic Price plus CV	Hedonic price	2,019,987	CV (M-R+RLP)	538,480	2,558,467	2,341,291	217,176	18%

8. Distributive Impact

The difference between economic and financial flows represents rents or monetary flows that accrue to someone other than AySA. Taxes represent monetary flows accruing to the government, while subsidies are transfers from the government to AySA. Winners and losers from the project were identified by decomposing economic and financial costs for each input of the project and then estimating the difference between economic and financil results. This analysis uses the economic results obtained with Estimation 1, which was considered the best approach.

As table 25 shows, the big winners are the customers with a return of US$ 2.8 billion. If this benefit is distributed among the poor and non poor, assuming the poor are those who lack basic services, which corresponds to 23%, according to geographical information of beneficiaries and the 2001 Census, results show that poor beneficiaries will reap about US$ 0.6 billion of this profit. The earnings come from the benefits obtained with the increase in property values when sewerage service is connected; this benefit offsets the payment these households have to make to AySA when connected and billed, as well as the investment cost they incur to adjust in-house connections. The big looser is the government due to the subsidy to the investment, which is not

offset by the higher taxes received; the total loss for the government is about US$ 1.6 billion. The net gain for the economy as a whole is US$ 1.1 billion (table 25).

Table 25. Distributive Impact	*NPV of Flows ('000 US$)*			
	Sewerage	*MR*	*MR and RLP*	*Total*
Government				
Fiscal Impact				
Taxes on Investment	136,714	154,119	218,900	355,614
Taxes on Operating costs	32,639	1,718	69,134	101,773
Total taxes	169,354	155,837	288,034	457,387
Subsidy on Investment	(787,735)	(888,017)	(1,261,280)	(2,049,015)
Subsidy on Operating cost	-	-	-	-
Total Subsidy	(787,735)	(888,017)	(1,261,280)	(2,049,015)
Net Fiscal Impact for Government	(618,381)	(732,180)	(973,246)	(1,591,628)
Customers				
Poor Population				
Payments for the service to AySA	(30,136)	-	-	(30,136)
Benefits for increase in property value	464,597	148,175	148,175	612,772
Benefits from non use value	-	-	78,756	78,756
Costs of in house adjustments	(15,853)	-	-	(15,853)
Net benefit for poor Customers	418,608	148,175	226,930	645,539
Non poor population				
Payments for the service to AySA	(100,889)	-	-	(100,889)
Benefits for increase in property value	1,555,390	496,063	496,063	2,051,453
Benefits from non use value	-	-	263,661	263,661
Costs of in house adjustments required for connection	(53,074)	-	-	(53,074)
Net benefit for non poor customers	1,401,428	496,063	759,724	2,161,151
Total customers				-
Payments for the service to AySA	(131,024)	-	-	(131,024)
Benefits for increase in property value	2,019,987	644,238	644,238	2,664,225
Benefits from non use value	-	-	342,416	342,416
Costs of in house adjustments required for connection	(68,927)	-	-	(68,927)
Net benefit for all Customers	1,820,036	644,238	986,654	2,806,690
Others				
Labor	9,301	37,749	(9,749)	(447)
Suppliers	(59,588)	214,434	(34,294)	(93,882)
Total others	(50,287)	252,183	(44,043)	(94,329)
Total Project	*1,151,368*	*164,241*	*(30,635)*	*1,120,733*

9. Sensitivity and Risk Analyses

The results obtained in the analysis carried out so far assume certainty regarding all the variables. The sensitivity and risk analyses measure the impact of changes in assumed values for critical variables on the results. The sensitivity analysis measures the outcome if one of the variables changes while all others remain fixed. The risk analysis measures the outcome when all selected variables change at the same time, each one based on a probability distribution. Both analyses

were done to test the robustness of the economic outcome. The financial results were not tested given its non viability.

9.1 Sensitivity Analysis.

The variables selected as those conveying major risks were: (i) investment cost overrun; (ii) operating costs overrun; (iii) project delays; (iv) effective connection rate; (v) reduction of benefits from hedonic prices; and reduction of benefits from willingness to pay. Table 26 shows the impact on economic results when one of these variables changed while the other remain constant.

Table 26. Risk Variables and their Impact and Risk Significance

Investment cost overrun	Direct impact on investment costs. Largely under management control. Conveys a moderate risk to the economic results. The project would show positive returns for increase in value as high as 38 percent.
Operating costs overrun	Direct impact on operating costs. Largely under management control. Conveys a low risk to the economic results. The operating costs could overrun 87% and still shows positive results.
Investment delay	Direct impact on benefits. Largely under management control. Conveys a moderate risk to economic results. If the investment for cleanin up of both rivers is delayed up to 11 more years, the project would still show positive returns. The sewerage expansion investment could be delayed up to four years to allow positive returns. However when both investments are delayed more than two years, the project would show negative results.
Effective sewerage connection	It corresponds to the acceptance of population to effectively connect to the sewerage network and eliminate household on-site sewage disposal systems. It has a direct impact on benefits. It depends largely on the communication strategy of AySA and financial alternatives offered to the beneficiaries to make it easy to accept the connection and adjust households' in-house facilities. It carries an important risk for the project. The connection rate has to be higher than 65% for the project to still have positive returns.
Reduction of benefits from increase in property	Direct impact on benefits and beyond management control. It conveys a medium to low risk to the project. If the real state market does not react as expected, and the magnitude of the property value increase when sewerage is connected is only 33% of the assumed benefit, or just 2% of the assumed increase for the clean-up of the M-R river, the project would still show positive returns.
Reduction of benefits from WTP for environmental improvements in the two rivers	Direct impact on benefits and beyond management control. It conveys a low risk to the project. If the willingness to pay were zero for the non-use value (for the households living more than 20 blocks away from the M-R river), the project would still generate benefits totaling US$ 300 million and have a 26% internal rate of return.

9.2 Risk Analysis

To enhance the accuracy of the economic analysis, the uncertainties of the real world are approximated using Monte Carlo simulation with the Crystal Ball software. This software measure the extent of various risks and their impact on the results of the project by modeling a likely probability distribution that best describes the behavior of each of the selected variables. Based on a simulation of 1,000 trials the model recalculated the results of the financial and economic analyses by simultaneous changing each of the selected risk variables according to their probability distributions.

For each variable a probability distribution was chosen with the following criteria:

(i) For the willingness to pay, it was chosen a normal distribution with standard deviation of 2.76 for the MR and RP, and 2.94 for the MR River, according to results of the WTP survey.

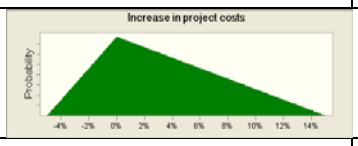
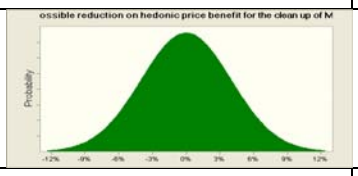
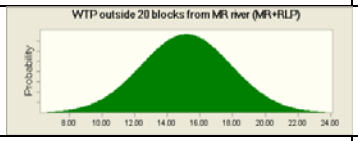
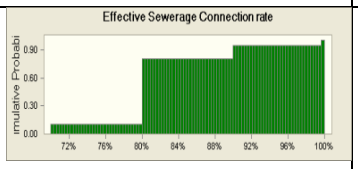
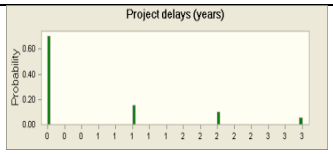
(ii) For the benefits of hedonic prices it was assumed a normal distribution with standard deviation of 4%, according to hedonic price results.

(iii) For costs overrun, it was assumed a triangular distribution with the likeliest outcome of none increase, minimum value a reduction of 5%, and maximum increase of 15%.

(iv) For project delays it was assumed a probability of no delays: 70%; one year delay: 15% probability; two years delay: 10% probability, and three years delay: 5%

(v) For connection rate it was assumed a 10% probability of a 70% connection rate; 70% probability for an 80% connection, 15% probability for a 90% connection; and 5% probability for 100% connection.

Table 25. Probability Distributive

Variable	*Distribution*	*Range*
Investment Cost Overrun		*Triangular Distribution with following parameters* *Minimum: -5%* *Likeliest: 0%* *Maximum: 15%*
Reduction in benefits from hedonic prices		*Normal Distribution with parameters:* *Mean: 0%* *Standard Deviation: 4%*
Willingness to Pay for the existence value of the clean up of both rivers		*Normal Distribution with parameters*: *Mean: 15.15* *Stvd Deviation: 2.76*
Connection rate		*Value* *Probability* 70% 0.10 80% 0.70 90% 0.15 100% 0.05
Project Delays		*Value* *Probability* 0 0.70 1 0.15 2 0.10 3 0.05

The result of the risk assessment shows that the probability of having a positive outcome is 67% which is very reassuring of the robustness of the project.

ANNEXES

Annex 1. WTP Study and Data Base(Diomira Faria)

Annex 2. Hedonic Price Study (Aydet)

Annex 3.

Beneficios Asociados por las obras de cloacas. Ingo. Roberto Bergman

Annex 4. Health Benefits of water sanitation and water source improvements in Matanza Riachuelo Basin (Elena Strukova)

Annex 5. Model used for Economic evaluation