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ECUADOR

GUAYAQUIL WASTEWATER MANAGEMENT PROJECT (P151439)

EXECUTIVE SUMMARY OF

THE ENVIRONMENTAL AND SOCIAL ASSESSMENT

March 15, 2015

Introduction

The proposed Ecuador Guayaquil Wastewater Management Project ("the Project") involves **four main components** as follows: 1) Installation of Household Connections; 2) Rehabilitation of Sewerage Network; 3) Wastewater Treatment Plant and Disposal Facilities; and 4) Project management and administration, including communication plan and management of social, environmental, and safety issues. These components are described in more detail below.

The overall Project impact is expected to be positive due to the improved effluent quality that will be discharged into the Guayas River and the reduction of untreated wastewater that is presently leaking from the existing sewer system and affecting shallow ground and surrounding surface water bodies, like the "Salado" Estuary.

The proposed Project has been classified by the World Bank, per OP/BP 4.01, as an Environmental Category A due to the type and size of the Project Component Three, the construction of the WWTP. This Component requires the expropriation of a 40.74ha area which is host to one resident, a radio antenna and a shrimp production facility. Because expropriation has been taking place prior to World Bank engagement a Remedial Resettlement Action Plan has been prepared, which when implemented, will ensure the expropriation process is in conformity with the World Bank's policy on involuntary resettlement. Related to Component Three, an Environmental and Social Impact Assessment (ESIA) has been developed by an international consulting firm[1] with the support of a local environmental consulting firm[2], under supervision of the Empresa Municipal de Agua Potable y Alcantarillado de Guayaquil (EMAPAG EP). The remaining sections of this document present an executive summary of the March 2015 ESIA for Component Three prepared by the mentioned consulting firms.

Project financed works in Component Two have relatively moderate potential negative environmental impacts and can be readily mitigated with standard measures, and even less impacts are associated with works in Component One. For Components One and Two, an Environmental and Social Management Plan (ESMP) was developed for each component and includes an assessment of potential impacts and proposed mitigation and monitoring measures. Component One will finance the installation and rehabilitation of household connections in specific areas of the City of Guayaquil, where household toilets discharge directly to the estuary or to reportedly poorly constructed and maintained pits or septic tanks, which contributes to the degradation of the Estero Salado. The works involve establishing a connection from an existing sewer line on the street to a house, and the potential environmental impacts are relatively minor. Component Two involves the rehabilitation of the sewerage network in "La Chala" basin and will improve sewer efficiency by reducing infiltrations and contribute to the reduction of the contamination of the Salado estuary from domestic wastewater. The works should have relatively minor to moderate potential negative environmental impacts during construction (for example, generation of noise and dust, minor traffic disruption, disposal of waste) and can be readily mitigated with standard measures established in the ESMP. Even less impacts are associated with works in Component One. The ESMPs include a "chance finds" procedure and natural habitat protection measures to be used if needed given the proximity to the works and the Guayas River and the Salado Estuary. The draft ESMPs for Components One and Two were disclosed and consulted in January 2015, and

[1] Hazen and Sawyer P.C.
[2] Consultambiente Cía. Ltda.

revised ESMPs have been prepared by EMAPAG EP and disclosed on February 27, 2015.

Project Components

1. **Component One: Installation of household connections (US$18 million, with US$2.8 million of IBRD loan financing).** This Component will finance the installation and rehabilitation of household connections in specific areas within the southern districts of the City of Guayaquil.[3] These districts are equipped with a dense sewerage collection network which, although requiring rehabilitation of main collectors to reduce infiltration, reaches and could serve almost all inhabited areas. Nonetheless, despite a broad network coverage, just 82 percent of the households in the area are currently actually connected to the system. Most of the remaining 18 percent (around 30,000 families) are poor households located in Suburbio Oeste, Isla Trinitaria, Sector Guasmo and Casco Central sectors, which are riparian areas of the Estero Salado estuary, where household toilets discharge directly to the estuary or to reportedly poorly constructed and maintained pits or septic tanks, which contributes to the degradation of the Estero Salado.[4] Although many houses have a sewer passing in front, these households have not been connected—despite a legal mandate to do so—mainly because of the cost of the connection fee.[5] Under the Project, household connection costs—including the cost of required indoor works like piping, flooring, and others—will be partially subsidized and financed by EMAPAG EP (clients will pay EMAPAG EP the nonsubsidised segment in installments through the water bill). In parallel, a communication campaign will be launched to inform the beneficiaries about the initiative and its benefits and to promote improved hygiene and maintenance practices required to ensure the proper functioning of the condominial sewer system. The design of this Component has been developed based on previous successful experiences with connection campaigns led by EMAPAG EP, which managed to increase effective access to piped sanitation up to 98 percent in other districts of the city with high poverty rates.[6]

2. **Component Two: Rehabilitation of sewerage network (US$37 million, 100 percent financed by IBRD).** This Component will finance the rehabilitation of the sewerage network (including sections of the primary, secondary and tertiary network) in La Chala basin (Suburbio Oeste area), which, as stated above, is riparian to the Estero Salado estuary. The main collectors in this area have been identified to require urgent rehabilitation to reduce wastewater losses and enable their effective collection function. This Component of the Project aims at reducing

[3] With regard to the potential minor expansion of the secondary and tertiary networks which might be required in specific neighborhoods within the area to enable the installation of household connections, EMAPAG EP has agreed to include these within Interagua's annual network expansion targets. This will require coordinated planning with Interagua based on a plan for the connection of the different neighborhoods, which is already under preparation by EMAPAG.

[4] To address the problem of domestic discharge coming from neighborhoods which are riparian to the estuary on the northern side, there are three ongoing projects managed by EMAPAG EP to connect around 25,000 households to the sewerage network currently under implementation. These projects, which combined the household connection component financed by the proposed project and the *Guayaquil Ecológico* program jointly financed by the GoE and the municipality of Guayaquil, are jointly expected to completely eliminate domestic discharge to the estuary.

[5] This cost is US$500 and includes the cost of emptying and sealing of the septic tank or other on-site sanitation solution.

[6] Once home owners in a specific neighborhood have agreed to be connected to the sewerage network, a contractor hired by EMAPAG EP will carry out the installation in close coordination and consultation with each home owner. Once the work is finished, the home owner will sign a certificate that they are satisfied with the works constructed and acknowledge their connection to the service.

infiltrations in the south sewerage subsystem, thus contributing to reduction in the contamination of the Estero Salado estuary from domestic wastewater. It is estimated that of the total volume of wastewater collected and pumped in the pumping station of La Chala, approximately 25 percent corresponds to ground water infiltration,[7] which also increases wastewater pumping and treatment costs. Also, some segments of the Suburbio Oeste sewer network that are meant to function as gravity mains get pressurized during periods of high tide, which again suggests a high infiltration rate.

3. **Component Three: Wastewater treatment and disposal facilities (US$161 million, with US$58.5 million of IBRD loan financing).** This Component will finance the construction of a new WWTP, called Las Esclusas WWTP, and associated pumping and transmission facilities to treat 100 percent of the wastewater collected in the southern districts of the city of Guayaquil within the design year of 2045. Wastewater generated in the south subsystem is currently collected in two sewer mains: (a) the Guasmo sewer main, which conducts an average flow in dry weather of 0.60 m^3/s into the Guasmo H pumping station from where wastewater is pumped directly into the Guayas River through a 180 m long pipeline and an underwater outfall diffuser, and (b) the Parson's Sur sewer main, which conducts 2.10 m^3/s in dry weather into the La Pradera pre-treatment station (equipped with a mechanized pre-treatment, a disinfection system that is presently out of service and a underwater outfall diffuser). **Therefore, wastewater is currently discharged into the Guayas River with very little or no treatment**, failing to comply with the contaminants concentration thresholds established in the National Norm on Environmental Quality and Effluent Discharges (NCADE in its Spanish acronym).[8] To address this situation, EMAPAG EP will construct, through this Project, a new WWTP, Las Esclusas WWTP, near the current point of discharge of the Guasmo sewer main, which will treat all the sewerage collected in the south subsystem.

4. Different technological alternatives for the wastewater treatment were analyzed by EMAPAG EP before the Bank's involvement to develop the design of the treatment facility and these were discussed with the Bank during preparation. The Chemically Enhanced Primary Treatment (CEPT) option was retained after an alternative analysis was conducted since it will allow the municipality of Guayaquil to consistently meet the national regulatory authorized limits set for the Total Suspended Solids (TSS) below 100 percent and BOD below 100 percent and all other pollutant concentrations. CEPT is also considered a flexible technology which can easily be adapted to changes in influent operating characteristics or potential future stricter standards. The feasibility study commissioned by EMAPAG EP included a thorough analysis of 19 secondary treatment process alternatives, including aerobic and anaerobic processes,[9] and there is sufficient area and several options to install secondary treatment in the future.

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[7] The storm drainage and sewerage systems are separate systems but there is infiltration of rainwater into the sewerage system due to the poor conditions of the network.

[8] The NCADE sets the maximum limits for effluent quality standard at: BOD_5 = 100 mg/L; SST = 100 mg/L; Total coliform =100 NMP/100 ml. The effluent discharged at Guasmo H does not comply with these limits as BOD and TSS concentration in the raw wastewater is very high. The effluent discharged at La Pradera does comply with the NCADE most of the time, given the high dilution of the water that arrives into the facility due to ground water infiltration into the sewerage system.

[9] The secondary treatment alternatives analyzed had 19 processes, including aerobic and anaerobic solutions. The trickling filters process was selected as the most cost-effective and preferred option for secondary treatment.

5. **Component 4: Project management and administration, including communication plan and management of social, environmental, and safety issues (US$5.4 million with US$4.2 million of IBRD loan financing).** This Component will finance activities associated with overall project management by EMAPAG EP, including Project-related audits, monitoring and evaluation, equipment and training to strengthen the implementing entity, as well as individual consultants. It will also include support to EMAPAG EP related to the planning and management of environmental and social issues and safeguards. Specifically, this Component will fund: (a) a study to set up a system for the physiochemical, bacteriological, and limnologic monitoring of the Guayas River water quality;[10] (b) a study to set up a system for the physical-chemical, bacteriological, and limnologic monitoring of the Estero Salado estuary water quality in relation with Project Components One and Two; (c) a master plan for the management and final disposal or reuse of the bio-solids which will be produced at the Las Esclusas WWTP and other planned WWTPs (Los Merinos, Asuncion City, and others); (d) communication campaigns and technical assistance for community development and training; (e) a Project Impact Evaluation (IE); and (f) an integrated urban water management study for the planning of development and infrastructure in a growing flood-prone area of the city of Guayaquil (Sistema Tres) which requires interventions in urban drainage and wastewater management.

[10] The scope of this study is to be defined during project preparation and the objective is to enable monitoring of the Guayas River water quality at different points, which in turn will enable measuring of the benefits of the Las Esclusas WWTP and other future treatment plants on the water quality of the Guayas River.

Executive Summary

Environmental and Social Impact Assessment

Las Esclusas Waste Water Treatment Plan Project

March 2015

Hazen and sawyer, P.C. and Consultambiente

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Abbreviations and Acronyms

CEPT	Chemically Assisted Primary Treatment (*Tratamiento Primario Químicamente Asistido)*
EIA	*Estudio de impacto ambiental* (Environmental Impact Assessment)
EMAPAG EP	Empresa Municipal de Agua Potable y Alcantarillado de Guayaquil
LBA	*Línea Base Ambiental* (Environmental Foundation Baseline)
MAE	*Ministerio del Ambiente del Ecuador* (Ministry of Environment of Ecuador)
MG	Militamices Giratorios (Rotary Miliscreens)
PIC	Public Information Centers (*Centros de Información Pública*)
PMA	*Plan de Manejo Ambiental* (Environmental Management Plan)
SUMA	*Sistema Único de Manejo Ambiental* (Unique Environmental Management System
MAE	*Ministerio del Ambiente* (Ministry of Environment)

1. Project Background

The Project involves the construction of a new wastewater treatment plant (WWTP), called "Las Esclusas WWTP, and associated pumping and transmission facilities to treat 100 percent of the wastewater collected in the southern districts of the City of Guayaquil within the design year of 2045. Wastewater generated in the south subsystem is currently collected in two sewer mains: (i) the "Guasmo" sewer main, which conducts an average flow in dry weather of 0.60 m^3/s into the "Guasmo H" pump station from where wastewater is pumped directly into the Guayas River through a 180 meters long pipeline and an underwater outfall diffuser; and (ii) the "Parson´s Sur" sewer main, which conducts on dry weather 2.10 m^3/s into the "La Pradera" pre-treatment station (equipped with a mechanized pre-treatment, a disinfection system that is presently out of service and a underwater outfall diffuser). Wastewater is currently discharged into the Guayas River with no, or very little, treatment, which fails to comply with the contaminants concentration thresholds established in the National Norm on Environmental Quality and Effluent Discharges (NCADE in its Spanish acronym).

To address this situation, EMAPAG EP plans to construct a new wastewater treatment plant (WWTP) in the proximity of the current point of discharge of the Guasmo sewer main, which will treat all the sewerage collected in the south subsystem and will require: the adaptation of the Guasmo H pump station and the construction of a new pipeline to drive pumped water to the new treatment facility in Las Esclusas WWTP; the decommissioning of La Pradera pre-treatment station, the construction of a new pump station in the premises, and the construction of a pipeline to drive pumped water to the new treatment facility in Las Esclusas WWTP; construction of Las Esclusas WWTP, a new treatment facility for a design dry and wet flows of 2.7 m^3/s and 3.5l5 m^3/s. The facility will be equipped with mechanized pre-treatment, chemically enhanced primary treatment (CEPT), disinfection system, underwater outfall diffuser and hypochlorite production; and construction of a sludge digester.

2. ESIA Objectives

The objective of the ESIA is to establish the environmental and social impacts of the Project, and to propose an Environmental Management Plan including measures needed to mitigate the negative impacts that the project could generate. The Environmental and Social Impact Assessment will ensure the project's compliance with national laws and local ordinances, and will allow the Owner to perform the processes required for the authorization of the project's design and construction. The ESIA also complies with applicable World Bank safeguard policies.

The following are the specific objectives of the ESIA:

- To determine the area of direct and indirect influence of the project.
- To establish the Environmental Baseline (LBA, as per its acronym in Spanish) of the existing situation, that will allow an appropriate reference to assess potential project impacts.

- To identify and assess environmental and social impacts that may occur on biotic, physical, socioeconomic and cultural environments, associated with the different stages of project implementation.

- To compare basic design alternatives related to environmental and social aspects to assist in identification of the preferred design alternative from an environmental point of view.

- To propose the Environmental Management Plan to be applied in the construction and operation phases to enable timely implementation of measures for prevention, control, compensation, mitigation and rehabilitation of areas impacted by construction and operation activities; the Plan will emphasize on the following aspects: response to eventualities and contingencies, environmental monitoring, training, occupational health and industrial safety.

- To support the Citizen Participation Process set forth by the relevant law and its regulations in order to include in the Environmental Management Plan comments and requirements of the community in the area of influence, with which the Promoter may obtain the respective Environmental License.

3. Background on Guayaquil's Wastewater Management

3.1 Sanitary Sewer Collection System

Guayaquil's sanitary sewer collection system consists of 3,926 km of collectors and 61 wastewater pumping stations that provide coverage to 70 percent of the area of service. The city has separate sanitary sewer and storm drainage systems. Sanitary sewer networks are designed to discharge into Daule-Guayas Rivers, while the storm drainage is designed to discharge into the Estero Salado. Guayaquil generates approximately 280,000 m^3/day (3.24 m^3/s) of wastewater during the dry season, and 350,000 m^3/day (4.05 m^3/s) during the rainy season.

Due to the location of the City in relation to the Daule-Guayas Rivers and the Estero Salado, and the advanced age (estimated between 30 and 50 years) and condition of existing pipelines, considerable infiltration of groundwater into the sanitary sewer takes place. Also, tides in the river, with fluctuations up to 4 meters, influence the operation of the sewer system. As such, during high tide wastewater cannot be freely discharged by gravity into the river. This creates a need for control valves and pumping stations, causing the storage of the wastewater in the pipelines upstream of control structures.

Most of the City's wastewater receives pretreatment prior to discharge into the Guayas River. There are 2 discharges in Progreso and Pradera, and Guasmo subfluvial outfall. However, due to the large effect of dilution and self-purification of Guayas River (average flow ranges between 500 and 2,200 m^3/s in dry and rainy seasons), wastewater discharges do not degrade dissolved oxygen levels in the river. The greatest effect of the discharge of raw sewage water into the Guayas and Daule Rivers is aesthetic contamination and bacteriological contamination. However, sources of contamination along the basin of these rivers are diverse.

The main negative aspects of contamination of the receiving bodies are related to:

- Contamination of aquatic life (flora and fauna).
- Bacteriological contamination of rivers which are used for secondary contact recreation.
- Damage to the aesthetic appearance of the rivers in the stretches in front of Guayaquil due to the growth of aquatic plants and floating materials.

3.2 Treatment System

In order to deal with the above mentioned situation, EMAPAG and INTERAGUA have taken concrete measures to improve sanitary conditions in the city, including works to provide the city 100 percent coverage and connection to the sanitary sewer and plans to complement the treatment of 100 percent of wastewater produced by Guayaquil, according to the Potable Water and Sewer System Master Plan of Guayaquil prepared in 2011.

General characteristics of the system in accordance to the City's drainage basins are described below:

1. **Las Esclusas WWTP.** Final designs are currently under development. Construction is scheduled from mid-2015. The wastewater drainage basin for this plant covers an area of approximately 5,913 hectares, will serve a population of 1,077,948 inhabitants (2010 Census) and consists of several pumping stations, collectors and final disposal works in the receiving body (the Guayas river); this basin has two main pumping stations (Pradera and Guasmo H) that discharge wastewater into the Guayas River, which are described below.

    - Pradera Pump Station - The Pradera pump station is located in the south central region of the City and collects wastewater from its own basin, as well as of nine pumping stations located upstream. Stations converging on Pradera collection basin are: Trinitaria 1, Trinitaria 2, Trinitaria 3, Trinitaria 4, Trinitaria 5, Trinitaria 6, Trinitaria 7, La Chala, and Guasmo B.
    - Guasmo H Pump Station - Guasmo H is a main pumping station similar to that described above; to this station converge seven secondary stations that complement the wastewater management system for Southern Sector currently existing in Guayaquil. The following are the secondary stations: Guasmo D, Guasmo E1, Guasmo B2, Guasmo F, Guasmo I, Guasmo J, and Guasmo G.

2. **Los Merinos WWTP**. The construction of this plant is planned for 2018. This WWTP will treat the water from the following sanitary basins.

    - Guayacanes-Samanes, Sauces-Alborada, Garzota, Mucho Lote, Simón Bolívar, Mirador del Norte, Los Alamos, Huancavilca Norte, Orquídeas, Pascuales, Inmaconsa, and Florida.
    - Flor de Bastion, which includes Systems 2 and 3 that will drain into Los Merinos WWTP in the short and/or medium term, depending on the development by stages of the treatment system.
    - Progreso Sanitary Basin.

3. **Puerto Azul Dry Wetlands WWTP**. Treatment using wetlands. Implementation to start this year (2015).

4. **Road to the Coast WWTP**. The regional Road to the Coast WWTP is planned to begin construction during the fifth year of the concession (2015), for which a 20 hectare lot is already available.

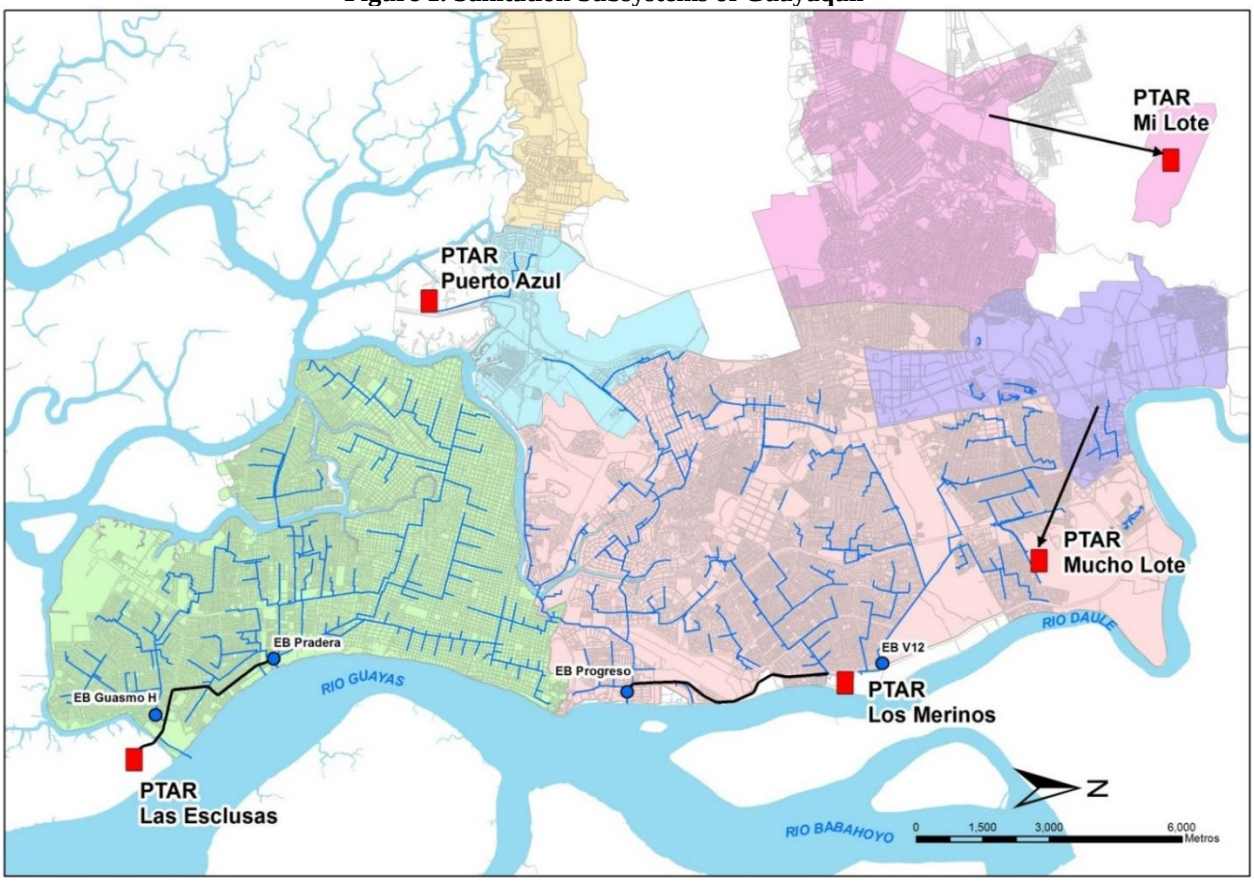
5. **Mucho Lote WWTP**. This project involves the rehabilitation of existing treatment systems type lagoons in Mucho Lote and Orquídeas, in order to convert them in aerated lagoons to expand treatment capacity. Currently under design process. Areas of contribution envisaged for this plant include the Inmaconsa Industrial sector, Pascuales, and some developments of Daule Road.

6. **Mi Lote WWTP**. In the premise where currently there are found treatment lagoons for housing development MI LOTE, the construction of a treatment plant for Flor del Bastion basin is planned.

Figure 1 shows the location of the WWTPs and the location of the main components of the main sewerage system (subsystems North and South) proposed for Guayaquil.

The proposed WWTP for the South Subsystem (Las Esclusas) is an important component of the overall Sanitation Program for the City of Guayaquil and the subject of this ESIA.

Figure 1. Sanitation Subsystems of Guayaquil



Source: Hazen and Sawyer & Consulambiente Cía. Ltda.

4. Project Description[11]

As the urban population of Guayaquil grows, the volume of wastewater and organic wastes which contaminate the environment increases, therefore it is important to take measures to overcome environmental contamination and thus help to:

- Prevent sickness and protect the population's health
- Prevent nuisances
- Maintain waters clean for bathing and other recreational processes
- Maintain waters clean used for propagation and survival of fish and aquatic resources
- Keep water for potential touristic, industrial and agricultural uses
- Prevent siltation of navigational channels

The proposed Project will assist in helping meeting these objectives.

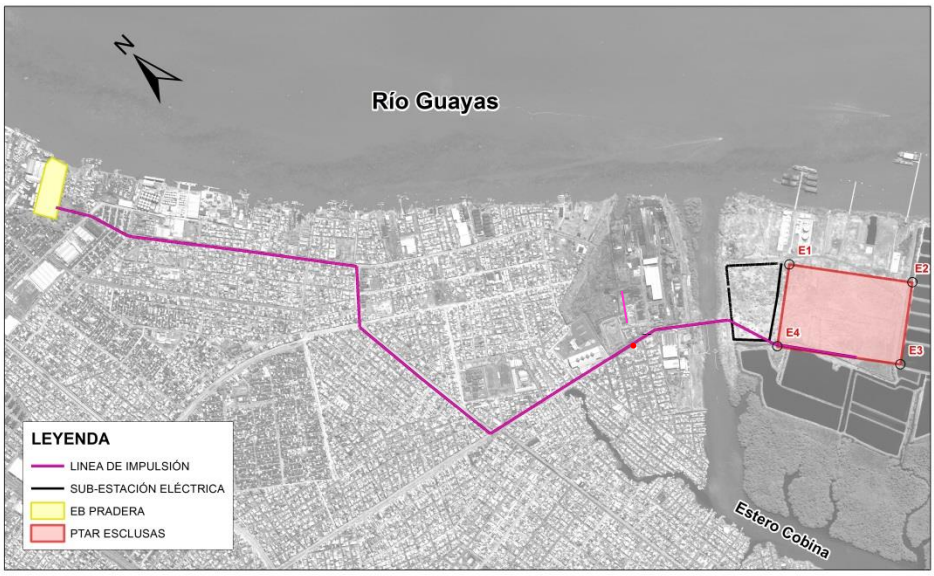
4.1 Main Components and Location

The Project (South Subsystem) comprises three (3) main components:

- La Pradera Pump Station
- Force main Pradera - Las Esclusas WWTP
- Las Esclusas WWTP

The South Subsystem requires redirection and extension of the existing force main between the Guasmo H Station and the subfluvial outfall, as well as repowering this Guasmo H pump station. Figure 2 illustrates the general scheme of the area of South Subsystem project.

Figure 2. Main Components and Location of South Subsystem



Source: Hazen and Sawyer & Consulambiente Cía. Ltda.

[11] Throughout this document, "Project" refers to Component Three of the Guayaquil Wastewater Management Project (P151439)

Figure 3 and table 1 show the specific location of Las Esclusas WWTP and demarcate the area and respective coordinates of the lot assigned for the construction of WWTP.

Figure 3. Geographical Location of Las Esclusas WWTP

Source: Hazen and Sawyer & Consulambiente Cía. Ltda.

Boundaries of Las Esclusas WWTP are those shown in the following table:

Table 1. Boundaries of the Project Area

BOUNDARY	DESCRIPTION
NORTHWEST	Celec - Transelectric
SOUTHEAST	Shrimp farms
NORTHEAST	Termoguayas
SOUTHWEST	Shrimp farms

Prepared by: Hazen and Sawyer & Consulambiente Cía. Ltda.

4.2 Dimensions and Characteristics of the Project

The main components of the South Subsystem are described in the following subsections.

4.2.1 Pradera Pumping Station

Configuration of the proposed Pump Station comprises a wet/dry well with 6 centrifuge pumps of 800 HP that will be located at the lowest level of the dry well. The capacity of the station is

6,360 L/s and is based on data of the projection of population together with estimations of inflow during dry/wet season conditions to 2040.

All inflow will be screened before reaching the wet well, in an effort to prevent damages to pumping units. The installation will have 4 screens and 5 channels.

There will be odors control units to mitigate possible odors associated with raw wastewater. Foul air will be extracted from the screens area and the wet well by fans and ducts towards the odors control system to be treated.

Table 2. Characteristics of Pumping Stations

Component	Name	Quantitative Description
Pumping Stations	Pradera	Six vertical centrifugal pumps of 800 HP flow 6.36 m^3/seg and dynamic height of 33.5 m
	Guasmo "H"	Five vertical centrifugal pumps of 140 HP flow 1.4 m^3/seg and dynamic height of 22.5 m

Prepared by: Hazen and Sawyer.

4.2.2 Pradera - Las Esclusas WWTP Force main / Guasmo-Las Esclusas WWTP Force Main

The wastewater collector main will have a capacity of 6,360 L/s and an approximate length of 4.7 km from the Pradera Pump Station to Las Esclusas WWTP, with a diameter of 1,800 mm; while the force main Guasmo H - Esclusas WWTP will convey a flow of 1,380 L/s with a length of 1.6 km approximately and 900 mm diameter.

The diameters selected for both force mains, assure maintenance speed above 0.61 m/s in low flow conditions and below 2.44m/s in peak flow conditions.

Besides the selection of the pipeline diameter, micro tunneling and open trench systems as alternatives of installation were analyzed. The micro tunneling method has a lower impact on roads and local residents because the working area is limited to launching and receiving wells, whilst the open trench method requires to dig the trench, propping and casting the phreatic level followed by the installation of the pipeline and the corresponding filling/restoration, these activities are carried out in the total length of the trench as opposed to micro tunneling method in which these are required every hundreds meters.

As a result of the evaluation of the methods and their respective impacts, the method suggested for the main force is micro tunneling.

Table 3. Characteristics of Force Main

Component	Name	Quantitative description
Force Main	Pradera - Esclusas	Installation of micro tunnels, reinforced fiber-glass (GRP) pipeline with a diameter of 1,800 mm, peak flow 6.36 m^3/seg, length 4.7 km
	Guasmo "H" - Esclusas	Installation of micro tunnels, material GRP. Pipeline with a diameter of 900 mm, peak flow 1.38 m^3/seg, length 1.6 km.

Prepared by: Hazen and Sawyer.

4.2.3 Las Esclusas Treatment Plant: Analysis of Alternatives

The location of Las Esclusas WWTP was established in the Sanitary Sewage Master Plan of Guayaquil (August 2004). In this study, 5 location options for a WWTP to serve the south of Guayaquil were evaluated, concluding that the site "Las Esclusas" is the most appropriate location for the wastewater treatment plant.

During the development of the wastewater feasibility study, evaluations to determine the most appropriate primary and secondary wastewater treatment options were conducted. To select primary treatment, in a first identification stage, viability of various physical-chemical treatment technologies, were evaluated. These technologies were:

- Preliminary treatment with rotating milli-screens
- Chemically Enhanced Primary Treatment (CEPT)
- Chemically assisted dissolved air flotation (DAF)
- Chemically assisted high-rate clarification

As a result of the analysis, several of the above listed technologies were excluded from further consideration because of inability to meet effluent standards, not suitable for implementation in urban settings, no experience of their use in a large scale, or no feasible to be allocated within the available land. Considering the local conditions, the use of Chemically Enhanced Primary Treatment (CEPT) was recommended as it meets current wastewater discharge requirements at all times and is appropriate for local conditions.

The selection process of the secondary treatment optimal alternative was done in two phases; the first consisted of a qualitative screening of 19 technological options available in the market in order to select 3 alternatives to be evaluated into greater detail in the second phase. The following were the 3 alternatives selected:

- Conventional Activated Sludge
- Trickling Filters with Plastic Media
- Trickling filters with solids contact chamber

These alternatives were subject to a rigorous process of evaluation which included eight decision criteria (Table 4), to each criteria a weighting factor or relative weight based on their relative importance was assigned.

Table 4. Decision Criteria and Relative Weight Used to Select the Optimal Alternative

Criterion	Relative Weight (%)
	Las Esclusas WWTP
Economic criteria	
1 Construction Costs	20.0
2 Operation and Maintenance Costs	20.0
Technical Criteria	
Operational Aspects	
3 Ease of Operation	10.0
4 Operational Reliability	10.0
5 Adaptation to Future Changes in Regulations and/or Concentrations of Affluent and Effluent.	12.5
Supplies	
6 Necessity of Area and Possibility of Expansion	12.5
Environmental Aspects	
7 Production of Odors	7.5
8 Production of Biosolids	7.5

Prepared by: Hazen and Sawyer.

After a detailed analysis of each alternative and quantitative evaluation, which included a sensitivity analysis of the criteria, it was concluded that the Trickling Filters Alternative is the optimal alternative for future implementation of the secondary treatment in the Esclusas WWTP.

The Esclusas WWTP (South Subsystem), as mentioned before, will treat combined waters of Pradera and Guasmo basins. It is designed for an average flow of 2.67 m^3/s in dry season with capacity to manage peaks of up to 2 times the medium flow during rainy seasons. The mentioned WWTP will include installations for preliminary treatment, chemically assisted primary treatment, and disinfection, with the option to add in the future a biological treatment, if necessary. This treatment scheme was selected due to the characteristics of wastewater of the contributing basin, mainly its low concentration of organic material. Standards required by the national environmental regulation were achieved with the proposed treatment. Flexibility is an important aspect of this type of treatment, because the chemical treatment will be used depending on the characteristics of the city's wastewater. Nevertheless, if in the future, the environmental regulation becomes more demanding, a secondary treatment may be implemented at the WWTP to meet future regulation requirements. EMAPAG EP has planned for the future expansion of the WWTP to enable secondary treatment, if it was required by Ecuadorean environmental regulations in the future. The units with their respective features of each process of treatment are detailed in the following table.

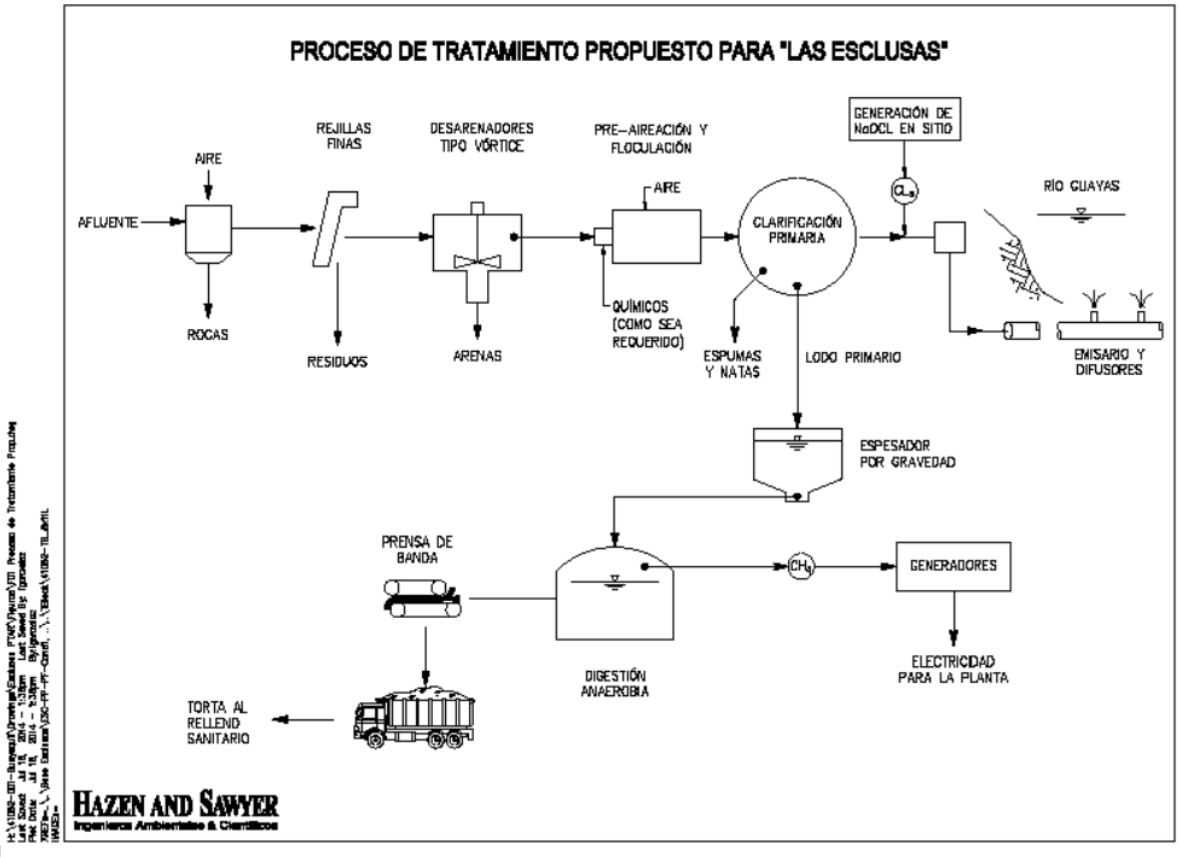
Table 5. Characteristics of Las Esclusas WWTP

Component	Name	Quantitative Description
Water and sludge Treatment	Pretreatment	1. Aired Chamber: An aerated mixing chamber through coarse bubble diffusers. 2. Screening chamber: four screens channels, coarse screens (8 MM) and fine (6 mm). 3. Vortex Grit Chambers: Three units designed at pick flow 3.07 m^3/seg.
	Primary Treatment	1. Rapid mixing, two units, 40 seconds retention time, between 300 to 500 seg-1. 2. Pre-aeration and flocculation tanks, two units with 17 minutes retention time. Mixers shall be mechanical. 3. Primary clarifiers - Three units 52.5 m diameter, 5 m depth.
	Sludge Digesters	1. Gravity thickeners - Two units of 13 m diameter. 2. Fine screens for sludge filtration. - Two units with slots of 2 mm. 3. Digesters. - Two operating tanks with 15 days retention time. Each volume unit of 5,000 m^3. 4. Solids dewatering - Two operating belt press 3 m wide. Solids are to be dewatered 35 hours per week, for 5 days. 5. Biofilter for odor control - One unit of 4,400 m^2.
	Disinfection	Sodium Hypochlorite in situ, with retention time 43 minutes at 3.7 m^3/s.
	Outfall	Diameter 2,000 mm, 15 vertical section diffusers of 900 mm, with side diffusers type “Tideflex” of 600 mm.

Prepared by: Hazen and Sawyer.

Figure 4 shows schematically the proposed treatment process for Las Esclusas WWTP.

Figure 4: Proposed Treatment Process for "Las Esclusas" WWTP



Source: Hazen and Sawyer & Consulambiente Cía. Ltda.

The main challenge is the final disposal or beneficial reuse of biosolids generated in the wastewater treatment process. The design includes thickening, anaerobic digestion, and primary sludge dewatering. Dewatered biosolids will be between 25 to 30 percent of dry TS content, thus fulfilling the landfill's material acceptance criteria.

The anaerobic digester will stabilize primary sludge from the thickening process. A biogas management system be included. Methane gas produced from the anaerobic digestion process will be used as fuel to generate electricity to be used on site. New cogeneration engines will be installed with all required auxiliary equipment of methane gas.

In the long term, incorporation of a Center for Management and Final Disposal (CMDN) of BS is considered. The CMDN biosolids management is a facility that combines all secondary dewatering processes (additional humidity reduction in BS), mixing, conditioning, and composting.

In the short and medium term, the place selected to discharge the biosolids is the City of Guayaquil solid waste disposal site, known as "Las Iguanas Landfill". The site receives approximately 4,500 tons of solid waste per day and currently its officials work in the optimization of a remaining sector known as sector D, where the solid waste has been discharged since 2006. It is expected that the lifespan of the sanitary landfill can be extended

at least 8 more years in an adjacent area known as sector E, which in the future will be the disposal site for debris and biosolids. An agreement has already been reached between EMAPAG and the consortium running the landfill, which has all required environmental permits to receive this waste. The landfill has the capacity to receive municipal waste, including the expected volume of sludge during the first eight to ten years of operation of the wastewater treatment facility, based on its current rate of exploitation. Plans for the future expansion or the construction of a new municipal sanitary landfill are under discussion between municipal and environmental authorities which will allow the continuation of the sludge disposal in this manner. A Master Plan study for the management of bio-solids generated from Las Esclusas and other future WWTPs will be financed under the World Bank Project - Component Four and should be completed by December 2017. This study will look at options for the reutilization of sludge through the production of compost (using secondary dewatering and structuring mix processes).

5. Institutional and Legal Framework

5.1 Institutional Framework

On April 11, 2001, the Empresa Municipal de Agua Potable y Alcantarillado de Guayaquil (EMAPAG EP) signed with INTERAGUA, the Concession Agreement for potable water, sanitary sewer, and storm drainage services for the Canton Guayaquil. The Concessionaire commenced operations on August 9, 2001 with a 30 year contract. According to Paragraph 4.2.2.1 of the Concession Agreement, "Collection, Treatment and Disposal of Wastewater", the Concessionaire is required to operate and maintain existing pumping, conveyance and primary treatment facilities; likewise will be responsible for planning, funding and construction of future wastewater treatment plants in the next five-year investment plan. Operation and maintenance of new WWTP's included in the system will be the responsibility of the Concessionaire.

5.2 Environmental Competent Authority

By means of the Authority Transfer Agreement of April 12, 2002, the Ministry of Environment of Ecuador (MAE, as per its acronym in Spanish) delegated powers of environmental matters to the Municipality of Guayaquil. For this purpose, the National Environmental Authority, by means of Resolution No. 002 on January 16, 2008, decided to approve and award the Municipality of Guayaquil the accreditation and the right to use the seal of Unique Environmental Management System (SUMA, as per its acronym in Spanish), the provision was published in the Official Record R.O. 282 on February 26, 2008. Thus, the Municipality of Guayaquil acquired the category of Environmental Authority of Responsible Application in Guayaquil canton.

According to the above, INTERAGUA initiated the Environmental Regularization Process of "Construction, Operation and Maintenance of La Pradera Pumping Station, Force Main and Las Esclusas WWTP" on November 19, 2012 before the Municipality of Guayaquil. However, the project was considered a national priority, therefore it was ordered that the Regularization Process will continue in the Guayas Provincial Directorate of the Ministry of Environment.

5.3 Ecuador Environmental Regulations

The Environmental Impact Study for "Construction, Performance and Operation of La Pradera Pumping Station, Force Main and Las Esclusas WWTP-South Subsystem" has been framed within the laws, rules and other regulations applicable to the activities to be undertaken in the project. These include:

- The Constitution of the Republic of Ecuador
- International Agreements Environmental Management Act
- Law on Pollution Prevention and Control
- Health Organic Law, Decree 3516: Unified Text of Secondary Environmental Legislation
- Regulation of the Environmental Management Act for the Environmental Pollution Prevention and Control.
- Safety and Health Regulations for workers and improved working environment
- Regulation for the implementation of social participation mechanisms set forth in the Environmental Management Act.
- Current and applicable environmental agreements and rules, as well as INEN environmental standards,

The legal framework defined the basis on which every project activity should be founded, either during the study, preconstruction, construction, operation, and abandonment phases.

The procedure developed in this Environmental Impact Study, is consistent with the provisions of the Ministerial Agreement 068 corresponding to the Reform of the Unified Text of Secondary Legislation of Book VI Title I of the Unique Environmental Management System (SUMA) of July 31, 2013, and as provided for by the Ministerial Agreement 006, concerning the reform of Title I and Title IV of Book VI of the Unified Text of Secondary Legislation of the Ministry of the Environment, dated February 18, 2014.

Per Ecuador regulations, the main purpose of an Environmental Social Assessment is to identify, describe and assess properly the impacts caused by the project on environmental factors during stages of construction, operation, implementation and removal, stablishing measures to prevent, mitigate or compensate any potential negative effects generated for phases of construction, operation and removal as well as maximize the positive impacts of the project. The EIA will allow that activities expected under the project implementation are environmentally feasible and sustainable in the short, medium, and long term, without affecting natural and social environment.

The Environment Impact Assessment and Environmental Management Plan are a basic prerequisite for implementing all engineering projects, as provided for Article 1 on basic environmental policies of Ecuador set forth in TULSMA, which states: "(…) The Ecuadorian State establishes a binding instrument before undertaking any susceptible activity that could degrade or pollute the environment, the preparation by interested parties who will perform these activities, of an Environmental Impact Assessment and the respective Environmental Management Plan and submit them along with applications for authorization before relevant authorities, who are obligate to make decisions about, and control compliance as provided by these studies and programs in order to prevent degradation and contamination, also ensuring adequate and sustainable environmental management. Both Environment Impact Assessment

and Environmental Management Plan are based on the principle of achieving the most appropriate level of performance to the respective space or resource being protected, through the most effective action".

In the same way, the development of the Social Participation Process of the project has taken into account the provisions of Executive Decree No. 1040, which was published in Official Record R.O. No. 332 dated May 8, 2008, wording establishing the criteria and mechanisms for social participation that must be adopted by the authorities that comprise the National Decentralized Environmental Management System. Also, the provisions of the Instructions to the Regulation for implementation of mechanisms of social participation, published in Official Record No. 036, dated July 15, 2013 have been considered.

5.4 World Bank Polices

The applicable World Bank safeguards policies for the Project are (see http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/EXTPOLICIES/EXTSAFEPOL/0,,menuPK:584441~pagePK:64168427~piPK:64168435~theSitePK:584435,00.html for details on these policies):

- Environmental Assessment (OP/BP 4.01)
- Natural Habitats (OP/BP 4.04)
- Physical Cultural Resources (OP/BP 4.11)
- Involuntary Resettlement (OP/BP 4.12)

The proposed Project has been considered an Environmental Category A under OP/BP 4.01.

6. Environmental and Social Baseline

6.1 General Environment

The area of the study is in Santiago de Guayaquil, the main district of Guayaquil canton, in the Republic of Ecuador, a country located in northwestern South America. The Guayaquil canton is located in the vicinity of the Andes Range, surrounded by the Guayas river network in the east, while crossed and encircled by the Estero Salado on the west.

Guayaquil is a coastal city with easy access to the Pacific Ocean through the Gulf of the same name. It is located at latitude 2° 19' south and longitude 79° 53' west at an average elevation of 4 meters above sea level and has a substantially flat topography. However, there are areas with low slope hills in Urdesa, Alborada, Sauces, and some sectors on north area of the city.

Guayaquil is one of the most important cities in Ecuador since the city is a major center of Ecuadorian social and economic development.

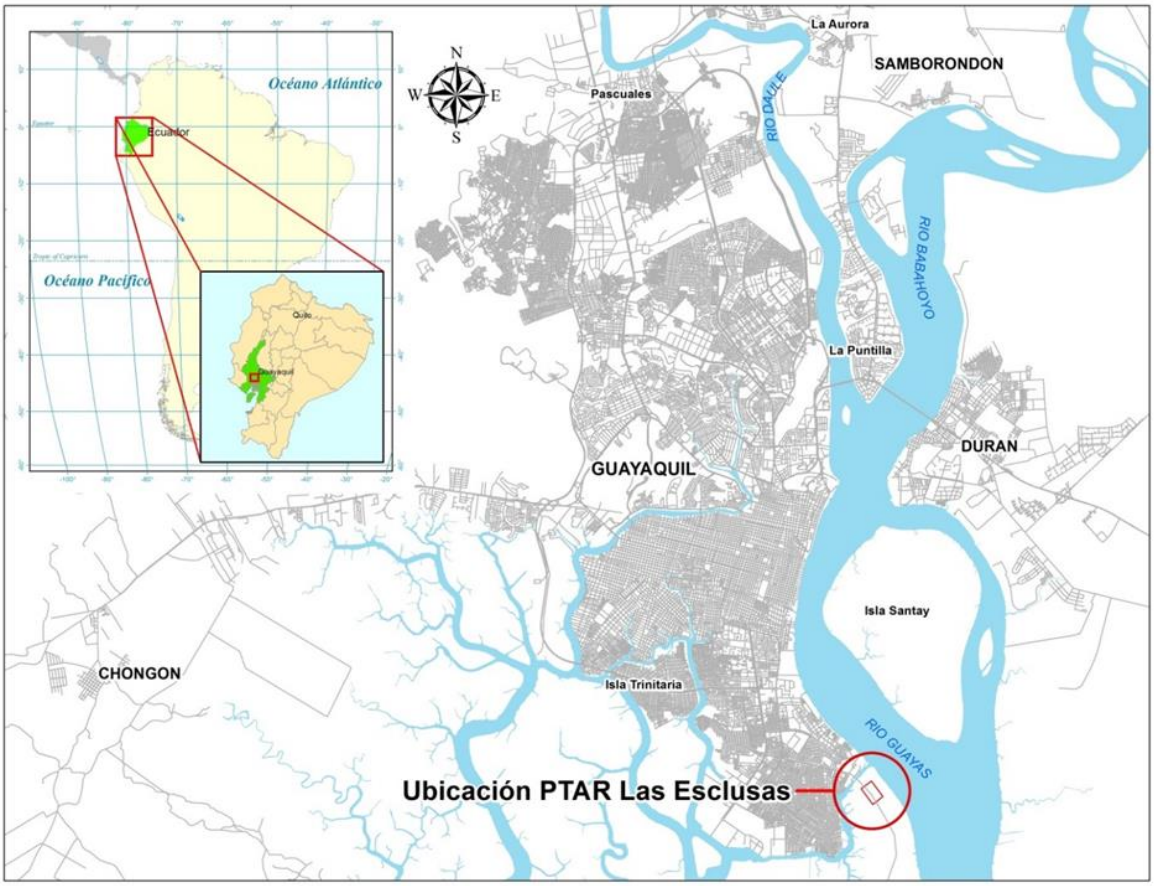
Currently, Guayaquil has an approximate area of 34,500 hectares. The climate is tropical, with two seasons clearly marked by the intensity of rainfall, dry and rainy seasons where the temperature varies between fifteen and thirty-five degrees Celsius throughout the year.

The city is surrounded by two major receiving bodies:

a. Daule and Guayas Rivers (formed by the confluence of Daule and Babahoyo) on the east side, which empties into the Gulf of Guayaquil, an estuary of the Pacific Ocean, and
b. The Estero Salado, on the west side, forming part of the estuary, up to the city center

Due to proximity to the ocean, the direction of flow in both receiving bodies varies depending on the tidal condition. The Gulf of Guayaquil contains a mixture of marine and fresh water, and is a rich environmental ecosystem of great economic and tourist importance for Ecuador. The gulf is a rich source of fisheries, particularly shrimp ponds located on the banks of the Guayas River. In vast areas around the different arms of El Estero Salado mangrove forests, also an important environmental resource, are found. Both the Guayas River and El Estero Salado cross residential areas and represent a resource of great recreational and aesthetic potential for the city.

Figure 5. Location of the Project



Source: Hazen and Sawyer & Consulambiente Cía. Ltda.

6.2 Physical Environment

- **Climatology:** Average annual rainfall of 112.3 mm, while the average aggregate rainfall in the area of study is 1,255.7 mm. Temperature varies between 23 and 26°C. Average annual temperature in the area of study is 25.5°C. August and September are the months of highest sun exposure, with values of 150 and 166.9 hours, respectively.

Wind speeds range from 4.00 km/h to 18.52 km/h. Annual prevailing winds are from the southwest (SW) direction with 45.6 percent frequency; and least prevalent from the northwest (NW) direction with a frequency of 2.9 percent.

- **Geology:** The geological foundation of the region constitutes the Piñón volcanic formation, on which is a sedimentary succession of the Upper, Tertiary, and Quaternary Cretaceous. It consists of a layer of submarine volcanic material and is the core of the Chongón - Colonche Range, of Jurassic age, composed of basic igneous rocks (granites), rhyolite, basalt, and andesite. The area of study is located along the Guayas River, which is mainly characterized by the presence of estuarine marine clays. The morpho-tectonic domains existing in the region are: Chongon-Colonche Range (CCC, as per its acronym in Spanish); Coastal Range (CCO, as per its acronym in Spanish); Santa Elena Peninsula (PSE, as per its acronym in Spanish); Progreso Basin (CP, as per its acronym in Spanish); and Manabi Basin (CM)

- **Soil characteristics:** In the study area there are 6 orders and 11 suborders of soil: Entisols, Inceptisols, Vertisols, Mollisols, Aridisoles, Alfisols, and Associations. Soils in the area are predominantly clay with a soft clay layer approximately 12 m thick. The stratigraphic profile describes the type of soil with strength parameters (Su) for cohesive soils and values of friction and number of blows (N) for non-cohesive soils

- **Quality of air:** From an annual total of 21,600 tons, thermal generation companies in the city are the main source of emissions of sulfur dioxide - SO_2, which represents a 59 percent of the total emissions. In the city of Guayaquil, emissions on the order of 27,000 tons of NOX per year have been identified, being the most important source the fleet of vehicles of the city. Also, it has been determined that there are emissions on the order of 59,700 tons of CO per year, primarily due to the City's fleet vehicles. Also, it has been determined that emissions of carbon monoxide - CO - attributable to mobile sources account for 87 percent of total emissions of that pollutant. On the other hand, emissions of particulate matter PM10 in the city reach 4,500 tons per year and come significantly from all sectors evaluated, although it is noted that the highest percentage corresponds to mobile sources: 39 percent. The manufacturing industry, particularly food and beverages processing contributes with 30 percent of total emissions of PM10. Guayaquil has several areas which concentrate a large number of fixed sources (industrial complexes) that generate significant emissions of pollutants into the air. One area of particular interest is located on the Road the Coast. Thermoelectric power plants, concentrated in few sources, emit significant rates of Particulate Matter (PM), nitrogen oxides (NOX), carbon monoxide (CO) and sulfur dioxide (SO_2) into the air. In addition to the power generation plants, the region is also the location of the Storage Terminal of Hydrocarbon Products El Salitral owned by the State company Petroecuador and a LPG bottling owned by Repsol-YPF.

- **Hydrographic System:** Guayas River Basin is considered the largest basin of the Pacific coast of South America. It has an area of 32,130 km^2 across 8 provinces. It is the most important river system of the entire Pacific coast of South America. Rivers comprising the Guayas Hydrologic Basin, are mostly navigable, run north to south, until merging with the Ecuadorian fluvial artery that empties in front of Puná Island, where the influx of tides of the hydrologic basin can been observed. Guayas Hydrologic Basin comprises the sub-basins: Daule River, Vinces River, Macul River, Babahoyo

River, Yaguachi River, Jujan River, and Minor Drainage. Guayas River is formed by the confluence of Babahoyo and Daule Rivers 5 km north of Guayaquil; its flow varies seasonally according to rainfall: in summer, the average flow of Guayas River is about 230 m^3/s, while during the rainy season increases to more than 1,500 m^3/s; Babahoyo River is the largest contributor accounting for between 60 percent (dry season) and 66 percent (rainy season) of the flow of Guayas River.

- **Dilution of Guayas River:** The diffusion coefficient in several stretches of the inner estuary of the Gulf of Guayaquil during the dry season has high values denoting the existence of strong turbulence processes found in the section corresponding to Cascajal Channel and Morro Channel of about 330 cm^2/s; this means that the mixture can be completed at a depth of 10 m and takes approximately one hour. The inner and outer edges of Jambelí Channel, have values of 42 cm^2/s and 6 cm^2/s, respectively; in the first case the diffusion and turbulence processes will last for several hours, showing stratification in the water column; while in the second, the diffusion processes are much slower and mixing periods may last for more than one day. The dispersion coefficient not only determines the diffusion associated with turbulent mixing, but also includes dispersion due to velocity gradients and the difference in density. Therefore at higher values of dispersion, concentrations of dispersed contaminant are greater. Values of dispersion coefficient are 25–40 km^2/day in the stretch corresponding to Guayas River between Punta de Piedra and Verde Island.

- **Water quality in the Estuary of the Guayas River:** Wastewater discharges are one of the various anthropogenic sources affecting the quality of the body of water. Other sources include poor disposal of solid wastes, agriculture wastes and wastes of industries. Natural sources of pollution must be added to this. Water quality of the river section of interest (from La Toma to Las Esclusas) is affected by the quality of the river upstream the section due to agricultural activities, mining, dam regulation and populations in the margins. Also river quality is affected by the quality of water downstream the considered section, which is possible due to the drag of contaminants (including salinity) by flow and back flow produced by tides. It is also affected by the discharges of urban developments on the western margin of Durán. This is due to the effect of the tide because flow and back flow actions carry pollutants to the area of influence. In other words, municipal and industrial discharges of Duran are conveyed downstream during low tide, but some of the contaminants are conveyed back during high tide affecting the area of influence of the two water streams around Santay Island. It is recognized that Daule-Guayas River is a large body of water with actual flow rates reaching values above 10,000 m^3/s by the effect of tides with high dilution. Under these conditions, only significant discharges can affect the quality of the river. This is the case of heavy metals and organic toxic substances which must be discharged in large quantities to detect. For the above reason, the quality of most parameters does not vary in the span of one day, even with the influence of the tide. Only parameters associated with salinity and suspended solids are consistently affected by a tide cycle. The river water is saline and its water quality is affected by several wastewater discharges and other pollution sources (for example, storm water runoff) upstream of the Project location with none or very limited treatment.

- **Current uses of water in the area of study and its area of influence:** During the walkthroughs along the margins of rivers and bodies of water, the following extensive

uses of waters of receiving bodies, Daule and Guayas, were found: discharge of solid and liquid wastes (breach of environmental regulations); navigation and water transport; landscape and tourism; preservation of aquatic life and wildlife; secondary contact recreation; thermoelectricity and industrial use. It is observed that in banks of rivers, waters are shallow and easily accessible for the aforementioned activities. Interest is focused on three stretches: Stretch 1 - Daule River, upstream from discharge site of Los Merinos, consolidated area of Guayaquil; Stretch 2 - Daule River between the discharge area of Los Merinos, meeting Babahoyo River, the beginning of Guayas River and discharge of Las Esclusas; Stretch 3 - Guayas River, downstream of Las Esclusas.

- **Exogenous Risks:** Guayaquil Canton is located on a flat relief area, which is part of the floodplain of Guayas River, which may be dramatically affected by floods during winter season associated with El Niño. Sensitive areas of flood risks are: Los Vergeles and Las Orquídeas; Sauces; Bastión Popular; Guamos. Regarding earthquakes and tsunamis Ecuador is considered one of the countries with the highest index of active volcanoes in the world. It is located in a seismic region called Ring of Fire, an area susceptible to experience the effects of earthquakes and volcanic eruptions. The coastal region is located in front of Nazca tectonic plate against the South American plate, making this sector highly vulnerable to natural disasters. The project area is classified as a "high" seismic hazard.

- **Endogenous Risks:** Related to activities of the project: construction, maintenance, operation, removal, performance, among others. More severe scenarios are: dispersion of particulate matter, spill of liquids, chemical substances and fuels on the ground, noise generation, generation of combustion gases and generation of solid wastes, cleaning and clearing activities of soil, earthmoving, excavation and land compaction, operation and maintenance of equipment and machinery, installation or breakage of potable water, sewerage and telephone supply systems, soil infiltration, handling and storage of chemicals, fire caused by transformer's short circuit, power outages in the electrical system, and bad odors by the water treatment plant.

- **Landscape:** The city of Guayaquil has the following main natural resources: Guayas River, Estero Salado, and Santay Island, landscape units that are noted by their functional configuration, vegetation, slopes, visibility, and presence of water, anthropogenic activity, accessibility, quality, and natural fragility.

- **Use of Land**: Las Esclusas WWTP is located south of Cobina estuary. The proposed site is presently undeveloped open space consisting of vegetation that has been impacted by man. The WWTP will receive flows from pumping stations of Pradera, Trinitaria, Guasmo, and South Central system. The Regulatory Plan defined by the GAD-Guayaquil divides the urban area into zones A, B, C, D, E and F, and in the expansion area into zones G, H and I. Located in Zone A are the sectors that have been formed based on invasions, among them those denominated Guasmos and residential complexes based on housing projects with state or private investment. All these sectors are located in Ximena district, current uses of land in the area of environmental direct influence (AIDA) of the project include: 1) Residential land (settlements located southeast of the city, the so-called Guasmo Norte, which includes the cooperatives of Miramar, Lorenzo Tous, Pablo Neruda, and Carlos Cevallos, comprising lower middle

class homes, mostly built of reinforced concrete and few houses built over reed or wood structure; 2) industrial land, represented by two distinct sectors: a) Cobina northern estuary, where metallurgy facilities ANDEC and controls the locks of the Port Authority of Guayaquil are located; b) area located south of Cobina estuary, represented by the facilities of Electrical de Guayaquil; 3) development land, space between Cobina estuary, existing mangrove forest on the site and Guayas River; and 4) non-development land, an area comprising almost the entire mangrove ecosystem. Several shrimp farms are located eastbound.

6.3 Biotic Environment

- **Life zone (bioclimatic)**: The project area is located in the Subtropical Region, between 0 and 500 m.a.s.l., with an average annual temperature ranging between 20 and 32ºC. Annual rainfall registered in the area ranges between 750 and 1,000 mm. The dry season covers from May to November, which may be extended to December, depending on the year. The number of months considered as ecologically dry is approximately 6 months and days considered as physiologically dry fluctuate between 54 and 99 days. The life zone corresponds to the semi-deciduous Forest ecologic formation of coastal lowlands. This formation occurs between 200 and 1,100 m in hilly areas where humidity is greater than in deciduous forests. It is estimated that among 25–75 percent of floral elements lose their leaves during dry season.

- **Flora:** Floral diversity in Guayaquil is the result of a variation of forests within the tropical and subtropical altitudinal belts. The area of influence of the project is located in the semi deciduous Forest vegetal growth of coastal lowlands, such formation is characterized by being between dry bushes as those found in General Villamil Playas and deciduous forests, in an altitudinal belt ranging between 50 and 300 m.a.s.l, is the most representative. Vegetation is characterized by losing its leaves during the dry season of the year, which is known as deciduous habit. Terrestrial flora species in the area of influence are the following: Mango (Manguifera indica), Castor oil plant (Ricinus communis), Mesquite (Prosopis juliflora), Guachapelí (Albizia guachapele), Saman (Samanea saman), Banana (Musa paradisiaca), Coconut palm (Cocos nucífera), Erythrinaespectabilis, Buganville (Bougainvillea glabra), Robinapseudoacaia, Acacia sp, Ficus (Ficus benjamina), Almond trees (Prunusdulcis), Neriumoleander, Cordylineterminalis, Red Mangle (Rhizophora mangle), Black Mangle (Avicennia germinans), White Mangle (Laguncularia racemosa). The type of dominant micro-algae in the Guayas River is Chrysophytas kind and contains Bacillariophyceae commonly known as Polymyxus coronalis, while downstream, in the area of the mouth, the presence of diatom Skeletonema costatum would increase. Dinoflagellates, tintinnines, cyanobacteria, sillicoflagellates and flagellates are scarce. Among the most representative algae, is Skeletonema costatum which is one of the most dominant, a Cosmopolitan algae representing estuarine waters with a temperature of 24 and 30ºC; this species is an important phytoplankton for feeding fish and crustaceans. Another predominant species is Chaetoceros affinis which is located towards Guayas River and Estero Salado. In the inner estuary of the Guayaquil Gulf and its internal waters (Guayas River), there is a low phytoplankton diversity due to the abundance and dominance of Polymyxus coronalis and Skeletonema costatum in its waters of high and low salinity, respectively.

- **Fauna:** The study area corresponds to the southwest tropical zoographic belt; which is distributed from Caráquez bay to Túmbez forming a variable width strip (20 to 50 km) which is only interrupted by the North-West belt extension that corresponds to the coastal mountain range. This belt is characterized by a dry climate and a flat and waved topography, where the highest relieves do not exceed 300 m in altitude. In the case of birds (ornithology) the area of study is located in Western Lowlands followed by deciduous forests. It is known that more than 80 species live in this location of the Guayas river basin, including the families groups: Ardeidae, Anatidae, Laridae, Fregatidae, Pelecanidae, Phalacrocoracidae, among others. Between endemic birds are: bandeado wren (Campylorhynchus fasciatus), Paloma tierrera (Columba buckleyi), batará collarejo (Sakesphorus bernardi), ovenbirds (Furnarius cinnamomeus), pigmy owl (Glaucidium nubicola), viviñas (Forpus coelestis), parakeets (Brotogeris pyrrhopterus). The only threatened species is the Grey-cheeked parakeet. (Brotogeris pyrrhopterus). The following are the ornithology bodies identified: nivea heron (Egretta thula), tierrera dove (Columbina buckleyi), Cowbird (Crotophaga sulcirostris), Yellow Warbler (Dendroica Aestiva), (Thraupis Episcopus), Jacanas (Jacana Jacana), Homer (Furnarius Cinnamomeus), little cattle egrets (Bubulcus ibis), Social Mosquero (Myiozetetes similis), Cigüeñelo cuellinegro (Himantopus mexicanus). The reptiles found in the areas of study are represented by iguanas (iguana). The areas of study are located in areas deeply intervened, that is the reason why large mammals will not be found, instead small mammals or mammals that live in close contact with human beings will be found, such as: Squiller (Sciurus stramineus), domestic Cats (Felis silvestris). Zooplankton in the project area comprises of arthropods and protozoans. The lower estuary biomass of the Gulf comprises more than 50 percent in arthropods. In addition, within such arthropods, copepods and other biological groups such as: Appendicularia, Cnidaria, Porifera, Nematoda, Annelida, Bryozoa, Brachiopoda, and Chaetognata are the most abundant. Copepods cirripede larvae, zoeas of brachyuran and carideos, zoeas of anomuros, porcelanidos, mysidaceans, amphipods, isopods, ostracods, and cladoceransare are also found. The presence of peneid larvae can be observed mainly in the stage of prototozoeas which are related to the systems of estuaries predominant in the area. The following zooplankton species have been identified: Brachionus plicatilis, Alona cambouei, Moina micrura, Mesocyclops longisetus, Pseudodiaptomus longispinosus, and Acartia tonsa. Regarding malacofauna, 11 species are reported, 7 belong to Bivalve, and 4 belong to Gastropods. The greatest abundance and diversity of species is in Portete Bridge and the least diversity in the west intertidal zone of Guayas river. Many of the dominating species are: Large oyster of Mangle (Crassostrea columbiensis), Mussels (Mytella strigata), Mussel (Mytilopsis trawtuineana), Bivalve (Protothaca asperrima), Bivalve (Macoma siliqua), Bivalve (Macoma siliqua), Miona (Polymesoda inflata), Snail (Theodocus luteofasciatus), Gastropod (Nodilittorina varia), and Gastropod (Cerithidea mazatlanica). Among the main fish species, the following are reported: Mouse (Leporinus ecuadoriensis), Bearded (Rhamdia cinerascens), Guanchiche (Hoplias microlepis), Bio (Sternopygus arenatuss), Bocachico (Ichthyoelephas humeralis), Dica (Pseudocurimata boulengeri), Raspabalsa (Isorineloricaria spinosissimus), river halibut (Achirus kluzinger), Tilapia fish (Oreochromis sp.), and Millonaria hembra (Poecilia sp.). The project area has a good level of flora, some species are endemic in the area and others are introduced; this flora houses an endless number of fauna species that feed and reproduce. Therefore, the alteration of the flora would cause a direct affectation to the existing fauna of such area and many of these species would adapt or seek other housing places to survive.

6.4 Socioeconomic and cultural environment

- **Current and Future Population:** The projection of population for the period 2011–2042 for Suburban District Ximena of Guayaquil: 2010 (base year) 546,254; 2042 (end year) = 659,399. The population is divided in men (50.52 percent) and women (49.48 percent). The average age is 45 years.

- **Community Structure:** Among social organizations identified in AIDA of Las Esclusas WWTP, their representatives are: "Lorenzo Tous" Cooperative (Mr. Rafael Gámez, President); 2) "Carlos Cevallos" Cooperative; 3) "Miramar" Cooperative (Mr. Andrés Rodríguez, President).

- **Recreation:** There is a green area with a sport court in good conditions in the Pablo Neruda Cooperative to practice indoor-football and volleyball. In Miramar Cooperative, there is a small green area with a sport court to practice indoor-football and volleyball.

- **Cultural Heritage:** Among the most emblematic places, the following can be mentioned: Luis Vernaza Hospital, Las Peñas Neighborhood, General Cemetery, Vicente Rocafuerte School, and Municipal Library.

- **Basic Services:** In the area of the project, 97.94 percent of houses have potable water service, from which 97.77 percent of studied houses water is provided by the public supply network, 1.72 percent is provided by a communal basin which is an alternative of supply, and 0.51 percent is provided by tankers. 98.1 percent of researched houses states they have a water meter and the remaining 1.9 percent reports they lack a water meter. 92.10 percent of houses have sewer systems services. In northern sectors, 92.78 percent of houses have rainwater collection service. Regarding disposal of sewage water, it was evidenced that 92.1 percent of the researched sample evacuates sewage water through a public network, 7.7 percent by the use of septic tanks and only one case of domestic wastewater disposal by latrine was found, representing 0.2 percent. The level of coverage of garbage collection service is 96.4 percent, while 3.6 percent lacks the service. Coverage of electric power service reaches 97.77 percent of the considered places, while the remaining 2.23 percent lacks this service. On the other hand, 99.2 percent has an electricity power meter. Coverage of fixed telephone service reaches 73.2 percent. 26.8 percent lacks this service; however, the use of mobile telephone satisfies needs alternatively.

- **Education:** Three educational establishments are identified in the area of influence of this WWTP: 1) Pablo Neruda Basic Education and Literacy Center 2, located at Raúl Clemente Huerta Avenue Number 2 Pasaje Southeast 12A with permanent Popular Education and fiscal support; it operates at night and is attended by men and women; 2) Pablo Neruda Basic Education and Literacy Center 1, located at Raúl Clemente Huerta Pasaje 53 west, with permanent Popular Education and fiscal support; it operates in late afternoon and at nights and is attended by women only; 3) Lorenzo Tous Febres Cordero Number 76 Basic Education Center, located at Las Esclusas 14, 53 alley southwest Coop. Pablo Neruda east, with a regular type of education and fiscal support; it operates in the morning and is attended by men and women

- **Housing:** In the area of the project, 76.46 percent of houses is occupied by only one family, 18.4 percent is constituted by departments, 3.78 percent by multi-family housing and 1.72 percent lives in rooms, which house one family. In the north of the city, 75.26 percent of families are owner of houses. 20.79 percent are renters and 3.95 percent is on loan or in exchange for taking care of the house. Most of houses are residential, 94.6 percent; while the remaining 5.4 percent of properties is shared properties with some kind of business. Regarding finishing of visited of houses, we find 1.55 percent of floors is ground, 44.67 percent is cement, 13.92 percent wood, 35.40 percent ceramic and 4.47 percent another material corresponding to vinyl. On the other hand, 43.13 percent of doors is made of wood, 38.66 percent aluminum, 0.69 percent cane and 17.53 percent corresponds to iron cataloged in the study as others. Regarding materials used in the windows of homes, the following results were obtained: 70.79 percent of houses has aluminum windows whilst 14.26 percent has wood, 10.48 percent others, in which iron prevails, 2.41 percent plastic and 2.06 percent of homes has cane windows.

- **Perception of Odors:** The analysis of perception of odors in the involved population pointed that 33 percent of the population assures unpleasant odors are perceived in the area, the remaining 67 percent indicates they have not perceived unpleasant odors in the environment. From the human group that assures odors are perceived, (33 percent of the population), it was determined that 54 percent of the population indicates unpleasant odors are due to sewage water. 30 percent of inhabitants in the sector considers odors are permanently perceived, whilst 70 percent indicates these odors are intermittent. On the other hand, 64 percent of inhabitants of the surveyed sector, indicates perception of odors takes place daily; however, 36 percent expressed this happens weekly. Twenty-three percent of people, who have perceived unpleasant odors in the area, estimate such odors are more intense in the morning, 63 percent considers the highest level of such odors takes place in the afternoon and barely 14 percent indicated there is greater intensity at night. From population group which assures to perceive unpleasant odors in the environment, 84 percent believes these intensify in winter and 16 percent says this happens in summer. Thirty percent of the total population exposed to unpleasant odors considers their lands may be devalued due to this condition and 70 percent believe the presence of odors is not the cause for the devaluation of their properties.

- **Levels of participation and interest of the community:** Willingness and interest of inhabitants on Las Esclusas WWTP construction project is high in the Cooperatives of the North Guasmo sector. Currently, there is a wastewater treatment plant located at the Pablo Neruda Cooperative, which emanates unpleasant odors and negatively impacts the population. Inhabitants consider that the construction of the new WWTP will allow eliminating existing contamination in the sector. The population considers the benefits generated by the project are high; all the population of the area of influence of the project and the southern sector of Guayaquil is benefited, improving environmental sanitation conditions. Once the project is constructed, services coverage will be increased. Regarding environmental impacts generated by the construction process of works, these will be mitigated by applying an Environmental Management Plan, therefore, troubles caused by the execution of works will be temporary and will be controlled to reduce the effect on the development of normal activities of the

population. Thus, the project acceptance by the community is favorable for pump stations, force main, and WWTP.

7. Environmental and Social Impact

7.1 Identification and Assessment of Impacts

The determination, assessment, and subsequent categorization of any potential impacts caused by the project performed using the cause-effect analysis method, which allowed interrelating actions to develop the project with environmental factors, to further define the consequence of impacts based on assessment criteria of magnitude and importance.

7.2. Description of Primary Project Phases

Listed below is a detailed description of all actions related to the implementation of the project.

7.2.1 Pre-Construction Phase

The phase where all administrative procedures before the execution of the works and project actions are developed, plus any other aspect related to the development of systems design to be applied, pre-feasibility, among others.

7.2.2 Construction Phase

This phase includes steps and activities required to execute the project civil works, such as wastewater treatment plant, force main, and sub fluvial outfall.

The following activities are scheduled for Pumping Stations and WWTP:

- Installation of contractor´s field office and shop: adaptation of spaces to develop administrative activities during construction, providing workers with safe and comfortable areas.
- Leveling and Lay out: laying out axis and structure leveling; this work will be performed considering that the area of implementation of WWTP is a site with lifted structures.
- Staff hiring: refers to hiring professionals and workers for execution and supervision of works to be performed.
- Terrain conditioning and preparation: Due to the partial floodable condition of the site and the poor geotechnical characteristics of the soil in the WWTP location, the terrain will be improved using vibrosustitution, which consists in building a gravel columns matrix in the terrain to improve its quality. Additionally, a compacted backfill over the matrix will be installed to create different platforms with finished levels above the maximum recorded flood level.
- Foundation and piling: the results of soil studies performed show that due to conditions of soil strata, construction of foundation slabs and piles are required.
- Excavation by machine: excavation of soil using equipment such as backhoe, mechanical shovel, front-end loaders, and other type of road equipment required; the evacuation of material from excavation will be transported by dump trucks to sites

approved by Illustrious Municipality of Guayaquil, and the hours stated by applicable law.

- Excavation by hand: small tools are used to form the walls; this activity is complementary to the excavation by machine and is performed when the machine cannot complete the excavation.
- Evacuation of excavated material: the evacuation of this material is performed by dump trucks to the site approved by Municipality.
- Materials transport: materials used in the work are transfer to the site for their use.
- Transport of non-hazardous solid and liquid wastes: comprises delivery and transportation of non-hazardous wastes to municipal management system.
- Transport of hazardous wastes: includes activities focused on the delivery of hazardous wastes to qualified operators for proper transport or treatment.
- Construction of sheet pile and perimeter walls: sheet pilling with metallic elements is a safety precaution and part of the retaining wall construction process of the slopes and an activity directly related to soil excavation until foundation level.
- Compacted backfilling: compaction of natural soil or backfilling material using vibratory plate or compactor frog.
- Placing concrete bed: spilled of pumpable ready-mixed concrete to be used as coating on access routes and various structures.
- Maintenance and operation of equipment: operation of machinery used for excavation, soil compaction and other activities; such machinery is subject to corrective and preventive maintenance to ensure proper operation.
- Formwork and cast structures: spilled of ready-mixed concrete for building structures.
- Waterproofing of tanks: using chemicals to prevent wastewater filtration into the ground.
- Installation of electric system: installation of electrical panels for equipment control, power supply network, lighting system, and temporary installation of power supply.
- Installation of hydro-sanitary facilities: includes the development of drainage facilities for storm water conveyance, pipes for wastewater discharge from the administrative and operating areas to treatment plant, also includes hydrants and other fire protection systems to be used according to the designs.

In the Force Main:

- Excavation of trenches and wells in natural ground or paved roads: according to the recommended methodologies for building force main, one of the following actions may be performed:
- Mechanical excavation of wells for entry of drilling and driving equipment; this activity is performed at points of entry and exit of the above equipment including strategic sites located at different sites of the area of implementation area of the force main.
- Open trench excavation along the installation site of the flow pipes and routing water.
- Installation of drilling and excavation equipment: installation of equipment and drilling machinery for trenching or tunneling in order to locate the pipes, according to the construction methods.
- Load equipment operation and maintenance: this type of equipment will be used in the construction process of the force main for tasks such as location of pipes in the right site, entry and removal of equipment, among others. Preventive and corrective maintenance must be made to this equipment, as required.
- Removal, transport, and disposal of wastes from excavation: wastes resulting from excavation are collected with equipment and then transported in dump trucks to the disposal site approved by the municipality.
- Transport of non-hazardous solid and liquid wastes: delivery and transportation of non-hazardous waste produced to Municipality management system.
- Transport of hazardous wastes: delivery of hazardous wastes to qualified operators for proper transport or treatment.
- Transport and installation of pipes: location of wastewater flow pipes at the site of force main installation.

During the construction of the subfluvial outfall it is expected that some common activities mentioned above will be performed, together with the following:

- Development and transport of dead weight: dead weights are used for fixing the pipe at the bottom of the water body, which are pre-developed and transported to the site where the outfall construction will start, under the support of specialized equipment for this purpose.
- Pipe location
- Dead weights fixing: weights are located at the respective points and the pipe is injected through high-pressure air.
- Drag and immersion of pipes: pipes are transported superficially using vessels to the points defined according to studies performed. Subsequently, the injected air is evacuated and pipes are submerged.
- Transport of non-hazardous solid and liquid wastes: comprises delivery and transportation of non-hazardous wastes produced to the Municipality management system.
- Transport of hazardous wastes: includes activities focused on the delivery of hazardous waste to qualified operators for proper transport and treatment.

7.2.3 Operation and Maintenance Phase

This phase is comprised of the steps of flow and external services, flow and internal services, and equipment. The main actions to be developed are described below:

In the Pumping Station:

- Operation and maintenance of equipment: includes pumping stations operating, and procedures performed for both preventive and corrective maintenance.
- Maintenance of mechanical structures: this activity includes all actions that are performed for piping maintenance embedded within the pumping station including replacement of parts.

In the WWTP - Pretreatment:

- Screening and classification of spoils: includes actions aimed at screening wastewater in order to separate the coarse solids.
- Classification and grit removal: process performed by a Vortex Grit Chamber which will separate grit particles contained in the water to be treated, and then are transferred to respective grit classifier.
- Collection and transportation of screenings: all material retained by the screening unit will be collected and delivered to the municipal system for transport and disposal.
- Maintenance of mechanical structures: consist of the piping integral maintenance including replacement of parts.
- Maintenance of metallic structures: includes maintenance procedures to be performed to metallic parts of the screening and grit removal units that comprise the pre-treatment.

In the WWTP - Primary Treatment:

- Chemical storage: appropriate storage sites of chemical used for flocculation of the solid particles from wastewater.
- Chemical dosing and influent mixing: addition of flocculation substances and mixing process will be performed to the wastewater within the flocculation tank to achieve separation of the solid particles.
- Removal of solid particle by settling: after flocculation, wastewater will be transported to a settling unit, where the suspended solid particles will precipitate, and then are conducted to the sludge treatment system.
- Operation and maintenance of equipment: includes maintenance procedures for equipment operating in the primary treatment units such as blowers, sludge pumps, among others.
- Maintenance of mechanical structures: consists of the piping integral maintenance including replacement of parts.
- Maintenance of metallic structures: includes maintenance procedures to be performed to metallic parts of the flocculation and settling units.

In the wastewater treatment plant - Disinfection:

- Handling and transportation of products and hazardous material (Sodium Hypochlorite): the hypochlorite solution used for treated water disinfection shall be site generated and eventually delivered by proper vehicles and directly placed at the storage sites.
- Sodium Hipochlorite dosing: Sodium Hipochlorite solution will be supplied to treated water at the required concentrations; dosing is performed automatically.
- Maintenance of mechanical structures: consists of the piping integral maintenance including replacement of parts.
- Maintenance of metallic structures: includes maintenance procedures to be performed to metallic parts of the disinfection units

In the WWTP - Sludge treatment units:

- Thickening and sludge transportation: sludge in settling units will be evacuated and transported by pipes to the sludge thickening tanks that, by the action of gravity, reduce the sludge water content.
- Thickened Sludge Anaerobic Digestion: After thickening the sludge, it will pumped to anaerobic digesters. In that process biogas will be also produced, which will be used to cogenerate electric power.
- Sludge storage: Digested sludge will be stored before being subjected to the dewatering process.
- Dewatering of Digested Sludge: The process is performed with belt press. It demands the addition of polymers.
- Transportation and sludge disposal: includes transportation of sludge to the municipal landfill and disposal in monofill.
- Operation and maintenance of equipment: includes equipment maintenance used for sludge management including belt press.
- Maintenance of metallic structures: consists of the piping integral maintenance including replacement of parts.
- Metallic structures maintenance: includes maintenance procedures to be performed to metallic parts of the sludge treatment units.

In the force main:

- Maintenance of the wastewater collection and transmission network: comprises maintenance procedures of the force main and its components.

In the subfluvial outfall:

- Maintenance of mechanical parts: consists of maintenance procedures of piping that form the sub fluvial outfall including diffusers.
- Monitoring of discharges: comprises the procedures for the development of water quality monitoring at discharge sites of sub fluvial outfall.

7.2.4 Abandonment

Includes actions to be developed in the event of occurrence of three different scenarios: abandonment at the end of construction; abandonment during construction; and abandonment during operation. Generally, in any of the proposed scenarios the following activities may be done:

- Removal of work camp: vacate, removal and retirement of all elements that are part of the field office.
- Removal of equipment and machinery: removing from the area equipment and machinery used during construction.
- Removal of materials, spoil and other wastes: all wastes produced are collected and transported to the disposal site
- Wells filling: wells or trenches excavated, according to the selected construction methodology, should be refilled once facilities have been abandoned.
- Readjustment of roads: once wells and trenches have been refilled, roads are paved and path repaired along with other elements that were modified during construction.
- Transport of non-hazardous solid and liquid waste: as a result of the dismantling of the facilities and equipment, non-hazardous solid waste can be produced which must be delivered to the municipal collection system for their transport to the disposal site.
- Waste hazardous transport: consists of the delivery of hazardous waste generated by abandonment activities to qualified operators for proper transport and treatment.

7.3 Environmental and Social Factors Considered in the Assessment

7.3.1 Bio-Geophysical factors

- Solid particles
- Gas emissions
- Noise
- Odor intensity
- Changes in terrain and topography
- Contamination by solid or liquid wastes
- Vibrations
- Ground water table
- Removal of topsoil
- Soil quality
- Drainage network
- Surface water quality
- Groundwater quality
- Variation in the water physical conditions
- Flow changes (runoff)
- Changes in the hydric dynamics
- Fauna habitat
- Flora habitat
- Migration of organisms
- Biostability

7.3.2 Socioeconomic Factors

- Destruction or alteration of landscape
- Destruction of natural systems
- Destruction or alteration of existing quality of life related to cultural, historical aspects, etc.
- Inconveniences caused by urban and traffic congestion.
- Perception of the Project
- Revenues and expenditures for the public sector
- Job creation
- Health and safety for workers
- Health and safety for residents
- Road infrastructure
- Community services and urban facilities
- Damages to urban infrastructure
- Expropriation of lands
- Energy consumption.

7.4 Assessment and categorization of impacts

The impact assessment process was performed by using cause-effect matrix / Leopold Matrix, to identify and assess environmental impacts according their magnitude and importance. Under this approach, an impact can reach a maximum value of 10 and minimum of 1, values close to 1 indicate insignificant impacts and of less influence, to the contrary, values over 6.5 are impacts of high incidence in the environment, whether they are positive or negative. Taking into account these considerations and according to approach applied, environmental impacts were classified under the following categories:

- Highly significant
- Significant
- Insignificant
- Beneficial

7.5 Results of the Environment and Social Impact Assessment

Below is a description of the principal potential significant negative impacts of the project:

1. **Removal of topsoil and changes in terrain and topography:** The preparation of the ground where preliminary works or tasks such as excavations, placement of fills, concrete depositing, among others are planned, will require the removal of topsoil and existing vegetation. During force main construction a lower or almost no significant effect will be experienced due to the urban environment. In general, the soil profile will be affected during the construction stage due to activities aimed at improvement and preparation of the ground for constructive purposes, as well as the implementation of foundations for structures.

2. **Contamination by solid or liquid wastes:** As a result of various activities performed during construction and operation stages of the project, different types of waste will be generated which can cause visual and health impacts. For this reason, this aspect becomes

one of the important control points and therefore should be considered in the Environment Management Plan.

3. **Generation of dust, combustion gases, noise, and vibrations:** Conducting preliminary works, site's preparation works, cast concrete, and excavations required during construction of the project, will produce particulate matter (dust) which can cause harmful effects on the population's health. However, being a temporary impact and of low dispersion, its effects would be limited. It is worth mentioning that the Environmental Management Plan shall implement actions to monitor this factor.

   It is estimated that during the construction phase gases will be generated as a result of combustion of machinery and equipment used. This impact has been considered of low magnitude and therefore represents "insignificant" impacts for the environment.

   Increasing sound (noise) levels is considered as the impact most likely to occur during different stages of the project. However, it is classified as "insignificant" impact because their levels do not reach the values needed to cause discomfort to the population during the operation; likewise, although higher levels will be presented during construction stage, damages will be only temporary. The higher effect of this factor focuses on the construction stage because the activities to be undertaken include earthmoving and operation of equipment and machinery.

4. **Odors Generation:** Odors could be generated during procedures of maintenance of facilities and equipment, collection, transportation and disposal of wastes removed from treatment system. However, odors will be efficiently controlled by odor extractor and biofilters during project operation. Also there are no residential areas immediately adjoining the WWTP or within the immediate surrounding area as the site location is in an industrial area. The project design allows for the consideration and construction of anaerobic digesters and cogeneration systems in order to achieve stabilization of primary sludge produced during wastewater treatment process. Thus, the stabilization of these wastes will be achieved along with their safe handling with a lower level of unpleasant odors.

5. **Inconveniences caused by urban and traffic congestion:** it is considered that quality of life of people along the main route of waste transportation could be adversely affected. However, such damages are considered as "insignificant" because they are related to the system construction and are temporary. The impacts are related to the generation of noise and vibrations. During the construction stage the installation of force main will require excavations at specific sites in the avenues 14ª SE, Adolph Simmons and Raúl Clemente Huerta. These works will temporarily alter the traffic around the sector and modify the condition of these roads. Existing urban infrastructure could also be affected by the vibrations caused during excavations and/or drilling. However, these impacts will be "insignificant" to the extent the Environment Management Plan implements protection measures and pedestrian safety. In general, these activities will be temporary. The Project ESMP includes traffic management.

   Similarly, in the operation stage the transport of biosolids will have an adverse effect because of the cargo vehicles which transport these materials must pass through common

transit routes. Stabilization of sludge produced in the plant is planned to minimize odors. The route for truck transport will established based upon safety issues also.

6. **Ground quality and groundwater table:** The normal shallow ground characteristics could be altered as a result of works of foundations and piling. It is considered that the excavations performed during plant construction would affect ground and groundwater table. While these impacts are not considered to be significant over a broad area, these effects should be controlled by proper construction procedures to avoid contamination.

7. **Drainage network:** Excavations considered by the project for both the construction of WWTP and force main can cause alterations and breakage to the existing drainage network. It is estimated that some situations will be present during operation of the project such as changes in water consumption habits by population, possible obstructions in discharge sites, maintenance of the pumping station or wastewater conveyance, and maintenance of the treatment units. The scenarios mentioned above cause some variation in the inlet flow to the WWTP, adversely affecting the treatment system. These impacts are not considered significant from an environmental viewpoint.

8. **Surface water quality:** It is anticipated that that the installation of the WWTP outfall could case damages to quality water of Guayas River, due to sediment removal and transport of materials, especially in Cobina estuary where the outfall will be installed. However, the construction method to be implemented for the installation of the outfall considers using temporary trunk type dams or other immersion methods which will minimize sediment removal. Excavations or drilling to the land will be required to install force main. Due to the nature of these activities this may cause contamination risks by sediment removal. However, this risk is minimized by the limited existence of groundwater bodies, and the impact is “insignificant”.

9. **Stability of fauna and flora habitat:** It is estimated that performing works such as placement of fills during the construction of structures and installing a sub fluvial pipe will cause “insignificant” impacts on terrestrial and aquatic flora, and its magnitude will depend on the biological conditions of the environment intervened. As a result of construction activities (foundation and piling, excavations, placement of fills, among others), habitat of certain groups of organisms which include birds, edaphic fauna, among others, but only in areas not occupied by urban expansion, will be affected.

10. **Destruction or alteration of landscape:** It is anticipated that during the construction stage the visual component of urban environment will be slightly affected.

11. **Health and safety for workers and residents:** Construction activities as excavations and operational activities as operation of treatment plant are risky activities for workers. The Environment Management Plan shall establish proper measures to safeguard the integrity of technical, administrative, and operational personnel and general population.

12. **Expropriations of land:** In terms of expropriation and resettlement, the project for Las Esclusas WWTP will affect seven (7) lots accounting for a total 40.74 ha of land. Over 50% of the land to be acquired (21.5 ha) do not have economic or residential uses. Two of the seven lots will be impacted, with the 16.74 lot owned by the company NATURISA (lot 7) which is dedicated to shrimp farming, while another lot of 1.5 hectares belongs to Radio

CENIT S.A. (lot 4) which has an antenna and a house where a female guardian lives . The graphic below shows the distribution of the lots. It is necessary to note that lot 7 is under an expropriation process and will be used for the future implementation of secondary treatment. A separate Remedial Resettlement Action Plan has been prepared explaining the extent to which the expropriation process conforms with the World Bank Policy on Involuntary Resettlement, and the additional measures that the client has taken to address the gaps identified. With the implementation of the measures outlined in the Remedial Resettlement Action Plan, the land acquisition and resettlement taking place on this site will conform with the provisions of the World Bank's Policy on Involuntary Resettlement.

13. As mentioned above, 16.74 hectares of an adjacent shrimp farm will be expropriated (Lot 7). The agreement to expropriate included compensation for all the investments made by the operator in the land acquired. Thus the expropriation will not adversely affect the livelihood of the operator who retains a large commercial operation. The expropriation of the land is the only impact on this shrimp farm as it is anticipated that the operations of the WWTP will not adversely impact its viability.

Figure 6. Lots affected by the WWTP

Source: EMAPAG.

In general, negative impacts due to activities performed during different stages of project "Construction, Operation and Performance of La Pradera Pump Station, force main and Wastewater Treatment System - Las Esclusas South Subsystem" are of "insignificant" type.

7.6 Expected Project Benefits

Likewise, the analysis performed shows that the positive impacts of higher magnitude and importance occur during the operation of the WWTP, being the purpose of the project the production of a treated effluent with physical, chemical or biological parameters within ranges set forth under the environmental legislation, which will be discharged into Guayas River, thus reducing deterioration of this receiving ecosystem. Among the existing benefits of the construction stages, due to execution of works to be performed (Force Main, Pumping Station, Treatment Plant, and sub fluvial outfall), the "increase of job opportunities" is highlighted.

In general, various activities included in the construction and operation phases would generate significant, positive impacts, among which the following are highlighted.

1. **Reduction of odors in La Pradera PS:** Activities such as maintenance of facilities and equipment, collection, transportation and sludge disposal may generate odors. However, biofilters and odor extractors are planned to be installed in order to reduce this impact in the system operation. For this, it is worth mentioning that the opinion survey conducted in the area of study determined that 30 percent of people perceive odors permanently and 70 percent said that odors are intermittent. Sixty-four percent of residents said that odors perception is daily and 36 percent said that the perception is weekly. Twenty-three percent of residents believe that odors are strongest in the morning; 64 percent believe that odors are strongest in the afternoon and 14 percent indicated that they are stronger at night. Eighty-four percent of residents ensure that odors increase in winter and 16 percent said that they increase in summer.

2. **Reduction/Elimination of overflows of wastewater in the streets:** The frequency of discharges of raw sewage into Guayas River will decrease considerably with the operation of the system, because the new pumping station and WWTP will have sufficient capacity to handle sanitary peaks in dry season and up to two (2) times sanitary flow peak in rainy season.

   Likewise, global implementation of the project enables the management of wastewater discharges from the population of the southern sector of the city, improving the sewer system and therefore the overflow of wastewater would be avoid.

   The Pumping Station will not be subject to tide conditions, therefore, the piping capacity upstream will be greater. Having a higher capacity, pumping and emptying times of the storage chamber in the Pumping Station will be less frequent, thus avoiding the generation of noise and vibration.

3. **Control of discharges and waste generation:** It is assumed by following best management practices, such as controlling illegal connections and implementing a wastewater treatment system, effluent will be of good condition before being discharged to the Guayas River. This would comply with applicable law and reduce the possibility of contamination by liquid waste.

   On the other hand, preventive maintenance of structures and equipment of WWTP will enable proper operation, avoiding incidental discharges of water without proper treatment. Additionally, proper management of sludge is a basic factor to prevent environment degradation.

4. **Improvement to the river's water quality:** Implementations of the project will result in treated effluent whose physical, chemical or biological parameters are within ranges set forth by environmental legislation. This will allow improvement to the quality of the effluent that historically has been discharged into the natural environment, avoiding losing the water quality of the receiving body. Likewise, studies on "Hydrodynamic Simulation and Environmental Quality of Duala-Guayas Rivers" indicate that DO of receiving body will be greater than 5 mg/l, if the WWTP is operating, value required for the development

of river aquatic communities. A disinfection system of the treated water prior to discharge will also be available; fecal coliforms will not enter into the receiving body.

Implementation of an efficient treatment system will allow the City to obtain an effluent of good quality, whose discharge does not represent risks to the existing fauna. Additionally, proper collection, transportation, and disposal of wastewater from the southern sector of Guayaquil will ensure effluent delivery to the body of water has right conditions permitting normal development of the area's flora. The WWTP will have a direct benefit on the biotic stability and water quality in Guayas River.

5. **Improvement of soil quality and ground water:** It is planned to perform tasks such as compacted fill, cleaning, clearance of debris, etc., in order to significantly improve soil physical conditions. The operation of WWTP provides proper collection of wastewater generated by population in southern city, limiting the possibility of discharges on the surface and avoiding contamination by direct infiltration. Similarly, placement of compacted fills, concrete structures, tanks and others will prevent the contamination of groundwater level and bodies of water in areas of implementation of the project.

6. **Citizen perception of the project:** The project will ensure an optimal treatment to the wastewater generated, improving health conditions of population, and avoiding discharges without treatment, which is reflected in the improvement of quality of life of inhabitants of Guayaquil city. Also, the project will enable to recover landscape and environmental quality of Guayas River for tourism and navigational uses. In this regard, the inhabitants in the sector agree with the project.

7. **Job Creation:** One of the most important benefits of the project is the creation of permanent and temporary employments sources during construction and operation stages of the project.

8. **Community services and urban facilities:** The project enables the fulfillment of one of the main objectives of the Local Government: to provide a proper mechanism for management of wastewater generated by the population. It is considered as the most significant positive impact arising from the development of the project.

9. **Health and safety for workers:** The installation of work camp during construction stage will provide a safe place where all workers can perform their administrative tasks outside the construction area.

   Furthermore, all safety and security personal measures required for the construction and operation of the project will be available in all its components: pumping station, force main, and treatment plant. With these measures, high levels of production will be achieved in the system and potential accidents and unforeseen circumstances resulting from the project will be avoided.

10. **Revenues and expenditures for the public sector:** The pre-construction process will require obtaining various permissions and the regularization of land use which include the cancellation of specific fees.

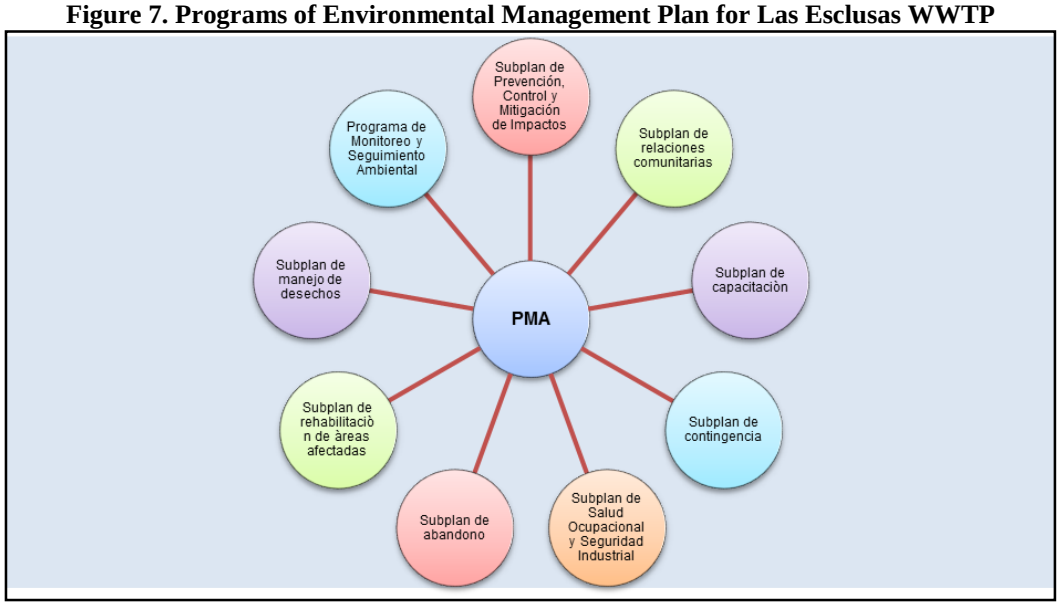
8. Environmental and Social Management Plan (ESMP)

8.1 ESMP Components

The Environmental and Social Management Plan (EMP) is a management tool comprising a series of plans, procedures, and actions focused on preventing, eliminating, minimizing and controlling negative impacts associated with the Project, as well as maximizing positive impacts of the activities related to operation and maintenance of the WWTP.

The Environmental Management Plan has been designed to take into account provisions set forth in the Environment Impact Assessment Subsystem of the Ministry of Environment and the applicable World Bank safeguard policies. Therefore, each program has been designed based on results obtained in the prior chapters of this Environment and Social Impact Assessment. Environmental Management Plan has 9 programs which are detailed in the following figure:

Figure 7. Programs of Environmental Management Plan for Las Esclusas WWTP



Prepared by: Hazen and Sawyer & Consulambiente Cía. Ltda.

Components or programs that integrate the ESMP are aimed at reducing, correcting, or compensating environmental effects caused by the execution of the project during construction, operation, and implementation stages of the project. Environmental mitigation measures proposed refer to definition of responsible parties, technical specifications, monitoring indicators, means of verification, deadlines, and costs. A summarized description of the content of each plan is provided below:

- Plan for Prevention and Mitigation of Impacts. Includes technical, regulatory, administrative, and operational actions aimed at preventing and minimizing negative impacts on each environment's component before they occur, and mitigating or correcting them once they are generated.
- Handling and Management Plan of Wastes. Includes measures and strategies to be implemented in the project to develop a correct and timely waste management from generation to disposal.

- Monitoring and Measurement Plan. Monitoring and Measurement Plan aims to assurance compliance with environmental regulations through periodic characterization of environmental changes caused by the development of the project.
- Plan for restoration of degraded areas. It is a management tool to restore the degraded areas as a result of adverse environmental impacts of a work and its operation. This plan will set forth the activities and actions required for the area's recovery.
- Occupational Health and Security Plan. This program includes the implementation of measures to prevent work-related accidents and issues in the occupational health of workers.
- Community Relationship Plan. This program is aimed at providing a guide to establish a mechanism that enable the interaction between promoter company and population located within the area of influence, and use them to reach agreements for the benefit of all participants.
- Training Plan. Includes a training program for the employees of the promoter company and contractors involved in all activities of the project on the implementation of Environmental Management Plan and various topics related with its compliance.
- Contingency Plan. The contingency plan is aimed at providing procedures and actions for mobilization, warning, and coordination which shall be applied in any emergency event in order to prevent and minimize impacts to health, environment, infrastructure, and physical cultural resources.
- Abandonment Plan. This program describes a set of actions for the permanent abandonment, if happen, including the temporary and permanent removal of the structure, in order to return the site to its initial conditions.
- Environmental Monitoring Plan. This is a tool for environmental monitoring designed to assess compliance of ESMP according to the established execution schedule.

Each monitoring, prevention and/or mitigation measure of environmental impacts has the following structure to develop: 1) Objectives, 2) Potential impacts faced, 3) Procedures, 4) Reference Documents, 5) Records, 6) Verifiable indicators of implementation, 7) Expected results, 8) Responsible for implementing, 9) Cost of activity; cost of measure.

A separate Remedial Resettlement Action Plan has been prepared explaining the extent to which the expropriation process conforms with the World Bank Policy on Involuntary Resettlement, and the additional measures required to address gaps identified.

8.2 Measures of ESMP

As mentioned above, the ESMP has 9 programs that include 36 environmental measures and 122 activities; the stages of pre-construction (P) and construction (C) consists of 18 measures and 62 activities, while the operating stage (O) consists of 18 measures and 60 activities, which are listed below:

Table 6. Environmental and Social Measures Proposed

Nº	ENVIRONMENTAL AND SOCIAL MITIGATION MEASURES				DESCRIPTION
1	Measure1	P	Pre-Construction Schedule	Activity Nº 1.1	Proper Schedule to start pre-work.
		P		Activity Nº 1.2	Technical inspection for current assessment of the area of influence.
2	Measure 2	P	Work Schedule	Activity Nº 2.1	Proper schedule of works.
3	Measure 3	C	Work Camp	Activity Nº 3.1	Define areas that form the work camp.
		C		Activity Nº 3.2	Order and maintenance of work camp
		C		Activity Nº 3.3	Order of the storage warehouse of building materials.
		C		Activity Nº 3.4	Order and clean of dining rooms
4	Measure 4	C	Cleaning Of Waste Generated By Construction	Activity Nº 4.1	Daily cleaning of construction area
5	Measure 5	C	Preventive Maintenance Of Equipment And Machinery	Activity Nº 5.1	Performing preventive maintenance to equipment and machinery.
6	Measure 6	C	Measures To Control Noise Contamination	Activity Nº 6.1	Noise and vibration control
7	Measure 7	F	Preventive Maintenance Of System Installed	Activity Nº 7.1	Inventory of equipment and instruments.
		F		Activity Nº 7.2	Preventive and corrective maintenance of Las Esclusas WWTP.
		F		Activity Nº 7.3	Updating of equipment inventory of La Pradera Pumping Station and preventive and corrective maintenance.
		F		Activity Nº 7.4	Maintenance to the emergency electric generators.
8	Measure 8	C	Management Of Chemical And Hydrocarbons	Activity Nº 8.1	Handling and storage of chemicals.
		C		Activity Nº 8.2	Storage of hydrocarbons (fuel and lubricants)
9	Measure 9	C	Waste And Effluent Management	Activity Nº 9.1	Obtaining register as hazardous waste generators
		C		Activity Nº 9.2	General provisions for a proper wasted management
		C		Activity Nº 9.3	Waste's control and inventory
		C		Activity Nº 9.4	Segregation and collection
		C		Activity Nº 9.5	Reuse and recycling
		C		Activity Nº 9.6	Temporary storage
		C		Activity Nº 9.7	Debris management
		C		Activity Nº 9.8	Transport and disposal
		C		Activity Nº 9.9	Hazardous and special waste management
		C		Activity Nº 9.10	Wastewater management - Portable sanitation units
10	Measure 10	F	Control Of Waste And Effluents Generated	Activity Nº 10.1	Colored metal pan
		F		Activity Nº 10.2	Temporary storage
		F		Activity Nº 10.3	Transport and disposal

Table 6. Environmental and Social Measures Proposed

Nº	ENVIRONMENTAL AND SOCIAL MITIGATION MEASURES				DESCRIPTION
		F		Activity Nº 10.4	Sewage sludge management
11	Measure 11	F	General Provisions For Hazardous Waste Management	Activity Nº 11.1	Identification of hazardous waste
		F		Activity Nº 11.2	Hazardous and special waste management
12	Measure 12	C	Monitoring Program	Activity Nº 12.1	PM2.5 particulate matter monitoring
		C			PM10 particulate matter monitoring
		C		Activity Nº 12.2	Noise and vibration control
13	Measure 13	F	Monitoring And Measurement Plan During Operation And Implementation Of Structures Implemented.	Activity Nº 13.1	Odors monitoring
		F		Activity Nº 13.2	Quality monitoring of waste water discharge
		F		Activity Nº 13.3	Sludge monitoring
		F		Activity Nº 13.4	Noise Control and Monitoring
		F		Activity Nº 13.5	Pollutant gas Monitoring-fixed sources
		F		Activity Nº 13.6	Environmental air quality monitoring
		F		Activity Nº 13.7	Weather parameters monitoring
14	Measure 14	F	Monitoring And Measurement Plan For Receiving Water Body	Activity Nº 14.1	Phytoplankton and Zooplankton monitoring
		F		Activity Nº 14.2	Macro-Benthic organisms Monitoring
		F		Activity Nº 14.3	Surface water monitoring
15	Measure 15	F	Control Of Algae Proliferation In Receiving Bodies	Activity Nº 15.1	Report on event
16	Measure 16	C	Restoration Of Affected Areas	Activity Nº 16.1	Cleaning of waste in areas accidentally affected by construction activities and WWTP installation.
				Activity Nº 16.2	Restoration of sites affected by construction
17	Measure 17	F	Cleaning Of Affected Areas	Activity Nº 17.1	Cleaning of waste in areas accidentally affected by preventive and corrective maintenance activities of the WWTP.
				Activity Nº 17.2	Restoration of sites affected by force main maintenance.
18	Measure 18	P	Implementation Of Community Relationships Program	Activity Nº 18.1	Meeting with the community
		P		Activity Nº 18.2	Information sign - Safety signs
19	Measure 19	C	Implementation Of Community Relationships Program	Activity Nº 19.1	Meeting with the community
		C		Activity Nº 19.2	Brochure and flyers - occupational environmental
		C		Activity Nº 19.3	Information sign - safety signs
20	Measure 20	F	Implementation Of Community Relationships Program	Activity Nº 20.1	Relationships with interested parties
21	Measure 21	C	Occupational Safety Standards	Activity Nº 21.1	Application of safety rules for handling trucks
				Activity Nº 21.2	Safety standard for Manual load lifting
				Activity Nº 21.3	Safety rules for handling heavy machinery
				Activity Nº 21.4	Rules for temporary electrical installations

Table 6. Environmental and Social Measures Proposed

Nº	ENVIRONMENTAL AND SOCIAL MITIGATION MEASURES				DESCRIPTION
				Activity Nº 21.5	Rules for order and cleaning
22	Measure 22	C	Occupational Safety For Workers	Activity Nº 22.1	Reflective tape
					Safety cones
					Post of PVC and concrete base
					Protection helmet
					Protection glasses
					Anti-Dust Masks
					Leather gloves
					Rubber boots
					Vests
					Earplugs
					Confined Space Entry protection equipment
23	Measure 23	C	Signage Of Work Areas	Activity Nº 23.1	Information sign - safety signs
				Activity Nº 23.2	Road safety plan
24	Measure 24	F	Basic Safety Standards Of WWTP	Activity Nº 24.1	Application of Safety rules for operation of La Pradera Pumping Station and WWTP
25	Measure 25	F	Occupational Safety For Workers	Activity Nº 25.1	Safety cones
					Post of PVC and concrete base
					Protection helmet
					Protection glasses
					Anti-dust Masks
					Leather gloves
					Rubber boots
					Vests
					Earplugs
					Confined Space Entry protection equipment
26	Measure 26	F	Signage Of Work Areas	Activity Nº 26.1	Information sings - Safety signs
27	Measure 27	C	Personnel Training	Activity Nº 27.1, 27.2 y 27.3	Awareness meetings / Environmental Training
28	Measure 28	F	Personnel Training	Activity Nº 28.1, 28.2, 28.3 y 28.4	Awareness meetings / Environmental Training
29	Measure 29	C	Contingency Plan For La Pradera Pumping Station	Activity Nº 29.1	Developing and submitting of final contingency plan
				Activity Nº 29.2	Information of emergency numbers
				Activity Nº 29.3	First-aid Kit
				Activity Nº 29.4	Brigades for emergency care
				Activity Nº 29.5	Drills
				Activity Nº 29.6	Acting in case of fire
				Activity Nº 29.7	Acting in case of spillage of fuels and chemicals.
				Activity Nº 29.8	Acting in case of Natural Disasters.
30	Measure 30	F		Activity Nº 30.1	Final Contingency Plan

Table 6. Environmental and Social Measures Proposed

Nº	ENVIRONMENTAL AND SOCIAL MITIGATION MEASURES				DESCRIPTION
			Contingency Plan For La Pradera Pumping Station and The WWTP.	Activity Nº 30.2	Training brigades - Training session
				Activity Nº 30.3	Implementation of fire extinguishers and contingent and emergency equipment.
				Activity Nº 30.2	First-aid Kit
				Activity Nº 30.5	Information of emergency numbers
				Activity Nº 30.6	Acting in case of fire
				Activity Nº 30.7	Acting in case of spillages
				Activity Nº 30.8	Acting in case of Natural Disasters.
31	Measure 31	C	Abandonment Program	Activity Nº 31.1	Blocking Access roads, fencing, and abandoned site safety.
				Activity Nº 31.2	Removal of machinery, tools and equipment
				Activity Nº 31.3	Dismantling and removal of the area used as contractor's site and storage area for construction materials.
				Activity Nº 31.4	Cleaning and evacuation of waste and debris.
32	Measure 32	C	Abandonment Program	Activity Nº 32.1	Removal of machinery, tools, and equipment used in works.
				Activity Nº 32.2	Removal of unused construction materials and/or likely to be reused.
				Activity Nº 32.3	Dismantling and removal of the area used as contractor's site
				Activity Nº 32.4	Cleaning and evacuation of waste and debris and removal of portable toilets.
33	Measure 33	F	Abandonment Program	Activity Nº 33.1	Fencing and abandoned site safety.
				Activity Nº 33.2	Draining and sealing of force main and pipes.
				Activity Nº 33.3	Removal of equipment and appurtenances of La Pradera Pumping Station and the WWTP.
				Activity Nº 33.4	Dismantling and evacuation of Building.
				Activity Nº 33.5	Performing cleaning and removal of waste and debris.
				Activity Nº 33.6	Restoration of the intervened site.
34	Measure 34	C	Environmental Monitoring	Activity Nº 34.1	Environmental monitoring
				Activity Nº 34.2	Development of compliance report to competent authority.
				Activity Nº 34.3	Compliance environmental audit.
35	Measure 35	F	Environment Monitoring	Activity Nº 35.1	Environmental Monitoring
				Activity Nº 35.2	Development of compliance report to competent authority
36	Measure 36		Environment Compensation	Activity Nº 36.1	Improvement of La Pradera Park

Prepared by: Hazen and Sawyer.

Distribution and quantities to be applied to each project's components, that is, pumping stations, force main, and treatment plant are shown in the table above.

8.3 ESMP Budget

The estimated total budget for the implementation of environmental and social mitigation measures is US$483,011.66; from which US$326,324.55 correspond to pre-construction and construction stages, accounting for 0.2 percent based on works total cost; and US$156,687.11 per year for the operation stage. This budget has been prepared taking into account the following aspects:

- Deadline for works execution, 24 months for WWTP's construction, and 12 months for construction of Pumping Station and force main respectively.
- Environmental monitoring period during operation, annual (12 months).

The resources for these costs will be included as part of the construction contract for the Project.

Costs for environmental measures during operations and maintenance are included as part of the overall technical/engineering costs for project operation and maintenance.

9. The Project and Climate Change

Minimizing greenhouse gas produced by the anaerobic digestion process of primary sludge from the WWTP is a benefit that helps preserve atmosphere and reduce global climate change. The project includes cogeneration facilities for the production of electricity taking advantage of the calorific capacity of methane gas produced in the plant's digesters. Project engineering studies have estimated of 8,200 m^3 per day of biogas will be processed, 65 percent of flow is methane gas. Therefore, the direct emission of approximately 1.94 million cubic meters of methane gas into the atmosphere will be avoided. Thus the use of methane gas could produce annual net savings of approximately US$242,000 in energy consumption.

10. Social Participation

The process of social participation (PPS, as per its acronym in Spanish)—public consultation—is an integral part of the environmental regulation process under the legislation of Ecuador, basic requirement for obtaining the environmental license for the project.

The methodology applied to the PPS comply with the provisions of Guidelines to Regulations for the Implementation of Mechanisms of Social Participation set forth by Executive Decree No. 1040, published in the Official Gazette No. 332 of May 8, 2008. In general terms, the following aspects were applied:

Table 7. Mechanism Applied in PPS

Mechanism	Qty	Means to verify the mechanism	Location	Date	Media used for the call	Means to verify the call
A. Regulatory						
Public Information Centers - PIC Primary	2	Opening and Closing Minutes of PIC	Metrovía Terminal	18-09-2014 to 02-10-2014	Press releases (2) Private calls (42) Posters (6) Flyers (600) *Announcements by Megaphones* (5)	Copies of publications. Bill of publication Register of invitation Posters photo Photo of announcements by megaphones and delivery of flyers
			Health Center "Casitas del Guasmo"			
Public Hearing - AP, as per its acronym in Spanish	1	Attendance Record to the AP and recording of observations	Huancavilca Foundation	25-09-2014		
B. Recommended by Multilateral Banks						
Public Information Centers - PIC Secondary	2	Opening and Closing Minutes of PIC	La Pradera Park	22-09-2014 to 08-10-2014	Flyers (400) *Announcements by Megaphones* (4)	Photo of announcements by megaphones and delivery of flyers
			Pablo Neruda Park	23-09-2014 to 07-10-2014		
Information meetings - RI, as per its acronym in Spanish	2	Attendance Record to the RI and recording observations	La Pradera Park	07-10-2014		
			Pablo Neruda Park	30-09-2014		

10.1 Public Information Centers

The ESIA was made available to the public at a place of open access having personnel familiar with the project to provide the necessary explanations. Each PIC operated for two weeks at a time from 08:00 to 13:00.

The PIC are located in places of massive turnout at Metrovía Terminal and Health Center. For Pradera and Pablo Neruda it was considered appropriate to install the PIC in the park adjacent to La Pradera WWTP and H Pumping Station. Location of the PIC can be seen in the map below:

Figure 8. Location of Public Information Centers

Descriptive statistics on the number of people who made questions and comments at the PIC is shown in the following table. It is noted that the total of people who signed the register was 697.

Table 8. Participation Statistics at PIC

Description	PIC Number of Question			
	Metrovía	**Guasmo**	**Pradera**	**P. Neruda**
Total	194	236	148	119
Minimum/day	9	20	3	0
Maximum/day	20	23	13	21
Average/day	15	21	10	11

Comments made	19	37	26	7

The following table summarizes all comments (89) received at PIC which have been distributed in 12 main areas:

Table 9. Number of Comments Recorded at PIC

ITEM	SUMMARY	Metrovía	C. Guasmo	Pradera	P. Neruda	Total
1	Meter installation	3				3
2	Sewer maintenance	5	3	10		18
3	Sewer installation	6				6
4	Good service of commercial claims	1				1
5	Consultation on collection of investment	1				1
6	Damage to roads and debris management	3	3	1		7
7	Compliance with the deadlines of the work		9	1	1	11
8	Acceptance of the project		14		3	17
9	Organization of Community inspectors		3		1	4
10	Odors monitoring		5	12		17
11	Improvements to Pradera Park			2		2
12	No expropriation				2	2
	TOTAL	19	37	26	7	89

Approximately 20 percent of comments recorded are requests related to maintenance activities of sanitary sewer system to prevent overflows, followed by the monitoring odors with 19 percent; another concern of the community is related to compliance with the deadlines of the works (12 percent); 8 percent commented on damages to roads and debris management.

Based upon comments, the following are measures recommended to be included in the Project.

Table 10. Measures to Be Included in the EIA as a Result of PPS

Item	Community Comment	Application Method of comment in the Environmental Impact Assessment
1	Meter installation	Measure: the Concession Holder INTERAGUA should contact the residents of the area of influence of the project that have no water meter, in order to analyze each case and find the best agreed option with the owners to install the meter, because the sewer service is charged as a percentage of consumption of potable water.
2	Sewer maintenance	Measure: the Concession Holder INTERAGUA shall submit annually a Preventive maintenance Plan of Sanitary Sewer System, specific for the area of influence of the project, which shall be implemented under strict control of the EMAPAG EP.
3	Sewer installation	Measure: EMAPAG EP shall manage the universality of sanitary sewer service for the area of influence of the project, within a term not exceeding two (2) years.
4	Good service of commercial claims	Measure: EMAPAG EP shall continue the activities related to project's socialization, supported by its Social Communication Directorate and Community Management, explaining to the community, among other topics, the processes to be followed to raise a request, complaint or claim, and informing them that there is a third instance for which is responsible EMAPAG EP as a regulation and control body.

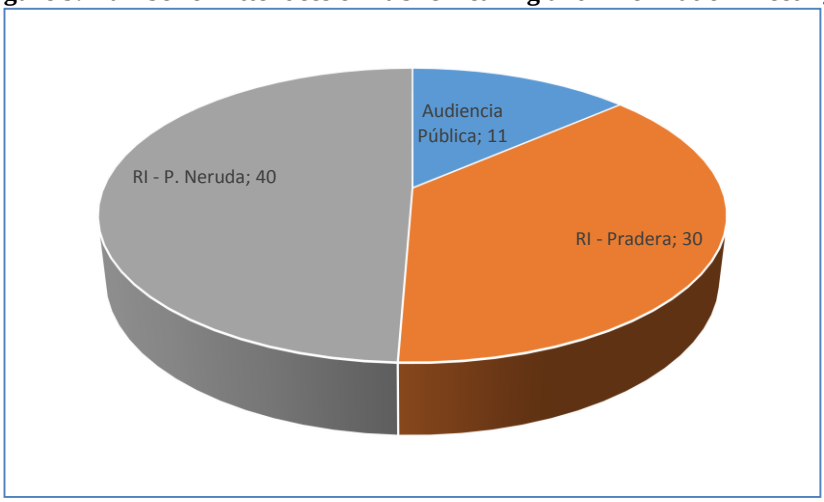
Table 10. Measures to Be Included in the EIA as a Result of PPS

Item	Community Comment	Application Method of comment in the Environmental Impact Assessment
5	Collection of investment	Measure: EMAPAG EP shall continue the activities related to project's socialization, supported by its Social Communication and Community Management Directorate, explaining to the community in general that investment will not be charged because the work will be funded by the budget allocation annually granted by the Municipality of Guayaquil.
6	Damage to roads	Measure: The contractor shall schedule the activities related to breakage of streets, where provided, in order to generate the least effect on roads (vehicle and pedestrian roads); also, high-risk areas should be signalized, both day and night and the community will be informed on this issue.
7	Acceptance of the project	Measure: EMAPAG EP shall continue the activities related to project's socialization, supported by its Social Communication and Community Management Directorate, explaining to the community the benefits of the project to ensure the support of the community.
8	deadline of the work	Measure: EMAPAG EP shall closely monitor compliance with the term of works set forth contractually to avoid extensions; in case of unforeseen situations that require extensions of term the community of the particular area of influence must, under the mechanism of greater implementation provided for by law, be informed.
9	Community inspectors	Measure: EMAPAG EP shall train to community leaders as citizen inspectors, supported by its Social Communication and Community Management Directorate, in order that they can fulfill this function linked to the project.
10	Odors monitoring	Measure: The concession holder INTERAGUA shall perform monitoring campaigns of gases (hydrogen sulfide) and surveys campaigns in order to confirm the level of no detectable gases; in case there are effects it shall propose immediate remedial measures accompanied by campaigns of socialization in which the actions to be taken to eliminate or minimize odors are explained.
11	Improvements to Pradera Park	Measure: As part of the Integral Project EMAPAG EP should consider within the project's costs, the rehabilitation of a park located near to the future La Pradera and Guasmo H Pumping Station, under close coordination of the Department of Parks and Green Areas, and the Directorate of Public Works of the Municipality of Guayaquil. Design to be submitted for this rehabilitation should be socialized with the community living in the vicinity of the park.
12	No expropriations	Measure: EMAPAG EP shall continue activities related to project's socialization, supported by its Social Communication and Community Management Directorate, explaining to the community that the project does not involve any type of expropriation or relocation of housing, except for the specific case of a house located on a lot owned by Radio Cenit S.A.

10.2 Public Hearing and Information Meetings

The ESIA was disclosed and a Public Hearing was held on September 25, 2014, at 18:00 hours, at the offices of the Foundation Huancavilca. The meeting provided a summary of the main features of the project, expected environmental and social impact and the respective mitigation measures, and responses to clarify questions and concerns about the project based upon comments and opinions of participants. The number of people who attended both the Public Hearing and Information Meeting are shown in the following graphic.

Figure 9. Number of Attendees of Public Hearing and Information Meetings



Data Source: EMAPAG

Two informational meetings were also held; one at Pradera and one at Pablor Neruda.

A summary of the questions made at the Public Hearing and Information Meetings and responses to each question are presented below:

Table 11. Observations Obtained at Public Hearing

Question	Answer	Measure
Will the operation of the project generate odors?	Treatment Plant and Pumping Stations have systems designed to treat odors in order to avoid affecting the community in the vicinities.	Measure: During the operation phase of the project, the Concession Holder INTERAGUA shall perform monitoring campaigns of gases (hydrogen sulfide) and surveys campaigns in order to confirm the level of no detectable gases; in case there are effects it shall propose immediate remedial measures accompanied by campaigns of socialization in which the actions to be taken to eliminate or minimize odors are explained
Which is the area of impact of shrimp farms? (question made by the representative of NATURISA)	The area required by Naturisa is approximately 16.5 ha which is located on the west side of the premises of Las Esclusas (note: the area was shown in a drawing).	Implementation of an action does not apply.
When the works will be executed and which is the term for completion?	It is planned to start construction in the second half of 2015 and has a term for completion of two years.	Measure: EMAPAG EP should perform a close monitoring of the terms set forth contractually to avoid extensions; in case of unforeseen situations that require extensions of term the community of the particular area of influence must, under the mechanism of greater implementation provided for by law, be informed.

Table 12. Observations Obtained at Information Meeting - Pradera

Question	Answer	Measure
Which is the term for completion of works?	Works will be executed from the second half of 2015 and has a term for completion of two years.	Acceptance during the process of social participation.
Will the project generate odors?	The odors that will be generated by the project in both the Treatment Plant and the Pumping Stations will be treated; therefore, community will not be affected by odors.	Acceptance during the process of social participation.
Will there be impacts during the execution of works?	There will be specific impacts during the construction of the works, such as noise and dust, to reduce these effects environmental measures have been designed.	EMAPAG will monitor the environmental monitoring plan
Which is the scope of works?	The works will be performed within Pradera Plant, at Pump Station H, in the area of Las Esclusas and force main will go from Pradera plant to Las Esclusas Plant.	EMAPAG will monitor the environmental monitoring plan.
Do wastewater will be treated or discharged untreated into the river?	Prior to discharge, wastewater will be subjected to pre-treatment, a primary advanced treatment and disinfection; untreated wastewater will not be discharged into the river.	EMAPAG will monitor the environmental monitoring plan.

Table 13. Observations Obtained at Information Meeting - Pablo Neruda

Question	Answer	Measure
Will there be expropriations because of the project?	The project does not represent any kind of expropriation for the construction of the pumping station Guasmo H.	Acceptance during the process of social participation.
Will there be Relocation of Premises?	The project does not represent any kind of relocation, except in the case of a surveillance booth where leaves a lady who has surveillance functions of a radio antenna.	Acceptance during the process of social participation.
Will the project generate odors?	Treatment Plant and Pumping Stations have systems designed to treat odors in order to avoid impacting the community in the vicinities	Acceptance during the process of social participation.
What happens if as a result of the execution of works appear cracks in the houses?	The contractor is required to leave the houses in the same or better conditions (prior to the execution of works); in case cracks appear, EMAPAG EP will ensure this will be complied.	Preparation of property records and purchase of third party liability insurance.

It should be emphasized that each of the questions made at the Hearing and Information Meetings, were answered by technicians from the designer consultant or otherwise by the promoter of the project.

Moreover, queries related to expropriation, relocation and title of lands that were made by the community of Pablo Neruda, are a result of the fact that in the sector the National Government is conducting a relocation process as part of the Recovery of the Estero Salado.

10.3 Grievance Redress

A grievance redress system has been set up by EMAPAG EP for the overall project including all components and a description has been posted in EMAPAG's website[12]. It includes contact details for community members or potentially affected parties to raise potential complaints or information requests (also before contractors are on board), as well as the responsible person and directorate within EMAPAG EP for managing and monitoring the grievance system (Dirección de Comunicación Social - Gestión Comunitaria [DCS-GC]).

The system for complaints handling regarding Component Three in particular is described in the sub-plan for community relations within this ESIA. During the implementation of the project, the contractor will be obliged to maintain a reception area onsite, for members of the adjacent community who may have questions, concerns or complaints related to the project. This reception should be staffed by someone who will maintain a register of complaints and how they were resolved. During the operation of the WWTP, Interagua will also have a dedicated specialist responsible for community relations who will be responsible for receiving, registering and resolving complaints.

11. Conclusions and Recommendations

The ESIA for "construction, performance and operation of Pradera Pumping Station, Main Force and Wastewater Treatment Las Esclusas - South Subsystem" allowed the collection of information on the characterization of the natural and human environment of the area of influence, shocking actions and potential environmental impacts of the project, obtained the following:

- Activities to be developed for the execution of the force main and the improvement of the pumping station will be performed within the urban area in intervened areas where the effects on the environment are minimized. In the case of the treatment plant and the sub fluvial outfall these will be built in remote places where there are no settlements, although it will be more likely to impact the natural environment.
- Construction of the project will involve an environmental disturbance on the site where will be located the WWTP and in different areas of the city, due to the installation of a 5 km force sewer main that will convey wastewater from the pumping stations to the WWTP
- Alternative analysis helped identify the applicable WWTP technological process

[12] http://www.emapag-ep.gob.ec/emapag/?page_id=731

- Studies conducted and the analysis of technical information of the project allowed establishing the areas of direct and indirect influence for each component in the construction and operation phases
- The project includes strategies for proper management of wastewater in the city of Guayaquil, such as: collection and conveyance of domestic wastewater by means of pumping stations and force mains, allowing greater control of illegal discharges, and the implementation of a treatment system that ensures an effluent with acceptable conditions to comply with the standards allowed by laws in force in the country, regarding the final discharge into the receiving body.
- Most of the negative impacts will occur during the installation of the main force because the work involves earthmoving and excavations in operating roads, which will cause discomfort in the area, in addition to alteration of vehicular traffic and high noise levels.
- Increase of sound pressure (noise) levels is considered the impact most likely to occur during the different stages of the project. However, it was assigned to a category of "insignificant", because it is estimated that during the performance its levels will not reach the values required to produce discomfort to the population and during construction although higher levels will exist impacts will be only temporary.
- Most of the positive impacts observed arise from the operation of the wastewater treatment plant and from complementary systems with direct benefits on the health of the population as it ensures proper treatment and disposal of wastewater produced by the inhabitants of the south of the city. These include:

    - Improvement of sanitation of the population of the city of Guayaquil through the reduction of pollution of waters of Guayas River front and downstream of the city of Guayaquil. Likewise, the balance of the ecosystem will be recovered through the recovery of quality of the landscape and preservation of flora and fauna species.

    - Decrease in current obnoxious odors around the existing pump station in Pradera as the new pumping station includes the implementation of appropriate control measures of odors.

    - Significant decrease in the frequency of discharges of raw sewage water into Guayas River because the new pumping station and the WWTP will have the ability to manage sanitary peaks in the dry season and up to two (2) times the peak sanitary flow in the rainy season.

    - Decrease in cases of gastrointestinal, parasitic, and skin diseases. The low risk of environmental pollution would be reflected in a decreased morbidity and infant mortality, allowing a reduction in the costs of healthcare for the population benefiting from the project. This suggests assessing the following indicators: infant mortality due to gastrointestinal diseases and general morbidity of gastrointestinal diseases. Monitoring or control indicators are fecal coliforms and E. Coli in the effluent of the WWTP and fecal coliforms and E. Coli in bodies of water.

    - Recovery of the quality of the landscape and preservation of flora and fauna species would be reflected in an increase of tourism and recreational activities, leading to increase family income and improve the quality of life of the population of Guayaquil

- As the urban population of the city of Guayaquil grows, so does the volume of wastewater and organic wastes that pollute the environment, so it is imperative to take essential measures to counteract environmental pollution to:

  - Prevent diseases and protect the health of the population.
  - Prevent nuisances to population.
  - Maintain clean water for bathrooms and other recreational processes
  - Maintain clean water used for propagation and survival of fish and other aquatic species.
  - Keep water for potential touristic, industrial, and agricultural uses.
  - Prevent siltation of navigational channels

- With the increasing population, laws and regulations governing pollution and wastewater disposal are becoming increasingly essential. Only by means of these legal procedures and strict adherence can be guaranteed to the entire population a clean, comfortable, and healthy environment.