E4103 v2

metro

ENVIRONMENTAL IMPACT STUDY OF THE METRO DE QUITO FIRST LINE.

EXECUTIVE SUMMARY

Noviembre de 2012. Exp. 1479

GESAMBCONSULT

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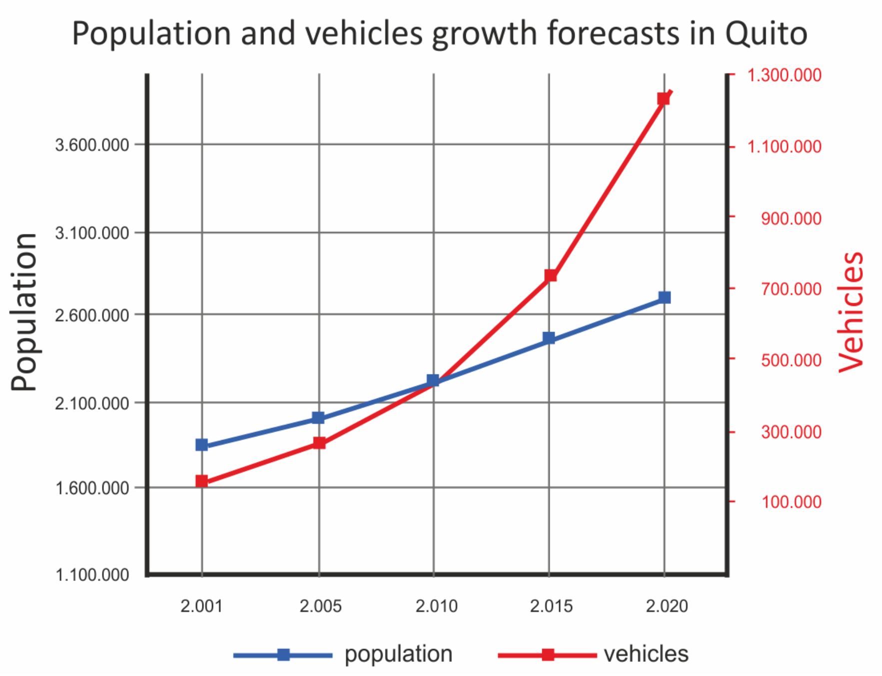
1. INTRODUCTION

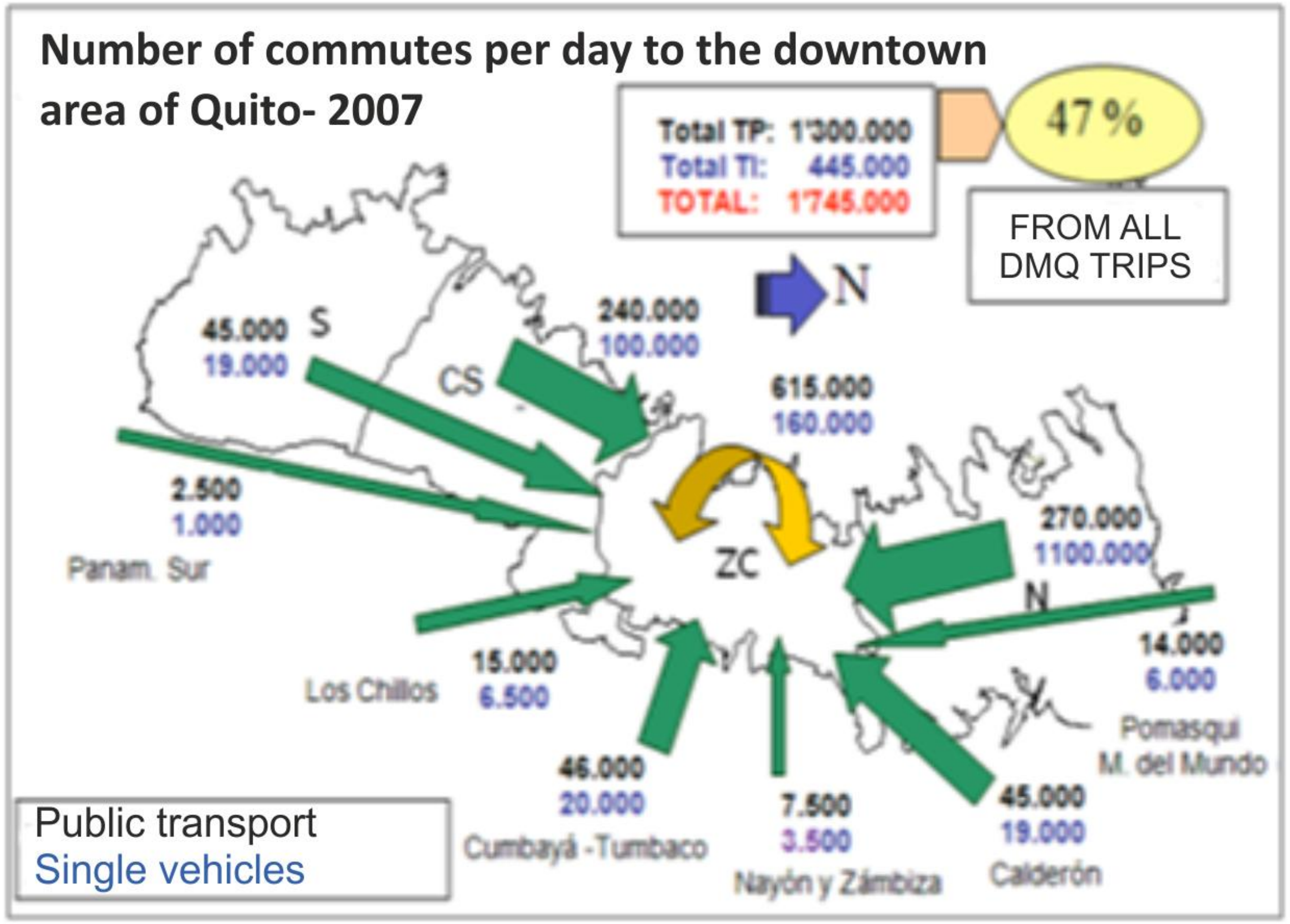
This document is a non-technical summary of the Environmental Impact Assessment of the first line of the Metro de Quito Project, which seeks to inform the general public of the impacts that this project will generate and the measures that will be applied to maximize positive impacts and minimize negative ones.

The grave mobility situation in the city of Quito has caused a clear deterioration in the quality of life of its inhabitants. The crippling traffic congestion, a fragmented and inefficient public transport system, the growing demand for mobility and public transport, the disorganized and poorly regulated intervention of private operators, rapid population growth and the longitudinal configuration of the city itself; are some of symptoms that characterize mobility in the city of Quito.

The mobility and demand studies warn that the number of cars in Quito will double by 2020, causing the collapse of the traffic system in the city with dramatic consequences for the population, which will end up spending between 3 and 4 hours a day, on average, to get to and from work. In addition there will be serious effects due to increasing and uncontrollable environmental pollution.   The graphics below represent the trend in vehicle increase in Quito, as well as the number of trips per type of transport.



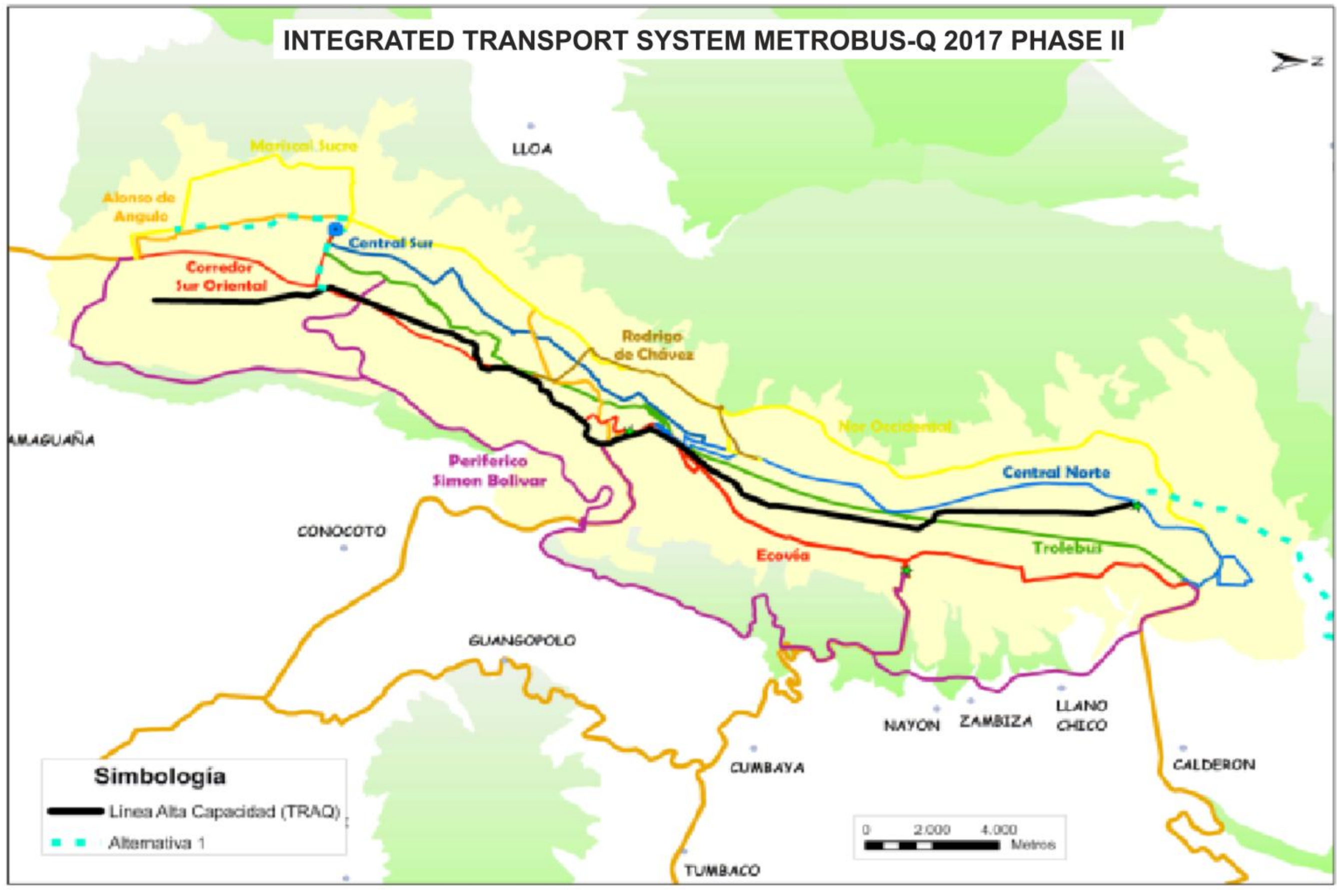
Source: CORPAIRE and PGDT Data. Elaborated: UNMQ, 2011



Source: EPMMOP-DMQ-Metro de Madrid S.A. Studies for the conceptual design of an integrated mass transit system for Quito and the Feasibility of the first line of Metro de Quito.2011

Faced with this reality, and consequently with the Plan Maestro de Movilidad para la Ciudad de Quito [Mobility Master Plan for the City of Quito] 2009-2025, the Metropolitan District of Quito (MDMQ) has resolved to design and implement a so called Integrated Mass Transit System (SITM), understood as the full complement of public transport options, including the Metro as its linchpin. It constitutes an efficient and sustainable public transport offer, integrated physically and in terms of tariffs, acting under the guidance of a municipal institution which plans, manages and controls the transport system, under an appropriate regulatory framework

This figure shows the transport system planned for 2017.



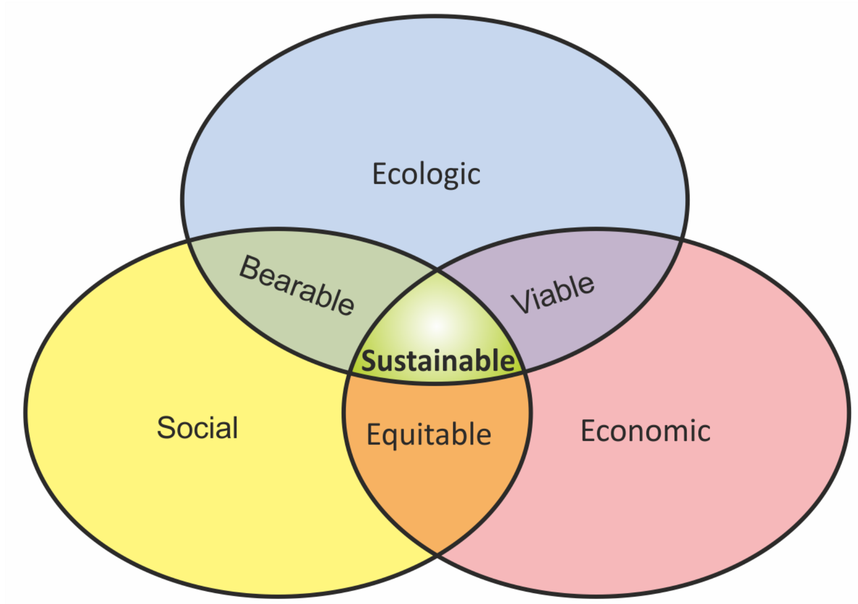
Source: EPMMOP-DMQ-Metro de Madrid S.A. Studies for the conceptual design of an integrated mass transit system for Quito and the Feasibility of the first line of Metro de Quito.2011

Studies and engineering designs of the first line of the Metro de Quito have been carried out by Metro de Madrid, SA, one of the best companies in the world in the developing and operating metro lines and systems. The environmental studies for the project were the responsibility of the Asociación Gesambconsult – EVREN; the first is Ecuadorian and has extensive experience in environmental impact assessment in complex projects, and the second, of Spanish origin, is highly specialized in mitigating the environmental effects during the construction of subway systems.

The scope of this environmental impact study includes the first line of the Metro de Quito. In addition to its usefulness as a management tool for the analysis and management of the environmental aspects of the project, this study also serves to comply with legal requirements and the requirements of multilateral the funding agencies such as the World Bank, the Inter-American Development Bank, the Andean Development Corporation and the European Investment Bank.

1.1 JUSTIFICATION AND OBJECTIVES

Metro de Quito's first line project has as its main objective the articulation of an efficient public transport system, which promotes the sustainable development of the Metropolitan District of Quito and the nation as a whole. Sustainable development is defined as development capable of "meeting the needs of the present without compromising the ability of future generations to meet their own needs, harmoniously articulating legitimate environmental, economic and social objectives, aspired to by a healthy, modern and competitive society—a seen in the following graphic."



As such the partial objectives of the Project are:

1. implement a modern public transportation system in the city of Quito, preserving ecosystems, species of flora and fauna of high value, air and water quality; using resources rationally and helping reduce emissions of greenhouse gases
2. Promote economic development by creating jobs, boosting economic sectors and improving productivity
3. Build and operate the First Line of the Metro de Quito protecting the welfare of the public by caring for their health, respecting for their principles, values, beliefs and customs, and preserving the cultural heritage of the city.

The environmental impact study objectives are:

a. Analyze and describe the area where the project will be carried out.

b. Identify the significant impacts.

c. Evaluate the environmental impacts.

d. Establish measures in order to take advantage of positive impacts and mitigate the negative ones.

e. Design a set of management plans that enable the monitoring and following up on the main impacts identified.

1.2 ANALYSIS OF ALTERNATIVE MASS TRANSIT SYSTEMS

Mobility demand in the city of Quito in 2010 was 28,000 passengers per hour per direction, while for 2030 a flow of 48,000 per hour per direction is predicted.

In order to balance the demand for mobility with the supply of transport, it is necessary to analyze and determine the most appropriate mass transit system, and in defining the system be sure it is able to meet the demand levels defined in the previous paragraph

The **zero alternative** involves continuing with the same transport system currently operating in the city of Quito, with the aggravating circumstance that, with the passage of time, the demand for public transportation is growing, resulting in the existing system becoming insufficient, especially within the urban growth dynamics. Thus, continuing with this system would result in its collapse within a few years.

The **conventional buses** have the advantage of flexibility of movement and are the choice for lower initial investment. The disadvantages arise from the difficulty of incorporating them into a central planning system, the unprofessional and at times even chaotic management of the transport units and their low capacity to meet passenger flow generated by the increasing demand. A conventional bus carries approximately 50 passengers per hour. In the case of Quito, the city currently has a fleet of around 2,800 units. Rather than a solution the conventional bus option is itself part of the problem for the above mentioned issues. Therefore, the option of conventional buses as the backbone of the Integrated Mass Transit System for the city of Quito has been completely discarded.

The **rapid bus system on segregated lanes,** or BRT, has been the option favored by the Municipality of Quito, as potential linchpin up until now. Four lines make up the Metrobus - Q system: the Trolley or Green Line which was the first to go into operation, the Ecovía or Red Line, continued by the South Eastern Corridor and finally the Central North Corridor or Blue Line. One of the main advantages of **BRT** is the appropriate cost-benefit ratio determined by the transport capacity versus the amount of investment needed to build it. While most BRT systems in the world operate on segregated lanes of traffic, these routes are not always exclusive, which results in certain sectors being given to invasions on the BRT route and thus competition with normal traffic or speed being restricted by the usual traffic problems such as traffic jams at intersections, time delay due to road and pedestrian crossings, etc., These complexities lead to rates of speed falling far below those expected in these systems.

Additionally, as a major factor, it is noteworthy that the capacity of this type of transport system has an operational ceiling limit. It can reach up to a certain maximum level of passengers per hour per direction. Maximum transport capacities for BRT systems are usually held to be in the range of 10,000 to 20,000 passengers per hour per direction[1], although with the most advanced and efficient BRT design in the world this has reached the 32,000 passengers per hour per direction, as in the case of Transmilenio Bogota[2]. This however, requires two segregated lanes per side for the BRT system, with the goal of having a number of “express" units, i.e. pausing at only a few stops on the route.

In order to meet the 2010 passenger flow demand of 28,000 passengers per hour per direction, as shown in Table 7, it would require the use of two lanes per side along an entire street as a BRT corridor and total exclusivity of the road, i.e. no traffic light controlled intersections for vehicles crossing the corridor transversely. The occupation of that amount of road space without intersections in order to create segregated corridors for BRT would become "urban wounds" that would effectively create a separation of city life on either side of the corridor.

In terms of the situation in 2030, a BRT system would be unable to transport 48.000 passengers per hour per direction as is determined by the calculation presented in Table 8, as it was previously noted that the most advanced BRT designs in the world have only managed to transport 32.000 passengers per hour. This mode of transport, as central and vertebral linchpin of an Integrated Mass Transit System would fail completely, bringing the public transportation system to a collapse.

Finally, a 4-lane BRT would have a high cost in terms of the scarcity of unused urban terrain. A quick calculation allows us to estimate that: the total width required to install a 4-lane corridor is 20 meters, if that value is multiplied by a longitudinal route of 20 km, it would require a total of 400,000 square meters. As the segregated corridor would be developed on the most important avenues of the city, one would expect a cost per square meter of at least $700; multiplying this value by the surface area previously calculated it would lead to a cost of urban land use of $ 280 million. To this must be added to the cost of the process of land expropriation.

It can be concluded that segregated bus corridors systems or BRTs are not viable operationally for the development of an IMTS for Quito. Given the creation of an "urban wound" disrupting the interaction between the two sides of the corridor and the high costs for occupied urban land, a BRT system alone would not be a solution as the backbone of the Integrated Mass Transport System for Quito.

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[1] Halcrow Fox, Mass Rapid Transit in Developing Countries Report, Department of International Development World Bank, 2000
[2] NESTLAC, Transmilenio un sistema de transporte masivo de alta capacidad y bajo costo, Consulta Regional NESTLAC (Red Latinoamericana de Transporte Sustentable), Panamá, 2003

Light rail and trams, whose acronym is LRT, are mass transit systems frequently used in Europe, especially in cities of less than two million inhabitants or those larger as additional lines to the existing metro systems and, in some cases as feeder systems for metros.

In the city of Quito, in 2007 preliminary studies were carried out for a project called "TRAQ" (Tren Rápido para Quito), which by its nature would fall into the category of a light rail or LRT.

LRTs have capacities ranging between 10,000 to 20,000 passengers per hour per direction. In LRT systems traffic segregation is the same as in a BRT. Furthermore investments are generally higher than with BRT systems, being between 10 to 30 million per km[3]. With the capacity stated as 10,000 to 20,000 passengers per hour for LRTs and given the demand that has been calculated in Table 7 for Quito in 2010 as 28,000 passengers per hour per direction, an LRT systems would be unable to draw together, channel and convey this demand. Worse still in the case of 2030 in which the demand calculated according to Table 8 would be 48,000 passengers per hour per direction, much higher than the capacity of an LRT.

In conclusion, for the case of Quito, an arrangement such as LRT vertebral solution for the Integrated Mass Transit System has no viability or sustainability due to its limited capacity to meet anticipated demand, and consequently LRTs, including the TRAQ project, should be discarded as an option.

Rapid transit system or metro system, variously referred to as underground trains, metro trains, subway, elevated rail or RT which stands for Rapid Transit, options are characterized by a greater ability to meet high demands for transportation and have the highest possible transportation speeds. The transport capacity of metro type systems has reached 80,000 passengers per hour per direction in cities like Hong Kong, while the Sao Paulo subway regularly records over 60,000 passengers per hour per direction[4]. Similarly, their average speeds also called commercial speeds including moving and stopping periods, reach 40 km / h, while their top speed approaches 110 km / h.

The conceptual basis of metro systems is both horizontal and vertical route segregation, i.e. the use of routes with total exclusivity. These systems can operate underground, on elevated viaducts, through false tunnels, in trenches and along the surface level, facilitating the implementation of various construction systems. The investment amounts for metro type systems are highly variable, ranging from 20 to 180 million per km[5], depending on a number of factors, among which are the construction or civil engineering system, geological and geotechnical characteristics of the terrain, the type and condition of the rolling stock, and the level of automation of facilities, among others.

[3] Halcrow Fox, Mass Rapid Transit in Developing Countries Report, Department of International Development World Bank, 2000
[4] Banco Mundial, Ciudades en Movimiento, Revisión de la Estrategia de Transporte Urbano, 2002
[5] GTZ, Mass Transit Options, Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities, 2002

In conclusion, it can be seen that based on its operational capacity, a metro would be the only type capable of carrying the passenger flows for Quito determined in Tables 7 and 8. Such flows are calculated as 28,000 passengers per hour per direction for 2010 and to be 48,000 passengers per hour per direction in 2030. This is based on the fact, as stated previously, that metro type systems can accommodate up to 80,000 passengers per hour per direction.

With the above considerations, it is instructive to compare the general characteristics of the different technological alternatives for mass transit, with the information on existing demand. This comparison clearly concludes that the subway or metro is the only option, from among the mass transit systems, capable of becoming the central, articulating and structuring axis of the IMTS, and of transporting passenger volumes at the speeds required and desired in the city of Quito This is especially true in the face of projected demand. It would not occupy the current road space, which is highly appreciated by the longitudinal condition of the city and in some areas could even free up spaces. Additionally, it is the only system that would not paralyze traffic in large parts of the city during its development and construction phase.

With support of all these considerations, it can be concluded from the commercial focus of mobility, i.e. the balancing demand with supply, the best transportation alternative to address the demands of mobility in a city with the characteristics of Quito, thus becoming an infrastructure project that articulates and becomes the backbone of an integrated mass transit system, in a long-term, sustainable and efficient manner.

1.3 ANALYSIS OF ALTERNATIVES FOR SELECTING THE METRO ROUTE

1.3.1 PRELIMINARY ROUTES

The first step taken was to identify recommended waypoints and main corridors for any of the alternatives to be developed. An initial analysis identified the following waypoints (from south to north):

- Terminal Terrestrial Quitumbe
- Parroquia de Solanda
- El Recreo Transfer Station
- The Historic Center
- Marin Station
- El Alameda Park
- Terminal Norte del Trole
- La Ofelia Transfer Station
- Terminal Terrestrial Carcelén

The main corridors identified were:

SOUTH	NORTH
Av. Antonio José de Sucre	Av. Amazonas
Av. Rumichaca	Av. 10 de Agosto
Av. Quitumbe	Av. América
Av. Pedro Vicente Maldonado	Av. De la Prensa
Av. Teniente Hugo Ortiz	Av. De los Shyris
Av. Cardenal de la Torre	Av. Eloy Alfaro
Av. Alonso de Angulo	Av. Galo Plaza Lasso
Av. 5 de Junio	Old Airport (Labrador)

With these premises, and the external conditions identified, a total of 12 alternative routes were mapped out. These alternatives gave variants in the southern areas as the routes passed through the historic center and as well as for the crossings of the river Machángara. In the North, it seemed much clearer than any alternative should follow Av. 10 de Agosto or Avenida Amazonas and avoid damaging the Trole during the construction phase.

Successive analysis allowed for refining these alternatives down to three, shown in Figure 4.2. They are described below.

1.3.2 OVERVIEW OF THE ALTERNATIVE ROUTES PROPOSED

The design of the various route alternatives was carried out using commercial design software for linear projects, ISTRAM / ISPOL, developed by Buhodra Ingeniería, SA, which is a software application that integrates the geometrical variables, for the optimization of space and travel time optimization as well as the nodal points of interconnection with other sub-components of the integrated system.

The three selected route alternative are summarized below.

• Alternative 1 (Central)

• Alternative 2 (Western)

• Alternative 3 (Eastern)

The three alternatives initially considered can be summarized as follows

ALTERNATIVE	LENGTH	No. of Stations	INTERCHANGES
1 CENTRAL	26.65 km	19	8
2 WESTERN	25.59 km	19	6-7
3 EASTERN	26.23 km	19	8-9

1.3.3 PROCESS ANALYSIS OF ALTERNATIVES

MULTI-CRITERIA ANALYSIS

For the multi-criteria analysis, Thomas Saaty's AHP (The Analytical Hierarchy Process) method was chose. An example of the process of calculation is presented in Annex 11 of the EIA Annexes Chapter.

This method is designed to quantify managerial judgments or opinions (qualitative or subjective elements) on the relative importance of each of the criteria involved in a decision process. Generically, AHP method steps are:

Break down the decision problem into a hierarchy of interrelated elements, identifying: OBJECTIVE OR GOAL, CRITERIA involved in the decision, and ALTERNATIVES to be decided on.

9. Develop a COMPARISON MATRIX OF CRITERIA by pairs, establishing a rating of importance relative to the other criterion in the pair. This rating is determined by using the following qualitative scale:

1 = equally preferred

2 = moderately preferred

3 = strongly preferred

4 = very strongly preferred

5 = extremely preferred

10. Obtain the NORMALIZED criteria comparison matrix by dividing each cell of a column by the sum of that column

11. Develop the WEIGHT VECTOR for each CRITERION, obtained as the average of each row of the matrix of normalized criteria

12. For each CRITERION, develop a MATRIX OF COMPARISON of PAIRS of alternatives, as is done with the criteria.

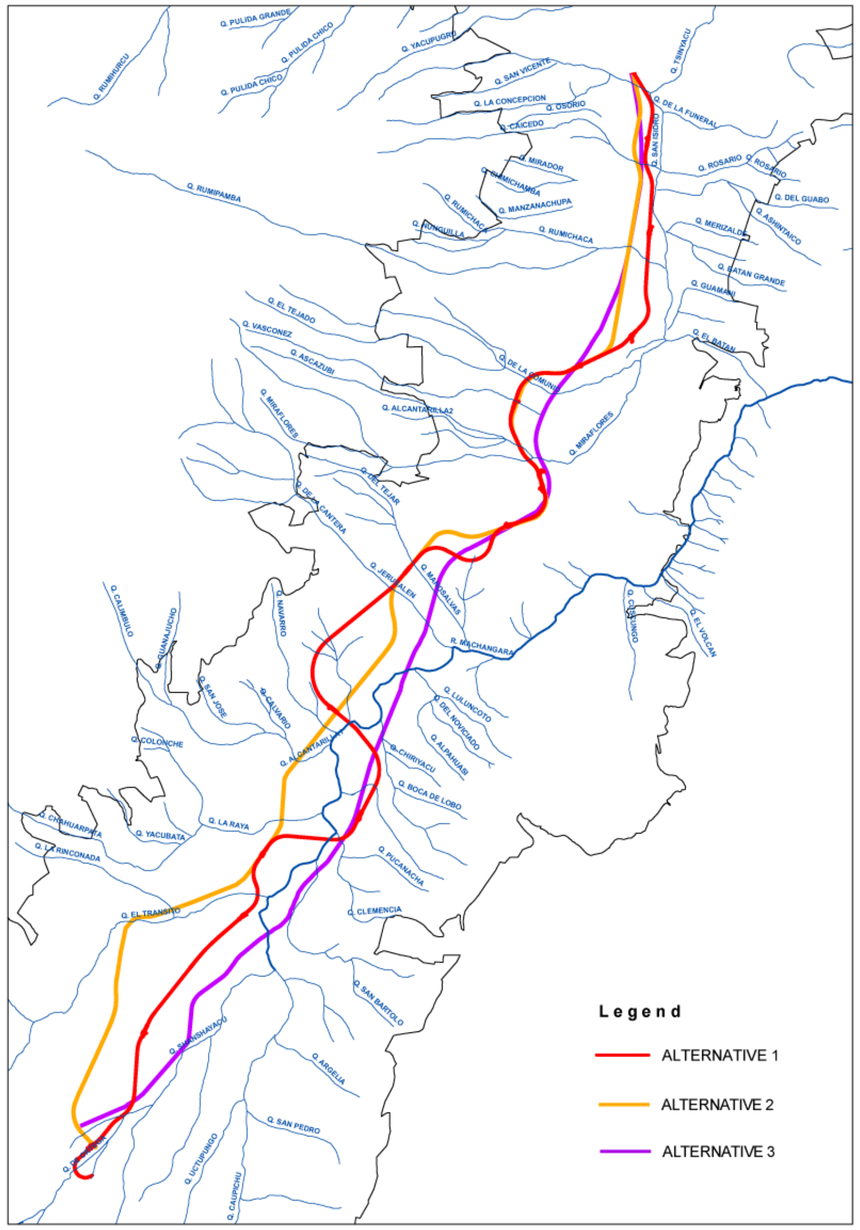
13. For each CRITERION, develop a comparison matrix by NORMALIZED pairs

14. For each CRITERION, obtain a WEIGHT VECTOR OR PRIORITY for Alternatives

15. Develop a PRIORITY matrix of CRITERIA by ALTERNATIVES

16. Finally, multiplying this matrix by the vector of weights for each criterion (step 4) gives the WEIGHTS of each alternative

The hierarchical structure of the problem within the Thomas Saaty approach is represented in the figure below:



SCORING CRITERIA

The analysis of the three alternatives was developed through a qualitative and quantitative methodology with proven validity, incorporating technical economic, environmental, social and cultural aspects.

CRITERIA CONSIDERED

The idea was to choose one of three preselected alternatives, which were evaluated based on the following criteria:

Demand characteristics:

- Location of centralities and administration / services concentrations.
- Present and future nodes generating personal mobility and transport demand.

Geo-engineering:

- Geomorphological safety and feasibility, geological / geotechnical / subsurface tectonics and seismic and hydrogeological condition.
- Topographical limitations and geographical accidents of geometric and constructive effect.

Infrastructure:

- Telecommunications, drinking water and sewer networks
- Civil constructions, existing and projected public works.
- City road system and articulation of current transport network

Urban Space:

- Equipment, urban development and housing growth trend.
- Design Limitations like minimum radii, transition curves, minimum lengths of straight sections, etc.
- Availability of physical space for the location and construction of stations, workshops and garages of the first line of the Metro de Quito.
- Interconnectivity requirements of future enlargements of the first line of the Metro de Quito.

Environmental, Social and Heritage Aspects:

- Identification and assessment of potential impacts on the environment, and social and heritage elements of the city.
- Identification and assessment of environmental and operational risks.
- Areas of possible expropriation.

ALTERNATIVE MATRIX

Criterion: Demand Characteristics

DEMAND	WESTERN	CENTRAL	EASTERN
WESTERN	1	1/3	1/2
CENTRAL	3	1	1
EASTERN	2	1	1

The central alternative is clearly better than the Western, as it penetrates Solanda better, and also the Western alternative bypasses El Recreo. The Eastern alternative (which more or less follows the route of the trolley) and the Central alternative are equally preferred, and the Eastern is better than Western as it passes through El Recreo.

Criterion: Geo-engineering

GEO-ENGINEERING	WESTERN	CENTRAL	EASTERN
WESTERN	1	1	1
CENTRAL	1	1	2
EASTERN	1	1/2	1

From the point of view of geo-engineering, all alternatives are equally preferred to one another, except the Central alternative compared to the Eastern, with a preference in that instance for the Machángara river to be crossed between Solanda and El Calzado.

Criterion: Infrastructure

INFRASTRUCTURE	WESTERN	CENTRAL	EASTERN
WESTERN	1	1/3	1/2
CENTRAL	3	1	2/3
EASTERN	2	3/2	1

With regards to infrastructure, the Western alternative is the worst because much of its infrastructure development interferes with the south-western corridor, which would have to be abandoned in that stretch. The Eastern alternative is somewhat better than the central as it is less affected by the collectors and ravines.

Criterion: Urban Space

URBAN SPACE	WESTERN	CENTRAL	EASTERN
WESTERN	1	1/3	1
CENTRAL	3	1	2
EASTERN	1	1/2	1

The Eastern and Western are similar, presenting similar paths and similar difficulties with the insertion of stations. The Central alternative is much better than the Western for the best position of the La Magdalena and Solanda stations, and somewhat better than the eastern in terms the positioning of El Calzado station.

Criterion: Environmental, Social and Heritage aspects

As input for the determination of the environmental criteria, following is presented the qualitative comparison of alternatives with respect to each of the elements considered. To this end, the level of impact, or risk was rated on a scale of three levels: high, medium or low.

ENVIRONMENT	WESTERN	CENTRAL	EASTERN
WESTERN	1	1	1
CENTRAL	1	1	2/3
EASTERN	1	3/2	1

From the environmental standpoint, the Eastern and Western alternatives are similar, as are the central and western. Among the alternative pairs mentioned the environmental impact level is almost the same.

Similarly, the level of risk among the three alternatives is similar, on the grounds that environmental risk factors are very similar in all three cases and operational risks are exactly the same regardless of the alternative that is chosen.

The eastern alternative is considered better than the central as it generates smaller areas of expropriation.

Next, criterion by criterion the comparison matrices are normalized in order to obtain the vectors of priority:

DEMAND	WESTERN	CENTRAL	EASTERN
WESTERN	0.16667	0.14286	0.20000
CENTRAL	0.50000	0.42857	0.40000
EASTERN	0.33333	0.42857	0.40000
GEO-ENGINEERING	WESTERN	CENTRAL	EASTERN
WESTERN	0.33333	0.40000	0.25000
CENTRAL	0.33333	0.40000	0.50000
EASTERN	0.33333	0.20000	0.25000

INFRASTRUCTURE	WESTERN	CENTRAL	EASTERN
WESTERN	0.16667	0.11765	0.23077
CENTRAL	0.50000	0.35294	0.3077
EASTERN	0.33333	0.52941	0.4615
URBAN SPACE	WESTERN	CENTRAL	EASTERN
WESTERN	0.20000	0.1818	0.25000
CENTRAL	0.60000	0.5454	0.50000
EASTERN	0.20000	0.2727	0.25000
ENVIRONMENTAL, SOCIAL AND HERITAGE ASPECTS	WESTERN	CENTRAL	EASTERN
WESTERN	0.33333	0.2857	0.375
CENTRAL	0.33333	0.2857	0.2500
EASTERN	0.33333	0.4286	0.375

1.3.4 DETERMINANTS

We considered two types of constraints: design and external constraints regarding which sufficient information was available at the time of the definition of the route and the constraints due to the innate mobility of people and centers generating and attracting travel.

As for the constraints due to the design criteria, geometric and kinematic parameters of design were considered, as well as potential sites proposed for the switches and crossings associated with the stations.

The following are the conditions considered for the definition of the various route alternatives.
• Determinants due to the design criteria
• External determinants
• Geo-engineering determinants
• Existing infrastructure determinants
• Urban space determinants
• Socio-environmental and heritage determinants

1.3.5 CRITERIA MATRIX AND RESULTS

In the following table the subjective values issued by the decision making center are set out for forming the matrix of preferences regarding the criteria adopted

CRITERIA COMPARISON MATRIX	DEMAND CHARACTERISTICS	GEO-ENGINEERING	INFRASTRUCTURE	URBAN SPACE	ENVIRONMENTAL, SOCIAL AND HERITAGE ASPECTS
DEMAND CHARACTERISTICS	1	5	2	3	4
GEO-ENGINEERING	1/5	1	1/4	1/3	1/2
INFRASTRUCTURE	1/2	4	1	2	5
URBAN SPACE	1/3	3	1/2	1	2

ENVIRONMENTAL, SOCIAL AND HERITAGE ASPECTS	1/4	2	1/5	1/2	1

The infrastructure criterion is, hierarchically, the second most important. Intermodality is closely related to the ability to capture demand. In third place is urban space, in terms of physical availability of space for the works (that planned stations can be located geometrically in the space available); the axes can be developed geometrically in compliance with the railway line parameters, etc.

The environmental, social and heritage criteria are in fourth place. In general, especially in the operating phase, many of the impacts will be positive since it will reduce greenhouse gas emissions, noise, travel time, etc. Although there are also negative impacts during construction, mainly due to the potential impact on traffic and the surplus earth due to excavation.

Geo-engineering criteria took last place. Although they are of great importance in underground works, especially for implementation, it has been determined that it can be made subject to other criteria, as preliminarily it will not affect the viability of the project, something which other factors can do.

Once the criteria are evaluated by pairs, the normalized matrix must be obtained:

NORMALIZED MATRIX OF CRITERIA COMPARISON	DEMAND CHARACTERISTICS	GEO-ENGINEERING	INFRASTRUCTURE	URBAN SPACE	ENVIRONMENTAL, SOCIAL AND HERITAGE ASPECTS
DEMAND CHARACTERISTICS	0.438	0.333	0.506	0.439	0.320
GEO-ENGINEERING	0.088	0.067	0.063	0.049	0.040
INFRASTRUCTURE	0.219	0.267	0.253	0.293	0.400
URBAN SPACE	0.146	0.200	0.127	0.146	0.160
ENVIRONMENTAL, SOCIAL AND HERITAGE ASPECTS	0.109	0.133	0.051	0.073	0.080

The weights that each criterion will acquire were then calculated for the weighing up of alternatives, consistent with the subjective preferences shown by the central decision maker in the above matrix:

WEIGHT VECTOR	Wi
DEMAND CHARACTERISTICS	0.4072
GEOENGINEERING	0.0614
INFRASTRUCTURE	0.2864
URBAN SPACE	0.1558
ENVIRONMENTAL, SOCIAL AND HERITAGE ASPECTS	0.0892

WEIGHTINGS

The next step is to obtain a set of weights for each of the alternatives according to each criterion, which is consistent with the subjective preferences shown by the decision making center and collected in the "pairs" comparison matrix in the tables above, obtaining the following

ALTERNATIVES	CRITERIA				
	DEMAND CHARACTERISTICS	GEO-ENGINEERING	INFRASTRUCTURE	URBAN SPACE	ENVIRONMENTAL, SOCIAL AND HERITAGE ASPECTS

WESTERN	0.1698	0.3278	0.1717	0.2106	0.3313
CENTRAL	0.4429	0.41111	0.38688	0.5485	0.2897
EASTERN	0.3873	0.26111	0.4414	0.2409	0.37898
WEIGHTING OF EACH CRITERIA	0.4072	0.0614	0.2864	0.1558	0.0892

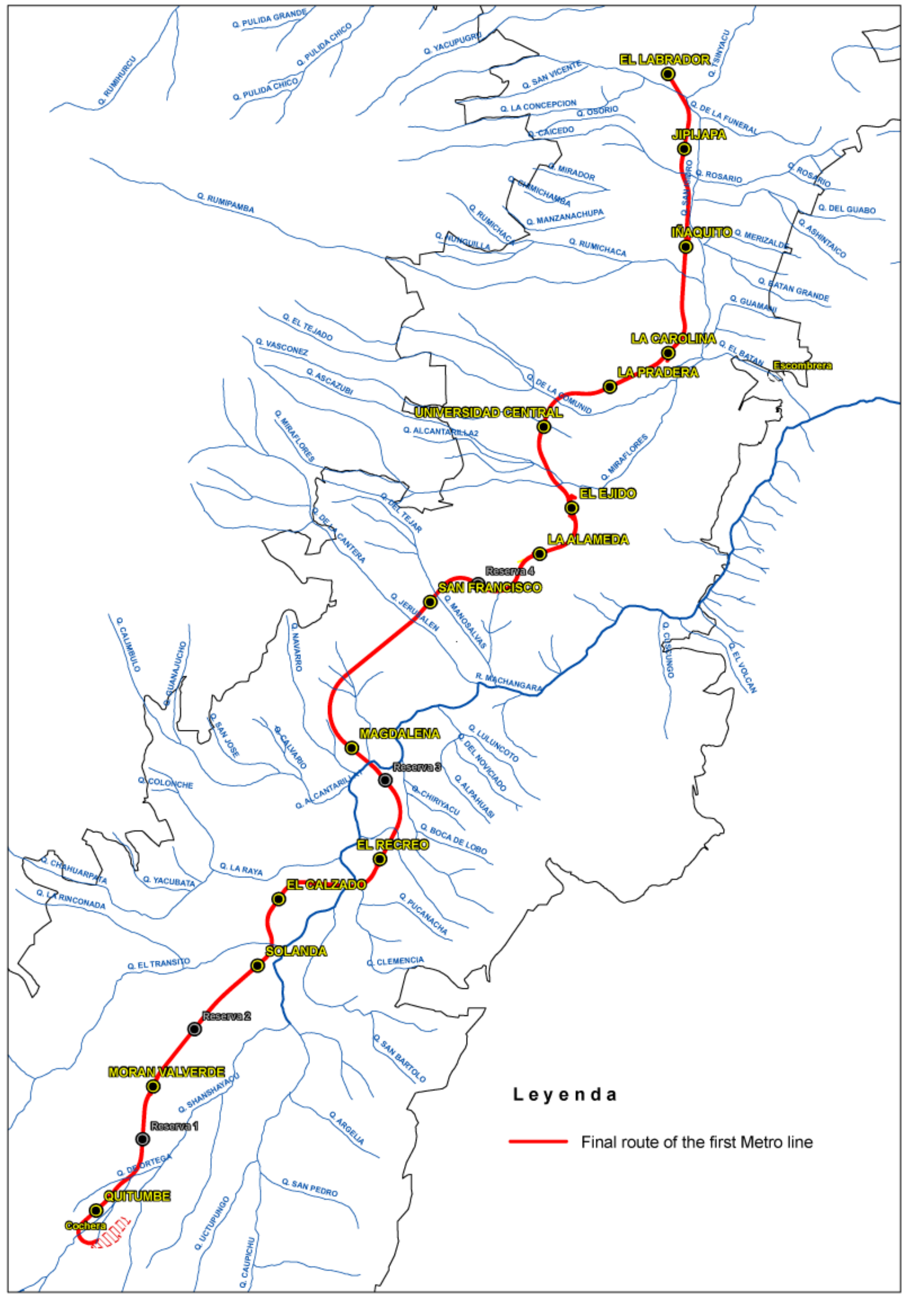
Having obtained the estimates of the weightings for the hierarchical levels 2 and 3, the next (and last) step is to obtain global weightings for both levels of hierarchy. This task is approached by a multiplicative aggregation between hierarchical levels, collecting the final result of the global weightings in the following table:

ALTERNATIVES	MULTIPLICATIVE AGGREGATION	GLOBAL WEIGHTINGS
WESTERN	0.1698*0.4072 + 0.3278*0.0614 + 0.1717*0.2864 + 0.2106*0.1558 + 0.3313*0.0892 =	0.2008
CENTRAL	0.4429*0. 4072 + 0.41111*0.0614 + 0.38688*0.2864 + 0.5485*0.1558 + 0.2897*0.0892 =	0.4277
EASTERN	0.3873*0. 4072 + 0.26111*0.0614 + 0.4414*0.2864 + 0.2409*0.1558 + 0.37898*0.0892 =	0.3715

In conclusion, the instrumentalization of the central decision maker preferences through AHP method (Thomas Saaty) leads to the consideration that the central alternative is the best solution.

1.3.6 SELECTED ALTERNATIVE

After studying and analyzing each of the alternatives in terms of the physical, biotic and socio-cultural characteristics of the project, of the construction methods and using the AHP method, Alternative 1 (Central) was chosen as the most viable both for now and the future, considering the demand for mass transit service and the restructuring of the current transport system in the city of Quito, as well as the possibility of the construction of Metro lines in the future that complement and further improve mass transit. The selected alternative is presented in the following figure:

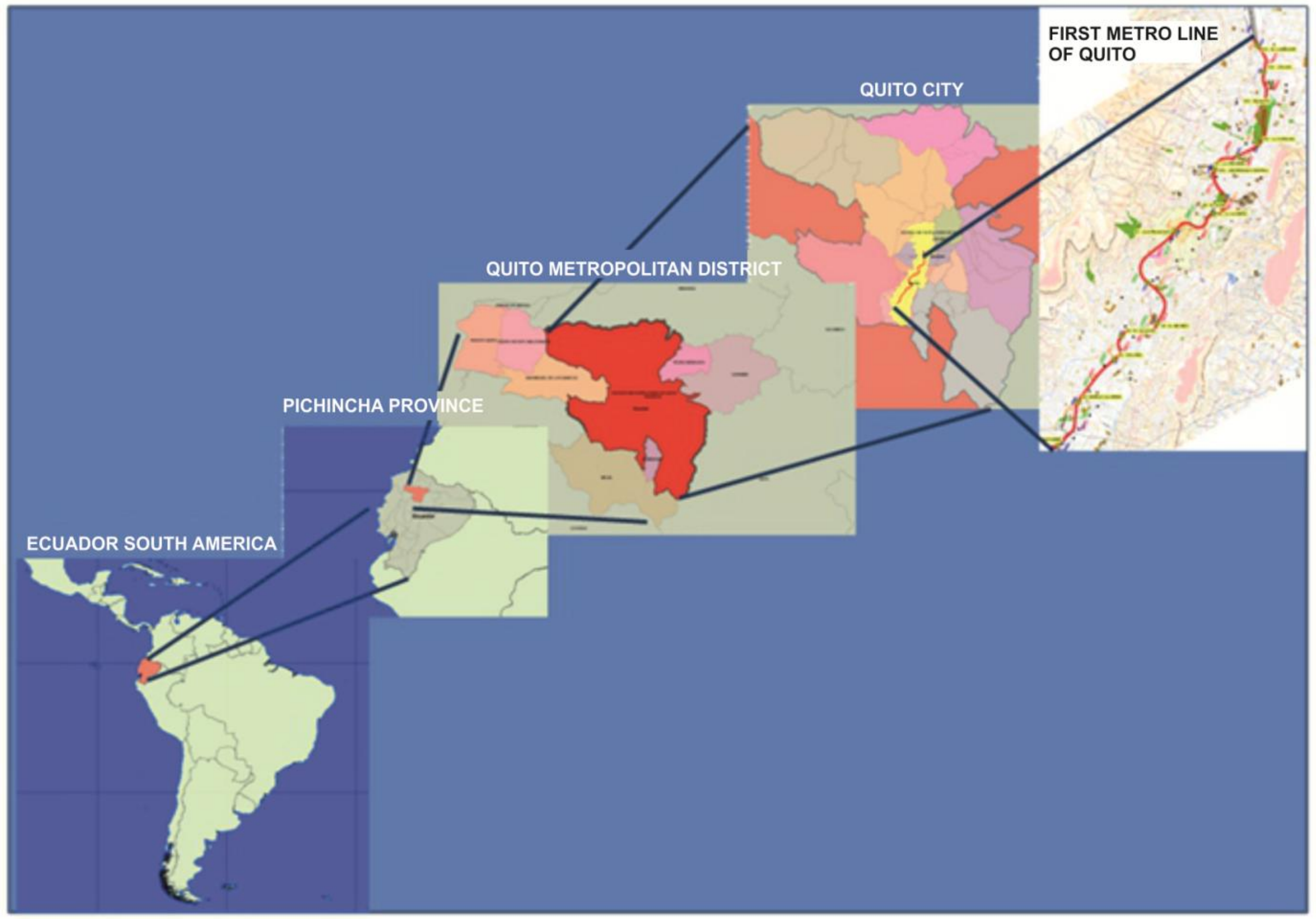


Source: Created for this report

1.4 LOCATION OF THE PROJECT AND EXECUTION TERM

1.4.1 LOCATION

The project is entirely located in Quito, capital of Ecuador, located in the Andes, on the eastern slopes of the Pichincha volcano (northern Andes) 78 ° 39'W latitude, and longitude 0 ° 15'S, which is at 2,800 m above sea level with a population of 2,500,000, a city declared by UNESCO in 1978 as the first cultural heritage of humanity. The following maps indicate the spatial location of the Project.



1.4.2 PROJECT EXECUTION TERM

The projected works have a planned execution term of 36 months from when the contract comes into force.

1.5 AREA OF INFLUENCE

Having carried out the respective analysis, and relating it primarily to the location, route lengths, stations, environment, topography, land use, population distribution, urban mobility and centralities, the areas of direct and indirect influence that will be produced by the implementation of the first line of the Metro de Quito can be concluded and established.

The analysis established different distances from the central axis of the route of the first line of the Metro de Quito and the infrastructure around the project. It is understood that the level of involvement of people and the environment decreases as one moves away from the axis of the project.

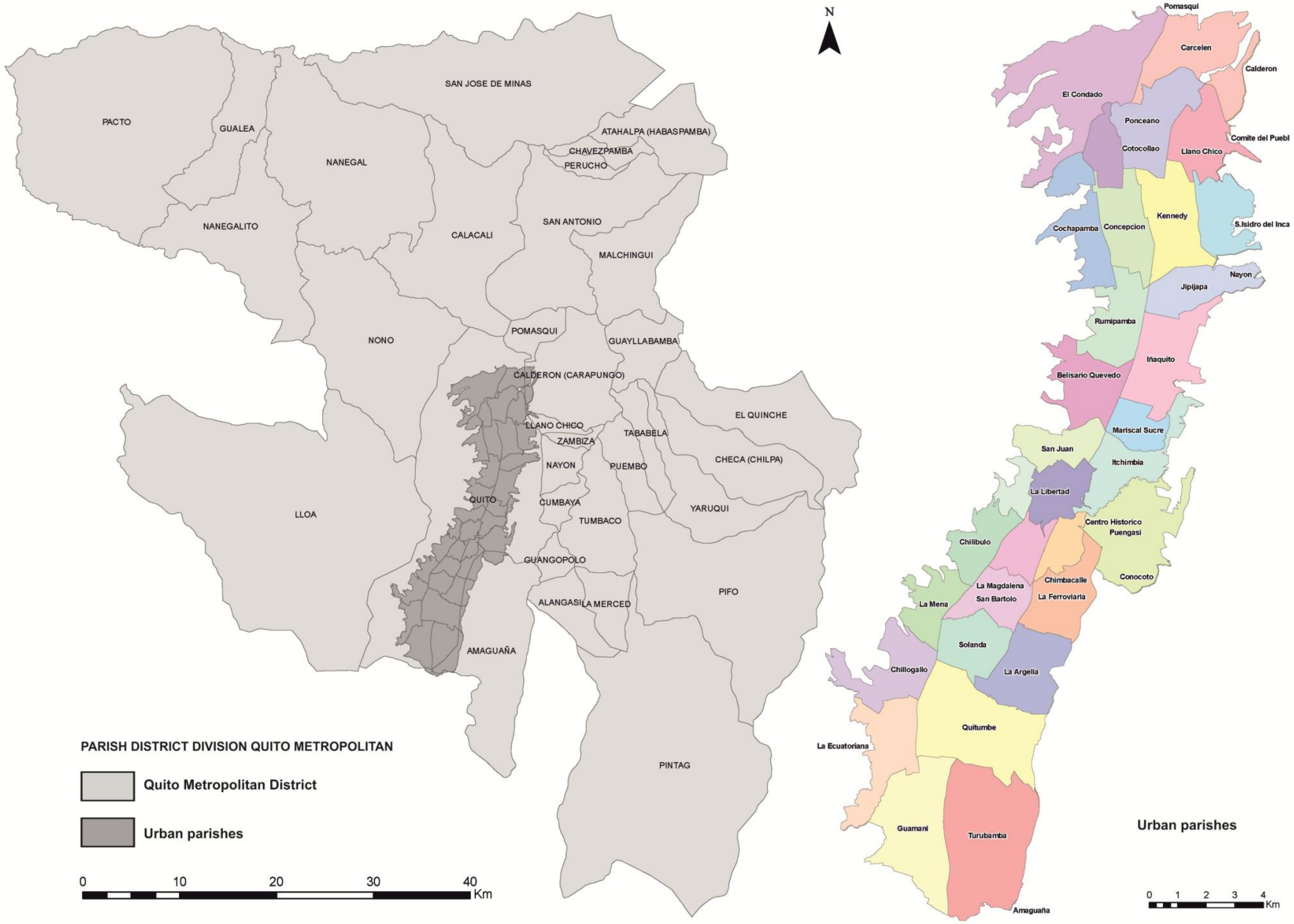
The Area of Direct Influence (ADI) is defined as the immediate surroundings where the construction activities of the project of the first line of the Metro de Quito which will be directly affect and the necessary temporary or permanent infrastructure will be implemented.

For the physical component the possible effects to soils where there will be earthworks is considered, for the biotic component the possible effect on the vegetation and fauna is considered; for the social component the possible involvement of housing, land, roads, community areas in the case of intervention in green areas and for the archaeological component the possible effect on cultural heritage that may result from earthmoving.

As a result of the foregoing the Area Direct Influence (ADI) was defined, in the strip where the project of the first line of the Metro de Quito is expected that have more influence, especially at the time of the construction activity. The space varies depending on the project's infrastructure, averaging the following areas:

- 300,000 m2 in the garage area at the Quitumbe line station;
- 50 m from the axis of the route of the first line of the Metro de Quito at the stations;
- 96,000 m2 in the El Labrador working shaft, and 26,000 m2 in the Solanda working shaft;
- 10 m. around the ventilation shafts;
- 50 m. established around the tailings and possible access routes yet to be constructed.

From a socioeconomic perspective, the area of influence is represented by the infrastructure for housing, business and public services along the routes immediately adjacent to the construction sites on the surface, in the 14 urban parishes through which the first line of the Metro de Quito will pass as shown on the map below:



Source: Dirección Metropolitana de Planificación Territorial

On the other hand, Areas of Direct Influence on culture and heritage areas are considered to occur where there will be:

Direct effect underground, either due to excavation, construction or other use, due to the possible presence of cultural remains of importance in those areas, mainly in the historic center of the city because it is a site of great cultural value and impact to buildings and spaces of significant archaeological, historical and cultural importance.

Those areas around the area of direct influence where indirect impacts of the project can be demonstrated are considered indirect areas influence (IIA). These areas can be defined as buffer zones with a determined radius, and their size may depend on the magnitude of the impact and the effected component. Thus, determining the area of indirect influence is variable, as physical, biotic, socio-economic and cultural components are considered, and even within each of these components the area of indirect influence may vary by environmental element analyzed particularly for the construction phase.

Regarding the physical component, the area of indirect influence has to do with the landscape of the immediate project area, with its soil, air and water components.

The area of indirect influence (IIA) corresponds to the space from the edge of the Area of Direct Influence to the distance where the degree of involvement tends to remain below the real or estimable permissible limits which according to the analysis should happen at:

50 m. around the ADI of the garage, pits and dumps;

50 m. around the ADI of the stations;

25 m. around the ADI of the ventilation shafts.

Also included within the area are the zones affected due to the debris generated as a result of the construction of the project, as well as the loading, transportation and disposal of the same, which can contaminate rain water or water used in their management, and then the runoff can affect soil or other water bodies.

Apart from the few plants and trees that will be removed in the area of direct influence, the only additional probable impact could be the accumulation of particulate matter (dust) on the leaves of plants in the vicinity of the affected area. Therefore, it is considered that the area of indirect influence, for purposes of this potential impact would be a stretch of about 10 m around the area of direct influence in areas where vegetation is present.

The indirect influence area for wildlife is defined in terms of the possible effects of noise outside the boundaries of the area of influence of the civil works, especially on birds, which are the most representative animals. This is estimated with a probable involvement in a range of about 50 m around the boundary of the area of influence, so this area is considered to be the area of indirect influence.

For the social component, the area of indirect influence of the construction phase is the area of people affected within the Metropolitan District of Quito, in the range around the project works, by movement and noise of machinery, vehicles, personnel, demands for services and socioeconomic changes.

As a result, all neighborhoods around the stations and tailings are considered areas of indirect influence.

In the First Line of the Quito de Metro project there will be no more earthworks other than those identified in the area of direct influence, so there would be no possibility of an indirect involvement to archaeological resources.

2. INSTITUTIONAL AND LEGAL FRAMEWORK

The legal framework applicable to the Environmental Impact Assessment (EIA) for the project of the first line of the Metro de Quito includes national, municipal and sector laws and regulations in force for environmental matters in Ecuadorian territory.

ENVIRONMENTAL LEGISLATION AND STANDARDS

The first body of law is the Constitution of the Republic of Ecuador, which states in the relevant part:

Art. 66. -, (Paragraph 27) promoting the use of clean energy alternatives indicates that " the right to live in a healthy environment, ecologically balanced, free of contamination and in harmony with nature", is recognized and guaranteed to people.

Art. 95. - The citizens, individually and collectively, will take a leading role in decision-making, planning and management of public affairs, and through popular control of the representatives and institutions, state and of society, in a permanent process of construction of citizen power and good living.

Regarding international conventions and treaties on the environment, the following are taken as reference:

• United Nations Convention to Combat Desertification, 1994

• United Nations Framework Convention on Climate Change, 1994

• The Kyoto Protocol, 1997

• Vienna Convention for the Protection of the Ozone Layer. Vienna, Austria, 1985

• Montreal Protocol on Substances that Deplete the Ozone Layer, 1987

• Convention on Biological Diversity (Rio de Janeiro, 1992)

• Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1979

• Convention on the Conservation of Migratory Species of Wild Animals, 1979

• Stockholm Convention on Persistent Organic Pollutants, 2001

• Rotterdam Convention on Trade in Hazardous Chemicals, 2006

• International Treaty on Genetic Plant Resources for Food and Agriculture, 2001

Declarations:

• Declaration of the United Nations Conference on the Human Environment, 1972

• Rio Declaration on Environment and Development, 1992

• Johannesburg Declaration on Sustainable Development, 2002

• Declaration on Fundamental Principles and Rights at Work, 1998

Among the international treaties and conventions on heritage resources the following are highlighted:

• Convention on the Protection of the World Cultural and Natural Heritage (1972)

• Convention for the Safeguarding of Intangible Cultural Heritage (2003)

• Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict (1954)

• Convention of the Organization of American States on protection of archaeological, historical and artistic heritage of the American nations (Santiago de Chile, 1976)

Within the legal framework of Ecuador the following laws have been taken into account:

• Law on Land Transport, Traffic and Road Safety

• Environmental Management Act

• Water Act

• Roads Act

• Mining Act

• Municipalities Act

• Law for the Metropolitan District of Quito

• Law Amending the Penal Code

• Law on Prevention and Control of Environmental Pollution

Standards:

• Environmental Standards for the prevention and control of environmental pollution

• Environmental quality and effluent discharge standard: water resource

• Ambient air quality standard

• Environmental quality standard for the management and disposal of non-hazardous solid waste

• National standards for managing hazardous chemicals

In terms of environmental regulations, the main body of reference is the Unified Text of Secondary Legislation of the Ministry of Environment, issued by DE 3399 by RO 725 December 16, 2002.

In regard to cultural issues the following legislation applies:

• Cultural Heritage Act

• Protection and Conservation of the Inca Trail Act, Coded

• Code of Territorial Organization, Autonomy and Decentralization

• Law Amending the Penal Code

• Environmental Management Act

• General Regulation to the Cultural Heritage Act

The latter body of law, i.e. the General Regulation of the Cultural Heritage Act, was published by Executive Order 2733, Official Gazette 787 of 16 July 1984. It presents the following main provisions:

Art. 37. When works are carried out without authorization, or there is a failure to comply with the appropriate standards, so that property deemed National Cultural Heritage is affected, the National Director of the Institute shall order the suspension of the restoration or reconstruction of the property, as applicable, in the period determined and subject to appropriate sanctions.

Art. 39. If the execution of a work of any kind can cause damage or effect an asset deemed to be National Cultural Heritage, in its area of influence or the historic centers of the cities, the National Director of Cultural Heritage can ask that the municipality or public or private entities suspend the work and, if necessary, terminate it. If the work destroys elements of an asset deemed National Cultural Heritage or one which forms part of an environmental area they must be restituted.

RULES FOR PUBLIC PARTICIPATION AND SOCIAL CONTROL

In accordance with Executive Order 1040, the realization of any project and the relevant environmental impact assessment, should consider following a process of consultation with affected groups. Social participation is a crucial transversal element of environmental management. Consequently, it is to be carried out during all phases of the proposed project or activity, especially those related to the review and evaluation of environmental impact.

PERMIT REQUIREMENTS

The first line of the Metro de Quito project will start when the EIS and Environmental Management Plan have been approved and the corresponding environmental license has been issued by the National Environmental Authority, under the Environmental Management Act and the Unified Environmental Management System.

Environmental License

The requirement to obtain an environmental license for the project of the first line of the Metro de Quito is established in Article 20, which states that for the start of any activity involving environmental risk, it should have the respective environmental license granted by the Ministry.

As expressed by the Article 21 of the SUMA: Before starting the process of environmental impact assessment, that is, prior to the development of the environmental certificate or the draft terms of reference, as appropriate, and depending on the description of the proposed activity or project, the developer will identify the legal and institutional framework under which the proposed project activity falls. The institutional analysis aims to identify all environmental enforcement authorities to be involved in the process of environmental impact assessment as well as the environmental authority responsible for leading the implementation of the process. This analysis will form an integral part of the environmental certificate or draft terms of reference for the EIA to be submitted for review and approval.

INSTITUTIONAL FRAMEWORK

There are several institutions whose activities effect, directly or indirectly, the project of the first line of the Metro de Quito. Among the main ones are:

- Ministry of Environment
- Ministry of Public Health
- Ministry of Transport and Public Works
- Ministry of Labor Relations
- National Institute of Cultural Heritage (INPC)
- National Council of Traffic and Land Transportation
- Metropolitan Environment Secretariat

3. GENERAL INFORMATION ON THE GEOMORPHOLOGICAL AND HYDROGEOLOGICAL ENVIRONMENT OF THE METRO DE QUITO PROJECT

The City of Quito is located in the Quito Metropolitan District, bounded on the north by the province of Imbabura, to the South by the cantons of Rumiñahui and Mejia, to the east by the province of Napo and to the west by the province of Santo Domingo de los Tsáchilas.

It is located in the inter-Andean region of Ecuador, a region that consists of two major mountain chains: the Andes and Cordillera Oriental.

3.1.1 OROGRAPHIC INFLUENCES

The city of Quito is crossed by the Andes mountain range that runs from north to south. They constitute two systems forming gigantic mountainous walls with altitudes ranging from 1200 to 4000m.

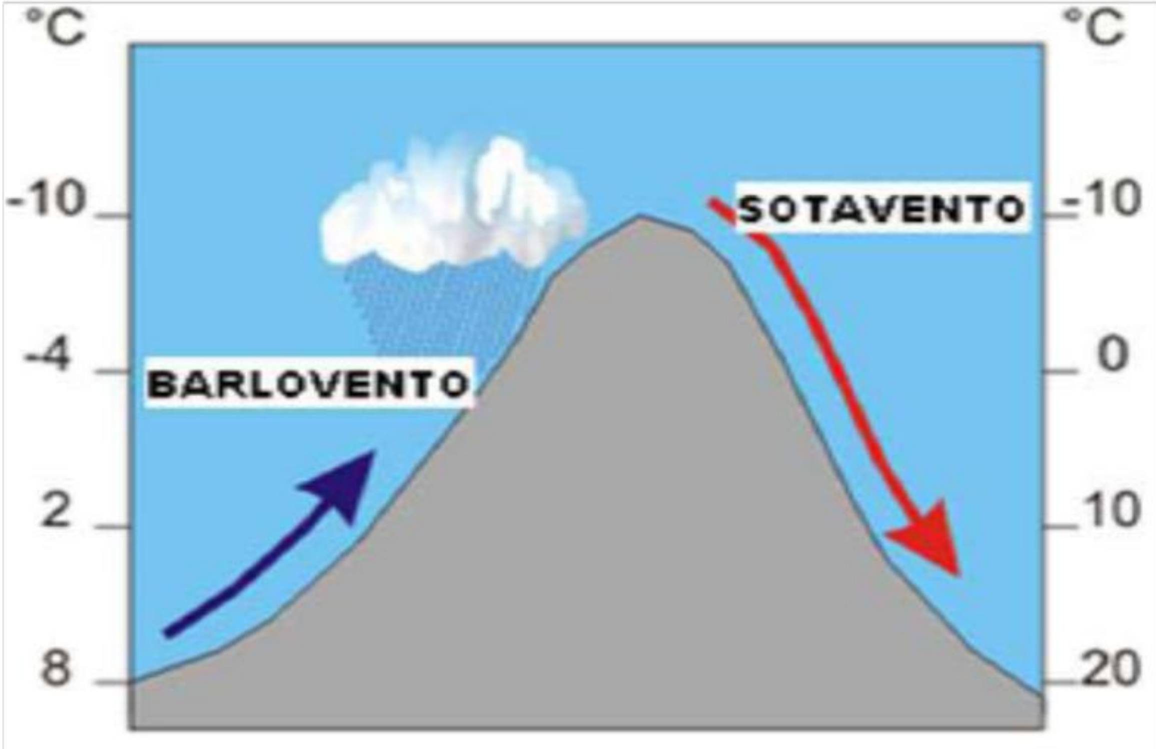
The diversity of heights imposed by the Andes mountain range produces a wide variety of climates and considerable changes over short distances.

3.1.2 BARRIER EFFECT AND FOHEN EFFECT

When the topography forces an air mass upward (windward), condensing the water vapor and giving rise to the orographic rain it is called a barrier effect and when downwind dry air descends rapidly increasing the atmospheric pressure and the temperature, the effect is called Fohen.

This situation is very common in the valleys that form part of the district of Quito, where rainfall levels are much lower than those that occur in the city of Quito and even more on the slopes to the west of the city.

The influence of this variable on the climate is important, as due to the location of Quito near zero latitude, the city receives more sun hours per year (12 hours a day) and generally the rays are perpendicular most of the time. The following figure represents the Barrier and Fohen effects:



The temperature decreases with altitude, which is why Quito has an average temperature ranging between 13 ° C and 14 ° C.

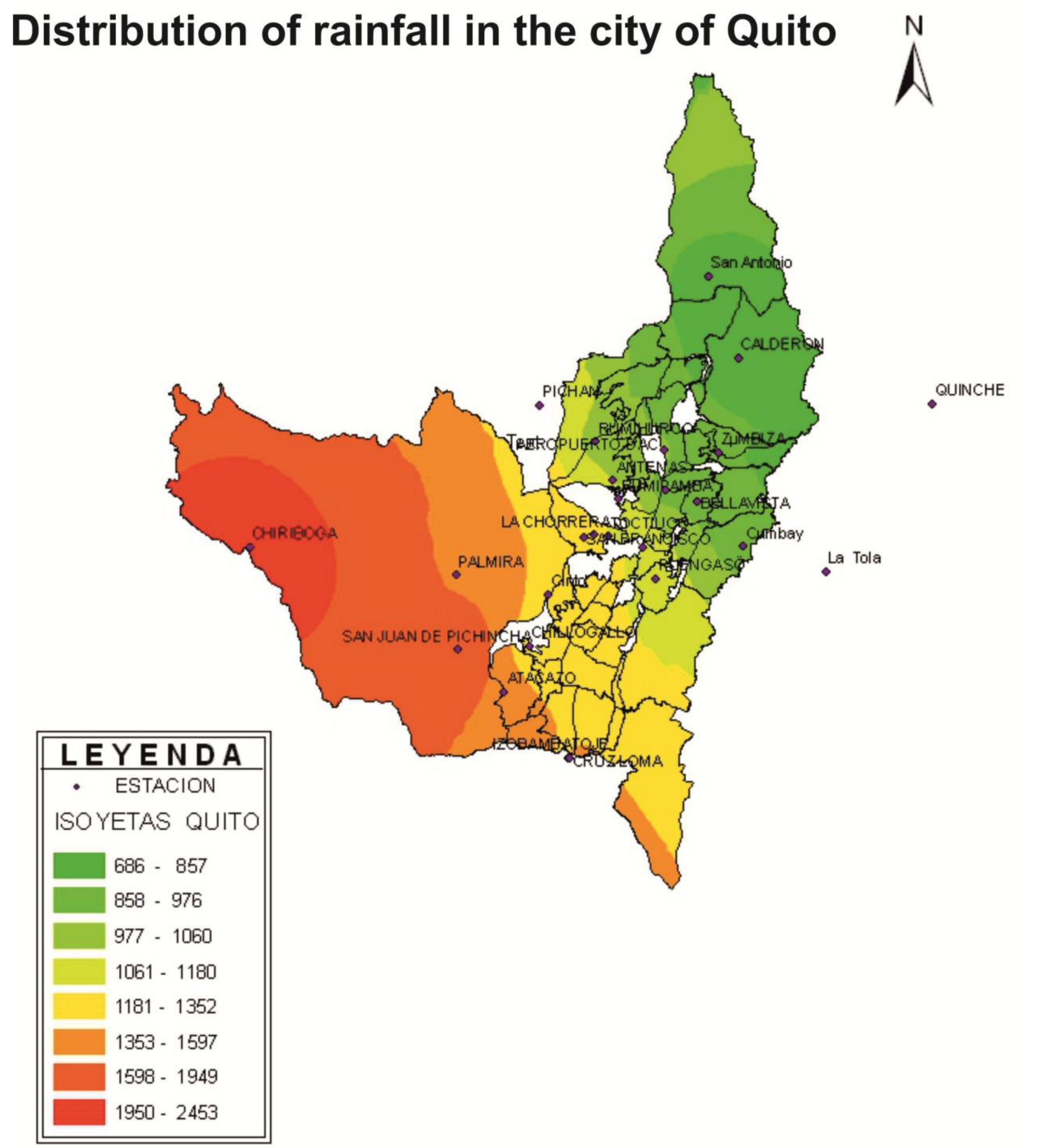
For Quito, the increase of wet and extremely wet days can be seen, which simultaneously produces an increase in the number of consecutive dry days and at the same time this happens with extreme rainfall. This may point to conclusions like those seen in general in other parts of the world, where the tendency is to a decrease in the number of days with precipitation, but when they do occur, it is in greater quantity.

The rainy season begins in October and ends in May, the wettest month being March to April, with average values ranging from 169.2 mm (Izobamba) and 126.2 mm. (Quito INAMHI)

The dry season runs from June to September. The driest month is July where values are recorded on average ranging from 20.2 mm. (Quito INAMHI) and 27.0 mm (Quito Observatory)

The rainfall spatial distribution is highly variable due to both the city's orography and the factors that influence it.

The highest values of both monthly and annual precipitation occurs in the southern part of the district and decrease as they move towards the north, while in the west higher rainfall is recorded and decreases as it moves eastward. The average annual values, ranging between 538.3 mm in Calderón and 3176.5 mm in Chiriboga, as can be seen in the following image.



The average temperature usually increases from south to north, except at Labrador, where a small decrease is seen because the station is located in a place free of major obstacles.

The representative area or the area of influence of Quito Airport according to the climatological study comprises the El Labrador to the Carcelén sector north of the city of Quito.

3.2 HYDROGEOLOGY

The area of influence of the Metro de Quito extends from Quitumbe Station in the south to the El Labrador in the north, as such it can be divided into two areas: one of rural character, affecting the Quitumbe area, in which the presence of natural channels is perceptible in the area, and the other, corresponding to the majority of the route, fully urban in nature, in which the problems associated with heavy rainfall are related to the layout and configuration of the surface drainage network

Therefore, a hydrologic-hydraulic study of the ravines and / or gullies was carried out in the Quitumbe area, ascertaining whether these channels have the capacity to drain the water in the recurrence periods considered. Subsequently, the possibility of runoff affecting each particular station of the projected Metro de Quito was analyzed.

3.3 HYDROGEOLOGICAL UNITS

Hydrogeological units are equipped homogeneous continuous aquifer systems and are natural units of planning and resource management.

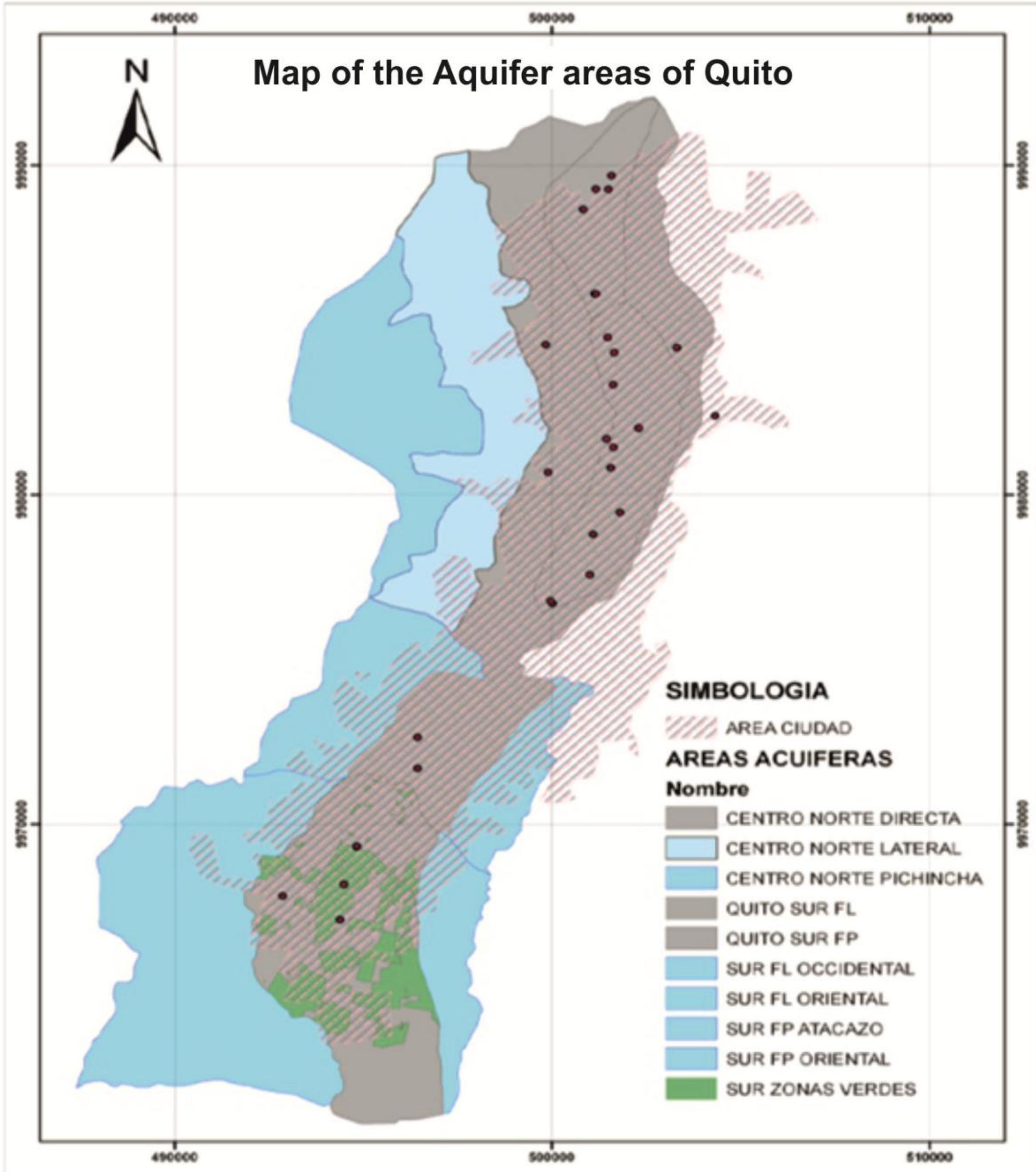
According to the National Hydrogeological Map of 1983, the geological formations have been classified into three main groups:

- Permeable, primary in nature, composed of unconsolidated clastic rock
- Permeable, secondary in nature, whose porosity is rooted in the existence of fractures, joints, cracks or cavities due to freezing or chemical dissolving.
- Impermeable.

To analyze the influence of the Metro de Quito on the aquifer in which it will be implemented, it has been zoned based on the criteria established in the Hydrogeological Map of the Metropolitan District of Quito Project

The criteria are as follows:

- Operational regime of existing Hydrogeological aquifers: existence of confined, unconfined or semi-confined aquifers
- Method of recharge: direct, lateral and deep lateral. Aquifer formations existing in the vertical axis of the area defined and are seen in the following illustration:



3.3.1 MACHANGARA FORMATION

In the north central aquifer system, there is a sequence of sandy sediments, gravel and cobble with sand in silty matrix, with an average thickness of 172m. Underlying these strata is the hydrogeological base layer composed of andesitic lava flows with low hydraulic conductivity characteristics due to its massive texture, presumably in the 300 to 500 m range.

The southern aquifer system is represented by the El Pintado deposit and the Guamaní deposit. The Guamaní deposit is located southeast of Acuífero Sur Artesian Basin, bordered to the north by the Reservoir El Pintado, to the west by the Ungí, El Cinto y El Atacazo hydrogeological massifs, to the east it is bordered by the mountains that separate Quito south of the Los Chillos Valley and south to the extent of the watershed (La Joya site).

From the information obtained It was established that the deposit, to the depth studied (100m), consists of two aquifer levels (A and B), separated from each other by low permeability strata (aquitards), corresponding to fluviolacustrine and mud flows.

AQUIFER A

The water table is important for the purposes of this project, as the excavations for the Metro de Quito will cross through the cangahua (aquitard) layer and reach down the aquifer layer that is reportedly at a depth of 100 m.

AQUIFER B

According to the geophysical research data bore holes drilled in the area, at 100 m deep there is an aquifer, apparently with better hydrogeological characteristics than those at 165 m deep.

This level has no further interest for the Metro de Quito project, given that the works do not reach this depth

3.3.2 CANGAHUA FORMATION

The lithology present at all levels is represented by sequences (a mixture of small strata and lenses of very varied dimensions) of friable material, eluvial, alluvial and proluvial in origin, comprising: sandy silt, silty sand, silty sand with gravel and blocks, fine-grained to coarse sand, gravel, and boulders and blocks, dominating in the cut the sands with gravel and sand or gravel in a silty matrix

In the north central aquifer system there is a second aquifer layer in this formation corresponding to detrital cones from the western slopes, related to the Rumihurco and Quebrada Grande ravines. These behave like a confined aquifer, the source of the material is varied and it is a sequence of silty sediments, sandy silt, and sand with gravel and ridges in a silty matrix. The thickness of the cone from the Rumihurco Ravine exceeds 200 m.

Considering the lithological and structural relationships, at the level of the whole south and north central aquifer, one can establish that: Hydraulically the levels (Cangahua and Machángara) are interrelated, as all the sediments present have varied conductivities. This relationship runs both in depths through the contacts as well as horizontally between different layers and lenses limits.

3.4 GEOLOGY AND GEOTECHNICS

The area where the project will be carried out is framed in a complex geodynamic environment, as it is surrounded by volcanoes and active fault processes: sedimentation, volcanism, tectonics and erosion; interact resulting in a complicated volcano-sedimentary basin within what is known as the Inter-Andean Valley

The Inter-Andean Valley is a geomorphological tectonic depression - NS to NNE-SSW, 25 km wide, 300 km long, ranging between 2 ° 10'S in the Alausí to 0 ° 30'N in the Chota zone, situated between the Western and Real Cordillera, and which began to form from the late Miocene-Pliocene, presumably from the North.

3.4.1 INTER-ANDEAN VALLEY SEGMENTATION

The Inter-Andean Valley is bounded by faults associated with major structural limits of the Real and Western Cordilleras. These faults were initially established during the successive accretion of oceanic and continental land from the Mesozoic; volcanoes occur from the latitude of Alausi towards the north and are mostly concentrated along faults that limit the Inter-Andean Valley structures and with some activity within the depression.

CORDILLERA REAL

The Cordillera Real consists of elongated belts of Inferior Paleozoic Cretaceous metamorphic rocks intruded on by granitoids and covered with Cenozoic volcanic deposits. It is composed of five lithotectonic units: Guamote, Alao, Loja, Salado and Amazon, which are separated by regional faults: Falla Ingapirca, Falla Peltetec, Frente Baños, Falla LLanganates, Falla Cosanga Mendes

CORDILLERA OCCIDENTAL

The base is constituted by two strata: Pallatanga and Macuchi, which are covered with volcanic and volcaniclastic deposits of Oligocene-Holocene. The Pallatanga strata from the early to late Cretaceous is composed of turbidites and igneous rocks, while the Macuchi strata which is Late Eocene to Paleocene comprises a volcano-sedimentary sequence in an island arc with a basaltic to andesitic composition.

INTER-ANDEAN VALLEY

The Inter-Andean Valley is divided into three segments, by two major nodes that mark changes in the direction of the depression. The central segment is the area of study (Quito-Guayllabamba), and has been called the "valle Interandino Central" and its northern boundary is the node formed by the Mojanda and Cusin volcanoes, while its southern boundary is formed by the node made up of the Rumiñahui Pasochoa, Cotopaxi and Illiniza volcanoes,.

The Inter-Andean Valley, in its northern segment involves several inter-mountain watersheds, (Chota-Guayllabamba Quito, Latacunga-Ambato, Alausí-Riobamba), with a sedimentary fill from the Late Miocene to Holocene.

The Quito-Guayllabamba Basin is a topographic depression NS in direction. It is thirty miles long and about five miles wide, morphologically there are two sub-basins: north central and south, separated by the river Machángara and El Panecillo.

The formation of this basin is directly related to the activity of reverse fault systems of Quito, whose morphological expression is a series of elongated hills in an N-NNE direction, located on the eastern edge of the city. This tectonic structure has been divided into three main segments: Lomas Calderon - Catequilla, Lomas Bataan - La Bota and Lomas Ilumbisì - Puengasì. These segments dip westward, the maximum rising rate of the system has been estimated at 0.8 mm / year

The deposits involved in this basin correspond to volcanic and volcaniclastic, whose sedimentary fill is divided into two sequences, separated by a major unconformity. The lower sequence consists of lavas, tuffs, sedimentary alluvial lahars, fluvial, deltaic and lacustrine, corresponding to Pisque and San Miguel formations. The upper sequence consists of primary volcanic deposits, lahars, hyperconcentrated flows and fluvial deposits, which correspond to the Formations: Guayllabamba, Chiche, Machángara, Mojanda and Cangahua.

QUATERNARY VOLCANISM

Quaternary volcanic activity is characterized by the development of stratovolcanoes, whose products include lava flows of basic to intermediate composition, pyroclastic flows and dacitic to rhyolitic domes.

The Pichincha Volcanic Complex of the pre Holocene age comprises two stratovolcanoes: Rucu Pichincha and Guagua Pichincha partially overlapping consisting of andesitic to dacitic lava flows. The deposits from the Rucu Pichincha are mainly andesitic lava flows, interbedded with breccias and pyroclastic fall deposits from flows and lahars.

3.4.2 LOCAL GEOLOGY

In the basin of Quito, the following Units have been differentiated:

MACHÁNGARA FORMATION

This has two subgroups: Sg. Basal volcanic and Sg. Quito.

Sg. Basal volcanic: included within this subgroup are avalanche deposits, mudflows, pyroclastic flows and lahars, intimately related to lava flows, characterized as heterogeneous, of a heavy texture, which are the product of eruptions of Rucu Pichincha

In the sub basin south of Quito the Basal Volcanic subgroup, includes lava flows, volcanic breccias, debris avalanches and mudflows from the Atacazo – Ninahuilca Volcano Complex and the Pichincha Volcano Complex.

Sg. Quito: includes fluvial deposits and minor mudflows slightly more homogeneous than those previous, with smaller grain sizes than those in the Basal Volcanic

In the Quito South sub-basin, the Quito subgroup, which presents primary volcanic deposits that include pyroclastic flows, pumice and ash falls has been called "Guamaní Volcano-Sedimentary Unit ", as well as those reported in the el Pintado Unit in which fluvial and lacustrine environment sedimentary deposits are include as fine sandstones and clays.

CANGAHUA FORMATION

This consists of altered tuffs, typically yellow to brown in color, usually interspersed with ash falls, pumice, paleosols and sometimes mud flow and alluvial channels, within them occur limestone crusts and manganese oxide, in the middle of the deposit, are layers of fine sand up to 50 cm deep, while at the base of the formation, especially on the flanks of Atacazo - Ninahuilca and Pichincha volcanic complexes, colluvials occur up to 2 meters thick, formed by blocks of andesite, dacite and pumice within a brown sandy silt matrix.

To the North deposits from alluvial fans flowing from the eastern slopes of the Pichincha volcano are to be found. They are oriented towards the main drainage that reaches the sub-basins (Rumipamba, Rumihurcu, and Quebrada Grande Ravines as well as principally the River Machángara)

LA CAROLINA DEPOSITS

It is sediment characterized by silt, clay, and medium to coarse sand packages, interspersed with ash and pumice falls, which occur in Alluvial and Lacustrine Palustre subgroups.

Sg. Alluvial: includes numerous lahars, primary volcanic ash and soil levels present and in the fans that form the main drainage basin. However, towards the axis of the basin there is a close related to Lacustrine and Palustre deposits, as well as small waterways, (El Ejido, La Carolina, Jipijapa).

Sg. Lacustrine Palustre: : this is considered like the following La Carolina deposits as it contains a package of silt and clay, interspersed with ash falls; in the records of the perforations in the Carolina and El Ejido traces of paleosols can be seen.

Formation	Medium permeability (m/s)	Maximum permeability (m/s)	Minimum permeability (m/s)	Standard Deviation
La Carolina Deposits	$8{,}97.10^{-7}$	$1{,}55.10^{-6}$	$2{,}44.10^{-7}$	$9{,}23.10^{-7}$
Cangahua Formation (Cl, Ca, Co, C_{Tb})	$2{,}34.10^{-6}$	$4{,}14.10^{-5}$	$1{,}81.10^{-8}$	$6{,}13.10^{-6}$
Machángara Formation	$1{,}84.10^{-5}$	$9{,}14.10^{-5}$	$4{,}29.10^{-8}$	$2{,}46.10^{-6}$

				GEOTECHNICAL UNIT (SYNTHESIS)	GENERAL DESCRIPTION LITHOLOGICAL
RELLENOS			R	RELLENOS ANTRÓPICOS	LIMO ARCILLO-ARENOSO CON FRAGMENTOS DE LADRILLOS, BOLSAS, MADERA, PLÁSTICOS, ETC
TURBAS MORÁN VALVERDE			Tur	DEPÓSITOS LACUSTRES	TURBAS
DEPÓSITOS LA CAROLINA			Fl, Ca	DEPÓSITOS LA CAROLINA. PALUSTRE-LACUSTRE Y ALUVIAL	CENIZAS, ARCILLAS, LIMOS Y CAÍDAS DE PÓMEZ
FORMACIÓN CANGAHUA			Cl	CANGAHUA LIMO-ARCILLOSA	LIMOS Y ARCILLAS ARENOSOS
FORMACIÓN CANGAHUA			Ca	CANGAHUA ARENO-LIMOSA	ARENAS LIMOSAS
FORMACIÓN CANGAHUA			Ce	CANGAHUA COLUVIAL	ARENAS Y GRAVAS CON ALGO DE LIMOS
FORMACIÓN CANGAHUA			Cm	CANGAHUA NO ALTERADA	TOBAS
FORMACIÓN MACHÁNGARA	MIEMBRO QUITO	"UNIDAD FLUVIO-LACUSTRE EL PINTADO"	Tu	UNIDAD FLUVIO-LACUSTRE EL PINTADO	TURBAS Y PALEOSUELOS
FORMACIÓN MACHÁNGARA	MIEMBRO QUITO	"UNIDAD FLUVIO-LACUSTRE EL PINTADO"	CH,B,A,a	UNIDAD FLUVIO-LACUSTRE EL PINTADO	CH: ARENAS Y ARCILLAS VERDES Y CENIZAS B, A, a: BRECHAS, ARCILLAS Y ARENISCAS. PRESENCIA DE MATERIA ORGÁNICA
FORMACIÓN MACHÁNGARA	MIEMBRO QUITO	"UNIDAD VOLCANO SEDIMENTARIA GUAMANÍ"	Ce	UNIDAD VOLCANOSEDIMENTARIA GUAMANÍ	CENIZAS, LIMOS Y ARCILLAS CON GRAVAS Y BLOQUES
FORMACIÓN MACHÁNGARA	MIEMBRO QUITO	"UNIDAD VOLCANO SEDIMENTARIA GUAMANÍ"	Py	CENIZAS Y OLEADAS PIROCLÁSTICAS. FLUJO PIROCLÁSTICO BLOCK AND ASH	ARENAS GRUESAS GRISES NO CONSOLIDADAS CON GRAVAS Y BLOQUES DE DACITA
FORMACIÓN MACHÁNGARA	MIEMBRO VOLCÁNICOS BASALES	UNIDAD DE BASAMENTO	Fl	UNIDAD DE BASAMENTO. FLUJOS DE LODO (LAHARES)	FLUJOS DE LODO CON GRAVAS Y BLOQUES CON CIERTO GRADO DE CEMENTACIÓN
FORMACIÓN MACHÁNGARA	MIEMBRO VOLCÁNICOS BASALES	UNIDAD DE BASAMENTO	Ae	UNIDAD DE BASAMENTO. AVALANCHAS DE ESCOMBROS	BLOQUES DE ANDESITA EN MATRIZ LIMO-ARENOSA DE BAJA COMPACTACIÓN
FORMACIÓN MACHÁNGARA	MIEMBRO VOLCÁNICOS BASALES	UNIDAD DE BASAMENTO	Bv	UNIDAD DE BASAMENTO. BRECHAS VOLCÁNICAS SOLDADAS	BRECHAS ROJIZAS ASOCIADAS A FLUJOS DE LAVA
FORMACIÓN MACHÁNGARA	MIEMBRO VOLCÁNICOS BASALES	UNIDAD DE BASAMENTO	VB	UNIDAD DE BASAMENTO. ANDESITAS	ROCA ANDESÍTICA AFANÍTICA

3.4.3 STRUCTURAL GEOLOGY

The structural study of Quito Valley mentions that "The study area is framed within an active tectonic environment, which presents a system of thrust faults associated with a non-tectonic deposition towards the terms of observed faults."

In the study zone, two important structures are found.

The Quito fault runs from the south to the east of Quito and ends in the second structure corresponding to a Horse-Tail Fault called Botadero, which is the second structure. This set of faults has generated uplifts along a southwest-northeast direction, known as Ilumbisí-Puengasí; Batan-La Bota and Calderon-Catequilla uplifts.

All evidence indicated that the system began to propagate from the North in a series of pulses along segments which together form the System of active thrust faults in Quito and that the uplifts in the area are relatively young.

This fault is the reason that the Quito Aquifer is not associated with what happens in hydrological terms with the ones in the Tumbaco and Los Chillos valleys.

4. SUPPORT WORK CARRIED OUT

As a fundamental element in order to characterize the engineering designs of the First Line of the Metro de Quito, the following technical support studies were carried out:

- Topographic survey and a cartographic restitution of the first line of the Metro de Quito.
- Archeological, Paleontological and Heritage studies in the primary influence area of the Metro de Quito line.
- Characterization of the route of the Metro line, by noninvasive means (Passive Seismic).
- Seismic monitoring, through the installation of accelerographs, vibration studies, seismic monitoring and neotectonics.
- Study of Climatology, Hydrology, Drainage and Pumping.
- Study of Buildings, Structures and Services Affected: Inventory of the current state of buildings, structures and services that may be affected by the construction of the first line of the Metro de Quito.
- Geotechnical Geological Base Survey based on 20 test probes.
- Detailed Geotechnical Geological Survey: 50 test probes.

- Seismic Effect

4.1 CARTOGRAPHIC INTERPRETATION

4.1.1 INTRODUCTION

For the realization of the first line of the Metro de Quito, one of the most important baseline data was Cartography and Topography, as it is the foundation on which the design is developed.

The technical documentation includes, as a final result, the appropriate scale mapping with the route of the Metro Line and the tachometric detail for the correct sizing of the necessary elements such as stations, wells, etc.

4.1.2 OBJECTIVE

Updated Cadastral, with 1:1000 scaled three-dimensional restitution; including Photogrammetric and georeferencing support of a secondary network.

4.1.3 AREAS OF ACTIVITY

- Project influence zone
- Length: 28 Km.
- Width: 400 m. each side from the axis of the Metro

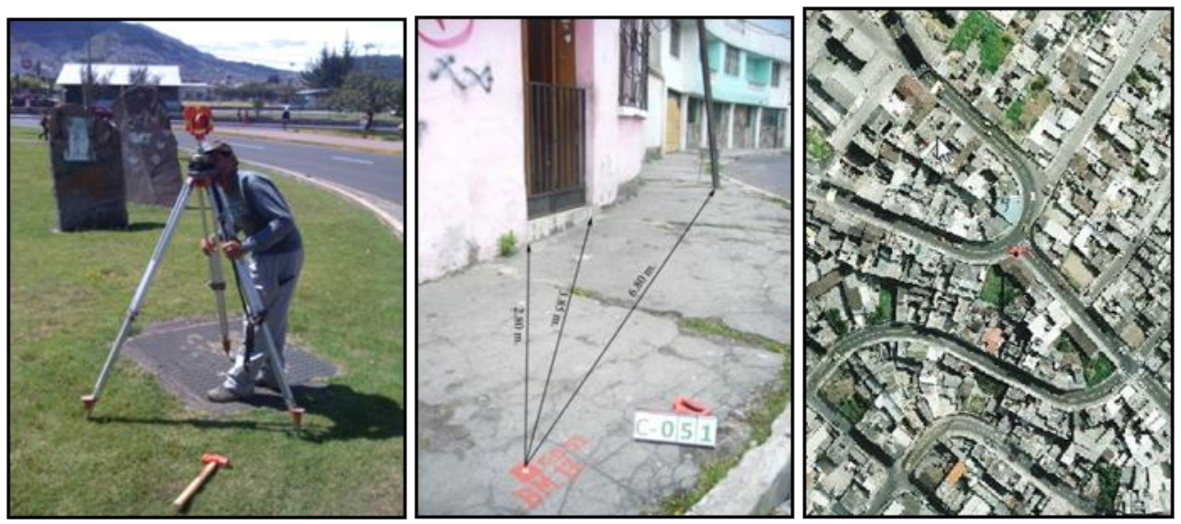
4.1.4 RESULTS

- Orthophotos of the route of the PLMQ (IGM monographs - stereocarto aerial photos)
- Secondary Network (115 nails placement - every 200m) and documented.
- Geometric leveling (bm's every 600m or 3 spikes)
- Photogrammetric Support and Aero triangulation (polygon total station)
- Photogrammetric restitution 400m wide belt scale 1:1000
- Restitution 1:500 scale of the work area in DGN format in 2D and 3D.
- Orto RGB digital photogrammetry 1:750 scale with a pixel size of 8 cm. TIFF format.
- CAD format files each section and by sheet.
- Files for each working scale continuously
- CAD resource files.
- Alphanumeric Model of data encoding used.
- Large scale plans of the defined supports in A3 format.
- Memory, reports and raw data from the work carried out.
- Reviews and graphics of milestones used and implemented.

The interpretation of the findings of the restitution are presented, with interpretation and analysis of cartographic updating, describing the changes found in spot morphology, civil infrastructure and urban spaces of the first line of the Metro de Quito (PLMQ)

To complement the knowledge of the area, the basic and secondary geodetic network, geometrically leveled is available, containing:

- Milestones from both the Basic Network and the Secondary Network, which should ensure its permanence, permanently materialized by brass plates or pins
- Horizontal and vertical control monographs of each milestone.
- GPS data files and post process results.



4.2 TOPOGRAPHY

4.2.1 OBJECTIVE

Have available a spatial register of the superficial work sites. Scale 1:500

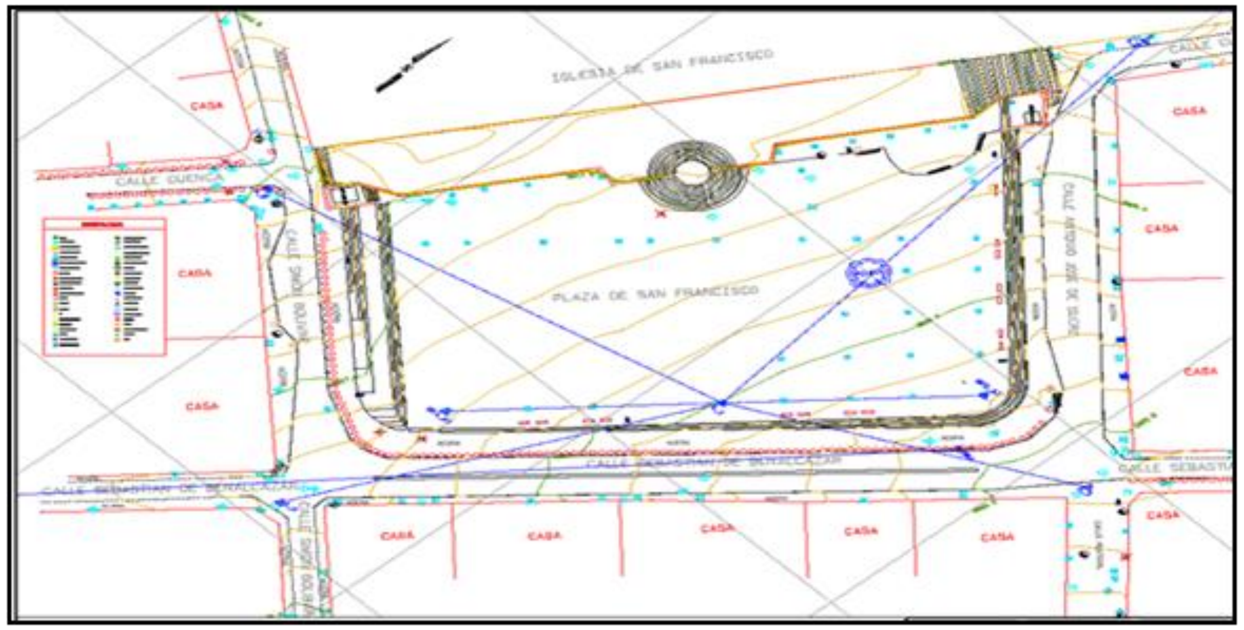
4.2.2 AREA OF ACTIVITY

- Stations
- Garages
- Special sites (Ventilation wells and emergency exits).
- Tunnel between screens.

4.2.3 RESULTS

- Stations (15) - erected 48 ha.
- Garages (14ha), workshops, terminus (10 ha.)
- Ventilation, pumping and emergency wells (11.66 ha.)
- Tunnel between screens – (11.08 Ha).

Surveyed for seasons		
ESTACIONES	DESCRIP.	REALIZADO EGV
ALAMEDA	m2	28.774,773
CALZADO	m2	24.858,512
CAROLINA	m2	44.157,988
EJIDO	m2	63.929,038
IÑAQUITO	m2	33.917,652
JIPIJAPA	m2	26.550,008
LABRADOR	m2	103.492,582
MAGDALENA	m2	29.201,572
MORAN VALVERDE	m2	17.931,111
LA PRADERA	m2	22.754,364
QUITUMBE	m2	28.910,564
RECREO	m2	68.079,171
SAN FRANCISCO	m2	12.143,442
SOLANDA	m2	49.918,544
UNIV. CENTRAL	m2	28.135,820
TOTALES	m2	582.755,141
	Ha.	58,28



Detailed topographic survey of the urban structure and the special sites, containing:

- DWG or DGN files with illustrations of the special zones in detail, with level curves each half meter, scale1:500 A1 sized sheet. With references and georeferencing.
- Interpretation of the data of the present relief, Urban Infrastructure and Surface Structures.

4.3 ARCHAEOLOGY AND PALEONTOLOGY

4.3.1 OBJECTIVE:

Archaeological and paleontology exploration, to identify the potential impact on the archaeological heritage of the city, which could result from the construction of the PLMQ

4.3.2 AREAS OF ACTIVITY:

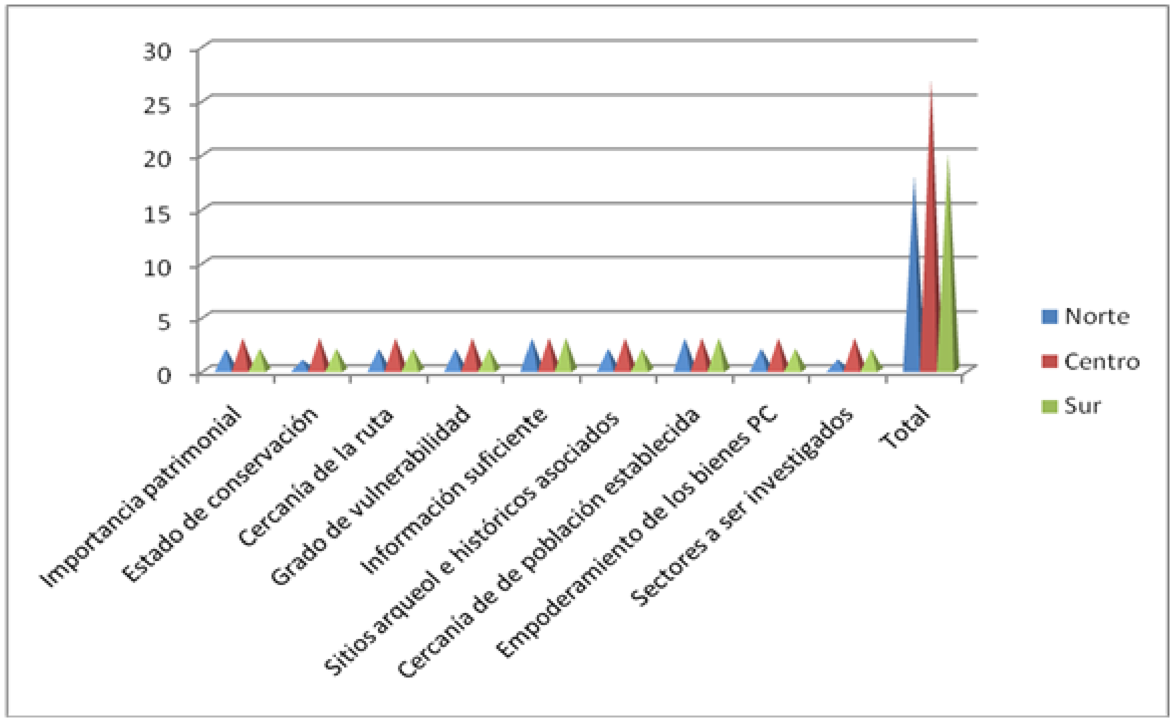
- Metro Stations: Quitumbe-Cocheras; Morán Valverde; El Recreo; San Francisco (parallel to calle Benalcázar); El Ejido.
- Special sites: Quitumbe; Solanda; Parque El Calzado; Panecillo

4.3.3 RESULTS:

From the analysis and evaluation of historical and archaeological sensitivity, the sensitive PLMQ areas were established and correspond to:

- North Zone sensitivity Medium
- Centre Zone sensitivity High
- South Zone sensitivity High

- The archeological evaluation was carried out in the entire designed space area of the plaza de San Francisco and excavation units in the areas around El Ejido and Cocheras station.



4.4 HERITAGE STUDY

4.4.1 OBJECTIVE

Identify the current state of conservation of heritage buildings, located along the route.

4.4.2 AREA OF ACTIVITY:

- Zone of Influence of the PLMQ in the Historic Center.
- Buildings and structures in the historic center of Quito.
- Special emphasis on convents, churches and essential buildings.

4.4.3 RESULTS

The city of Quito was declared the first World Cultural Heritage site by UNESCO on September 8, 1978, along with Krakow. This condition has been taken seriously by the Ecuadorian state and especially by the municipality for 24 years (1989), by means of the FONSAL - IMP, which has consolidated, reinforced, recovered, and revalued the social function of Quito's historic downtown.

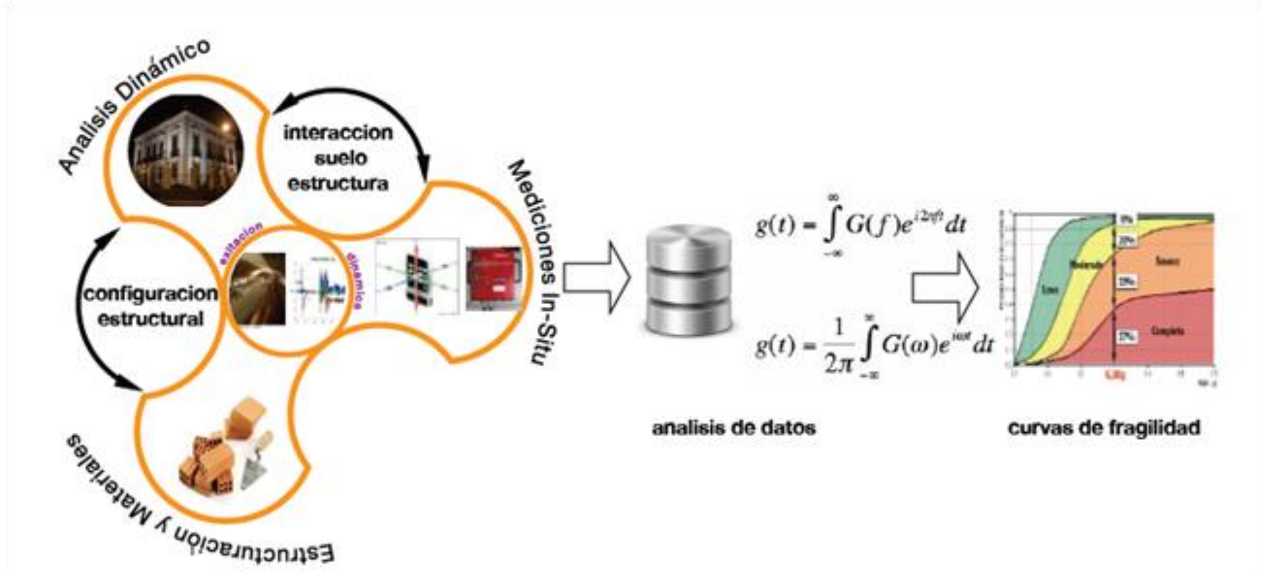
The route of the first line of the Metro de Quito strategically crosses the historic center without directly affecting any of the assets of major and medium relevance like religious complexes, churches or public historic buildings, in the core area and the buffer zone. There will be two stations: San Francisco, in the central core and Plaza del Teatro**,** in the buffer zone, both within municipal public spaces.

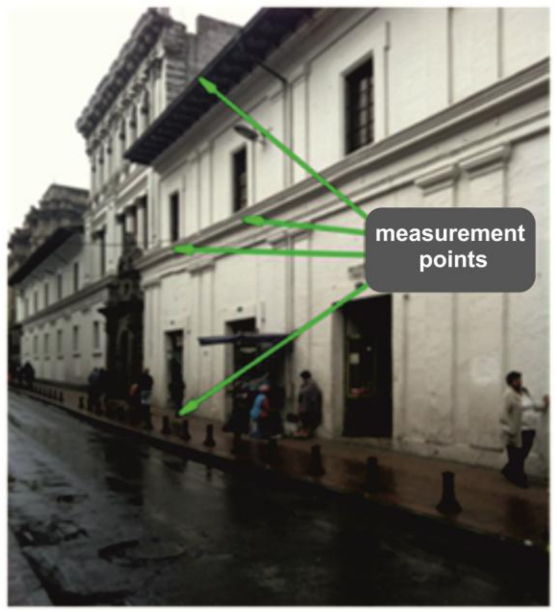
Technical studies, among others, of soil, passive seismic, hydrogeology, ravines, and natural soil vibrations, supplemented by special studies of archeology, paleontology, affected utilities, condition of buildings, engineering and vibration in buildings, ensure that the construction of the first metro line, to a depth equal to or greater than 19 meters, will not affect Quito's status as World Heritage site.

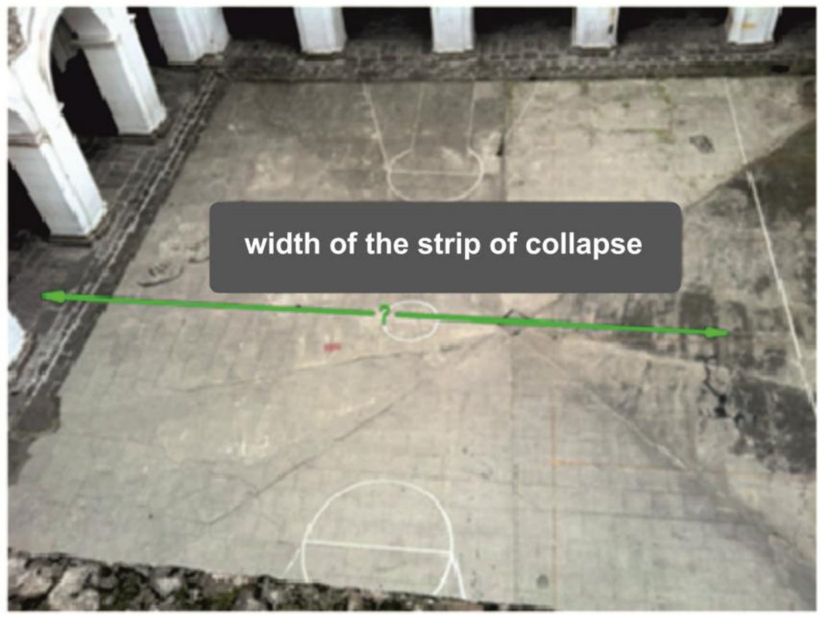
An extensive study of environmental impacts was conducted along the length of the track and in the historic center there are two stages: 1. - the construction process during which mostly mild temporary negative impacts would occur, and during which very few positive impacts would occur. 2. - the operation phase will generate a majority of medium to high positive impacts, and very few mild negative impacts. For all impacts a mitigation plan has been generated including social, economic and cultural impacts.

4.4.4 CONCLUSIONS

The methodology for continuous vibration measurements in order to determine exactly the soil-structure interaction, together with monitoring of settlements, to apply to buildings in the CHQ has been defined as shown in the following image:







4.5 PASSIVE SEISMIC

4.5.1 OBJECTIVE:

Continuous correlation of geological information gathered from test probes.

Seismic-stratigraphic characterization of the different levels of terrain, through refractive seismic measures of micro tremors.

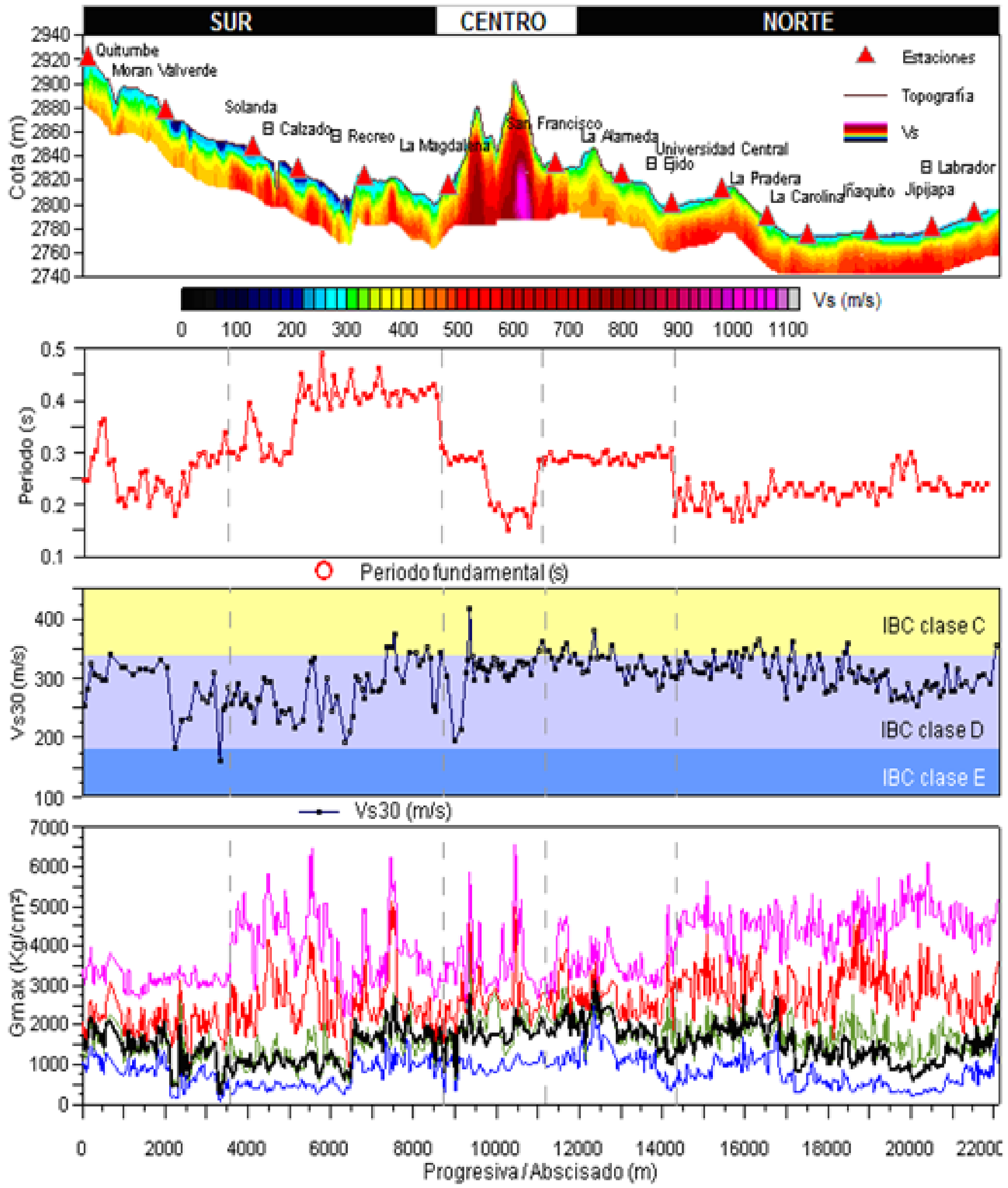
4.5.2 AREAS DE ACTIVITY:

- Metro route
- 23,000 meters of refractive seismic measures.

4.5.3 RESULTS:

- Stratigraphic earthquake definition sequence and behavior units in the valley of Quito. Correlation in function of the rigidity
- Definition of lateral distribution of seismic sequence and possible identification of lithological and structural discontinuities
- Characterization dynamic properties (static estimate) of the different stratigraphic quake units.
- Defining possible level associable to a geotechnical substrate (hard floors - dense) with shear wave velocity Vs> 360m / s. This could be considered the upper limit of the slope.
- Classification of the site along the route. Identification of "anomalous" areas with soft sediments
- From the dynamic modeling of the DH data the seismological conditions were evaluated at ground level of key importance in the design of the structure.

The following images show the seismic registers in detail:



4.6 VIBRATIONS STUDY

4.6.1 OBJECTIVE:

Understand the dynamic soil response and measure baseline levels of natural vibrations, by non-invasive methods.

4.6.2 AREAS OF ACTIVITY:

Area of influence of the route of the Metro

Geophysical evaluation of 220 natural vibration measures every 100 m, along the route.

Seismic By Micro Tremors & Vibration

In terms of the characterization study of the route of the first Metro de Quito line, the combination of using noninvasive methods such as seismic refraction by micro tremors and natural vibrations together with integration with borehole and geotechnical seismic tests (down hole), has allowed the definition of more precise concepts of the geotechnical environment of the city of Quito

The seismic refraction method for micro tremors - ReMi or surface wave analysis, using natural noise or noise generated by human activity to characterize the distribution of seismic properties in underground areas associated with geotechnical properties like the signal source, allows the calculation of the velocity of propagation of surface wave energy from which it is possible to estimate the velocity profile of shear waves (Vs). From these you can define the type and thickness of seismic stratigraphic sequences, its consolidation, determine substrate geotechnical / rock depth and also evaluate other parameters of engineering and seismology interest, local seismic response - micro zoning and define geotechnical parameters

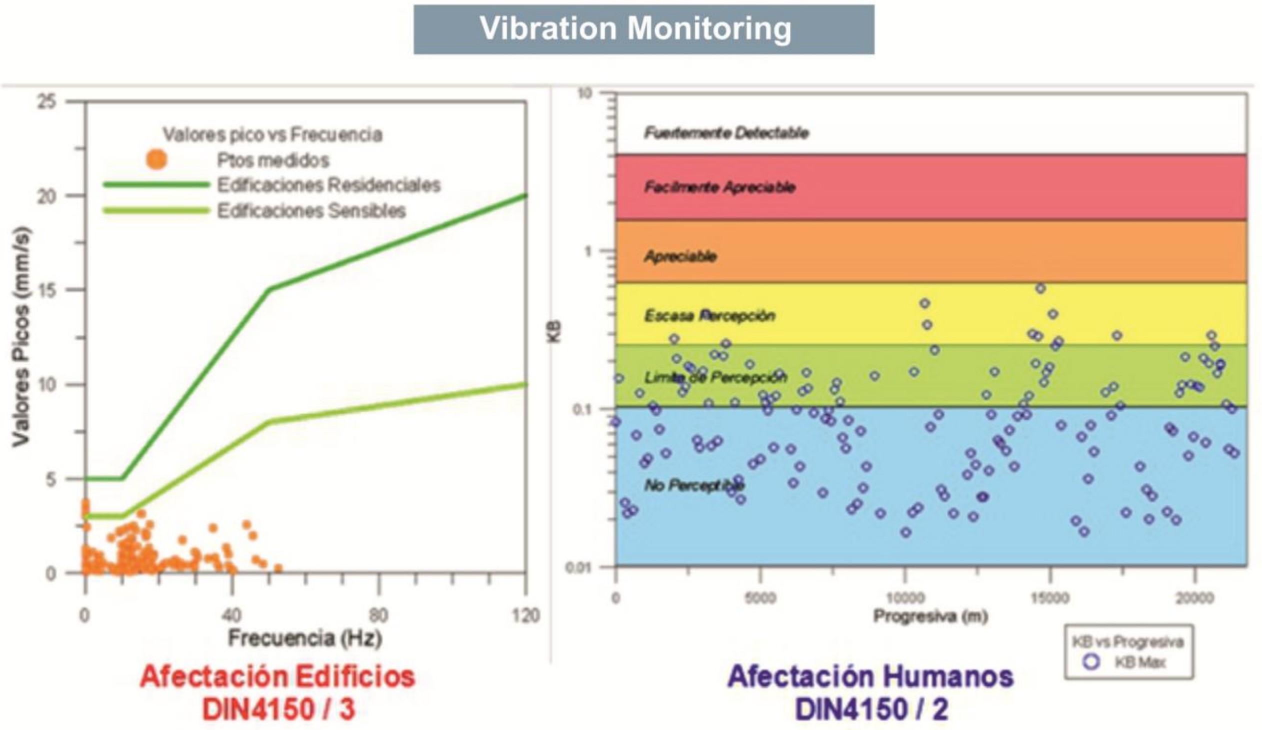
This aspect permits not only the optimization of the design work of the new Metro project but contributes to derive information like the geotechnical substrate depth (depth where rigidity / compaction conditions are compatible for installation of foundations of the structures and the properties of observed units in the city, defining risks and defining parameters relevant for micro seismic zonation).

In relation to the surface soil identified along the route, conditions were identified that can be considered semi soft terrain. Among these, in the area south of the Panecillo, specific soft soil conditions were identified (associated with lacustrine sediments) with thicknesses of up to 15-20m that could be associated with potential geological risks like settlement. In the north soft soils of similar lacustrine origin, are associated with thickness of less than 10m. The geotechnical substrate (suitable for foundation level) was identified at relatively shallow depths (10-20m) in association with a compacted layer of dense hard floors and ancient sediments represented by units of volcanic origin of the Cangahua formation.

In the historic center area more geotechnically favorable conditions are observed in floors and also rigid substrates on the surface.

In terms of seismic micro zoning the analysis of predominant periods of vibration with low values indicates the thickness of a superficial thin semi soft layer and the presence of a shallow substrate consistent with that defined by seismic activity.

The distribution and classification of soils in the urban setting reports the presence of dense semi rigid soils with conditions of lesser rigidity to the south. While the geotechnical substrate is clearly evident between 20 and 10m deep, the transition to rock (as defined by regulations) would be 84 m deep in the south and 55m in the north. The sensu stricto rock, the volcanic basement, would be 198 m in the south and 259 m in the north. These data, like the stratigraphic earthquake sequence are of vital importance for the seismic evaluation that is taken into account in the construction of the first line of the Metro de Quito. The following image shows an example of a vibration register:



4.7 EARTHQUAKE MONITORING AND NEOTECTONICS

4.7.1 OBJECTIVE:

Determine the resonance frequencies of the soil of the city, with emphasis on the area of influence of PLMQ.

4.7.2 AREAS OF ACTIVITY:

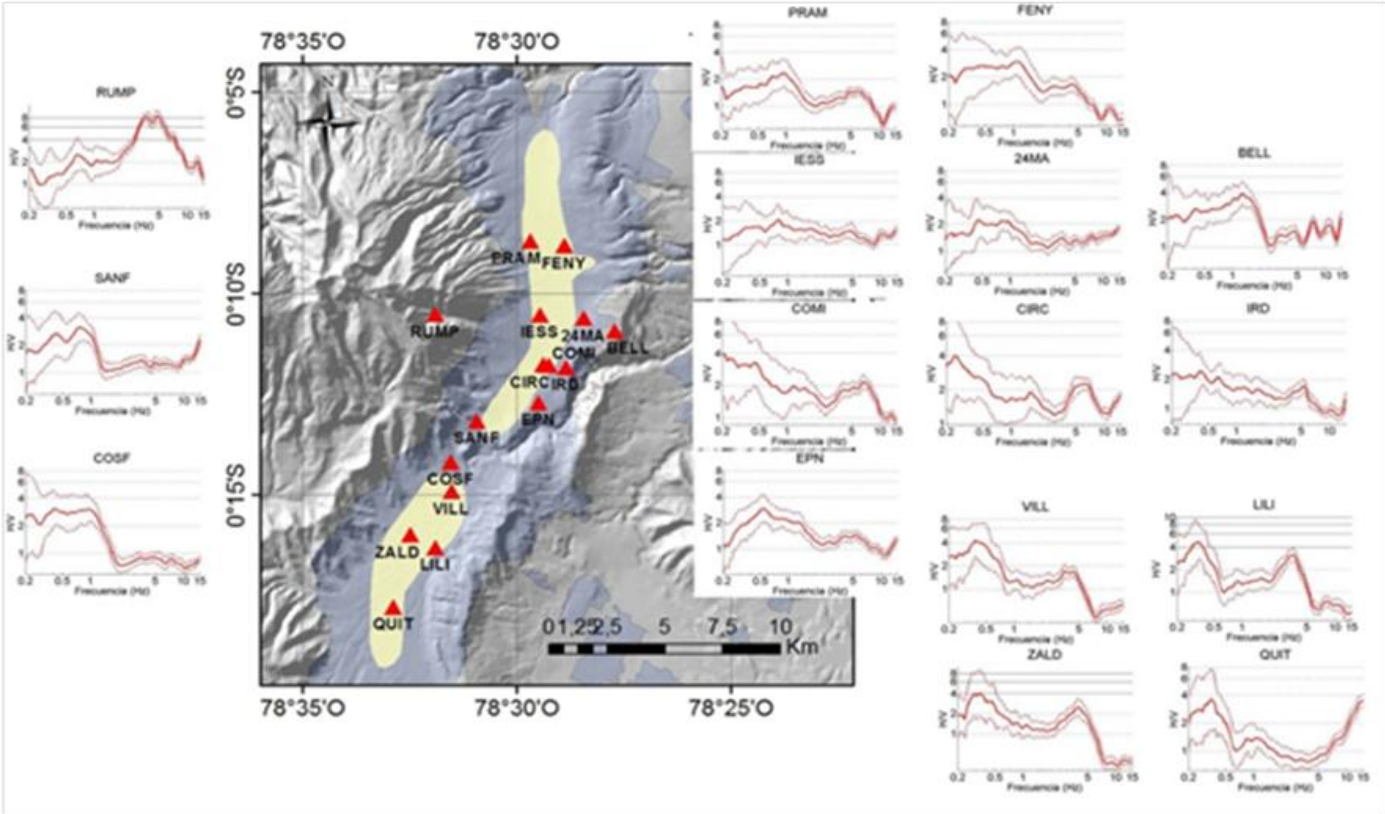
Seismic valuation of 16 accelerometers along the route of the PLMQ

Lithostratigraphic Control of test probes

4.7.3 RESULTS:

- There is a network with 17 stations that can help with the earthquake monitoring and determining the levels of amplification.
- Reliability of the amplification frequency at several sites in Quito with the Nakamura method.
- The results of the H / V reason for earthquakes give the amplification frequency that we cannot detect with Nakamura.
- From the results of noise and preliminary H / V with earthquakes, it can be concluded that in Quito the use of the Nakamura method

The following image indicates the registers in a seismic monitoring



4.8 HYDROGEOLOGY

4.8.1 OBJECTIVE:

Determine the surface and underground water condition, and their interaction with the works of the metro.

4.8.2 AREAS OF ACTIVITY:

Quito aquifers: South and North Central

Areas of influence of aquifers

Hydrogeology

Some previous studies of in the Quito aquifer have allowed the identifying of two hydrogeological units that operated separately.

South of the Panecillo the flow of groundwater is preferably in a South North direction towards the Machángara discharge area. North of the Panecillo the flow is west to east into the Machángara in the Batan area.

The gradients are high in slope zones, while in the center of the valley the gradient is reduced. The gradient increases again in the vicinity of the aquifer discharge into the Machángara.

From the calibration and model results it can be deduced that the Cangahua formation narrows at this point. Groundwater from both zones discharge into the river Machángara. The SUR FL OCCIDENTAL aquifer area presents relatively small transmissivity values compared to the central parts of the valley. That is, there is a zone of low transmissivity but it does not completely disconnect the north and south.

- North Central Unit, consisting of the upper basin of the river Monjas and drained by the El Colegio ravine and the El Batan ravine where the sewer network and underground river collectors converge.
- South Unit, consisting of the upper basin of the Machángara River leaving the basin by a narrow and deep valley. It must be emphasized that the abundant springs observed in the Machángara valley (more than 100 liters / second in El Sena and Guápulo) come from highly fractured andesite lava flows that play the role of privileged drains, in the South Unit the aquifers are very heterogeneous,

Based on the isotopic composition of the waters, two different schemes for natural recharge in the North-Central and South units of the Quito Aquifer are considered:

North –Center Unit:

The aquifer recharge was carried out by direct infiltration of precipitation on the valley and possibly by re-infiltration of a part of the flow of from runoff from springs located on the slopes of Pichincha.

Regarding the North Central Unit it has been characterized as a single multilayer aquifer consisting of two levels with good hydrogeological characteristics, they are interrelated, since almost all the elements present between them are permeable. The average depth of the water level of groundwater currently ranges between 5 and 17 m., Reaching 43 m at the Mariscal Sucre Airport.

South Unit:

The isotopic composition of water from boreholes reflects a deeper source than in the North-Central, while the springs show a hypodermic flow (surface).

Infiltration in the upper parts of the Atacazo volcano seems, therefore, much more effective than in the North-Central. This infiltration contributes to the recharge of the aquifer of the South Valley, which is consistent with the higher concentration of dissolved salts and iron contents observed in this aquifer, corresponding to a longer circulation time, increased contact time between the water and rock.

The South Unit shows rather chaotic sedimentation that has led to the formation of two heterogeneous aquifers with different hydrogeological characteristics. The El Pintado Aquifer corresponds to fluvial-lacustrine deposit levels composed of silt, sand and clay, which reaches a depth of 80 m., and with a thickness of 60 m. Due to its configuration, extension (12.5 km2. accumulation area with 23 km2. of recharge) and hydrogeological characteristics, there are no good prospects for intensive use.

The Guamaní Aquifer has greater significance for its lithological and hydrogeological characteristics. It has an accumulation area of 39.3 km2 and recharge area of 51 km2. It has been established that this aquifer is composed of two levels of about 70 m. thick, separated by a layer of low permeability, corresponding to fluvial-lacustrine deposits and mud flows of approximately 20 m. thick. The whole aquifer reaches the depth of 165 m.; Superior coverage corresponds to Cangagua deposits with an average thickness of 15 m.

Under these circumstances, it was important to determine what influence the aquifers could have on the building of underground works and obviously there would be the risk of them suffering some degree of alteration or contamination of groundwater during the construction and operation of the system.

As specific results developed throughout the development of the conceptual model the following is highlighted:

- Interpretation of all the existing relevant historical information: geological, geochemical, hydrogeological, hydrological, hydraulic, climatological, meteorological and geotechnical mapping among others.
- Determination of hydrogeological characteristics of the aquifers located in the south and north of the city center of Quito.
- Interpretation of latest / current information required principally of the hydrogeological and geochemical type.

4.9 GROUNDWATER FLOW MODELS USING NUMERICAL METHODS AND IMPACT OF WORKS ON UNDERGROUND HYDRAULICS

To complement the hydrogeological knowledge, the following details were obtained:

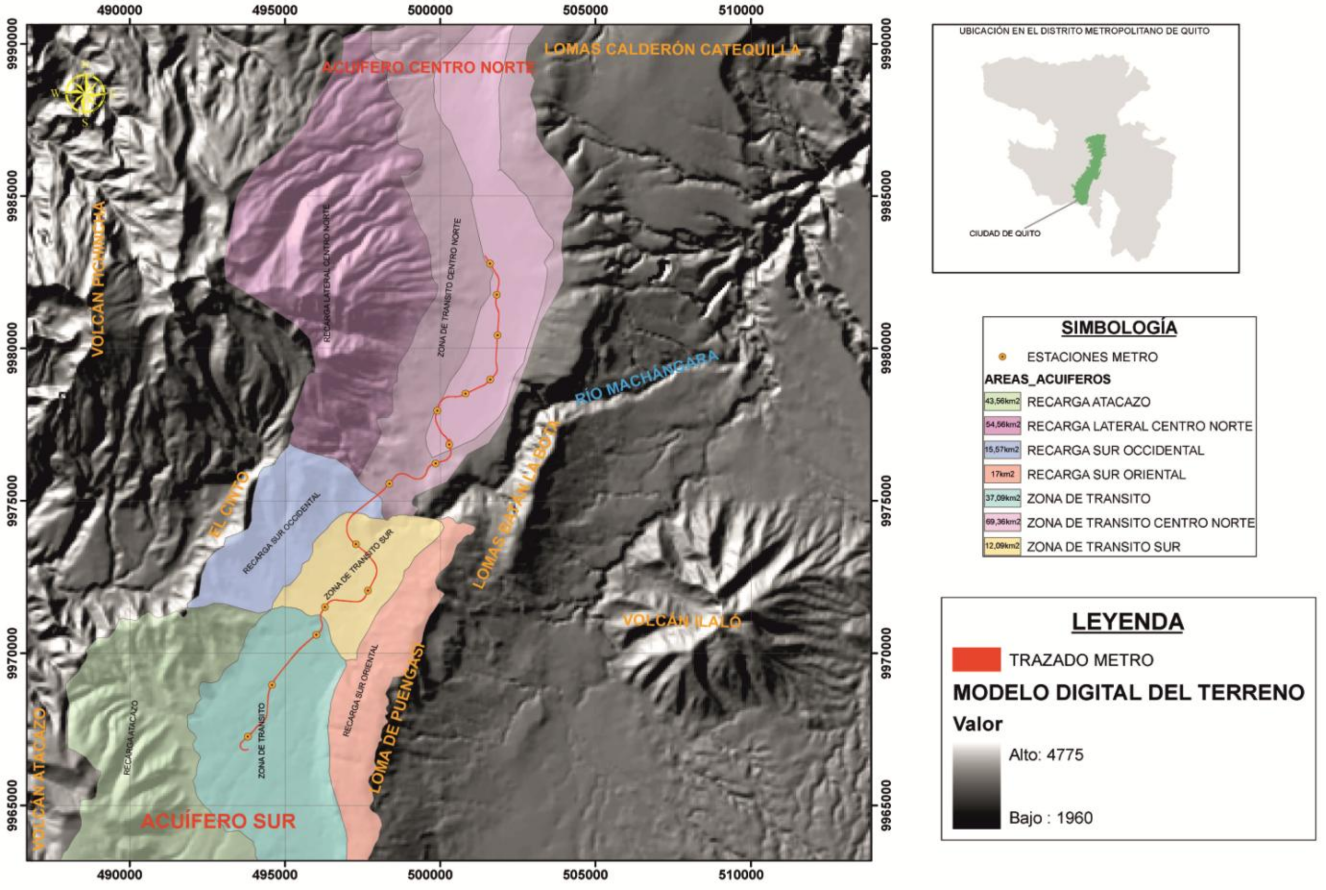
- Description hydrogeological conditions
- Hydrogeological parameters
- Hydrodynamic analysis (hypothesizing about location, level and movement of groundwater, storage coefficient, flow)
- Characterization of aquifer
- Groundwater runoff
- Conceptual Mode
- Hydrogeochemistry

4.9.1 RESULTS:

- There is no hydraulic disconnection or low permeability barrier between the South of Quito aquifer and the Quito north central aquifer.
- The transmissivity is varied between 4 m2/day and about 400 m2/day, meaning that there are variations of more than two orders of magnitude.
- In the south of the aquifer groundwater flow is from south to north, while to the north of the aquifer it is from west to east.
- The piezometric level varies between 3700 m and 2400 m in the discharge area.

Following is a map showing the location of wells and ventilation shafts:

LOCATION MAP OF WELLS AND SPRINGS



RESULTS OF SOME INVENTORY ITEMS

Indice de daños estructurales	Número de predios	Porcentaje
Terrenos baldíos	32	1,06
Daños ligeros (fisuras < 5mm)	2868	95,00
Daños moderados (grietas de 5 a 15)	102	3,38
Daños severos (tipo estructural)	17	0,56
TOTAL	3019	98,94

Nivel de Riesgo	Número de predios	Porcentaje
Terrenos baldíos	32	1,06
Nivel bajo	959	31,77
Nivel medio	479	15,87
Nivel alto	1549	51,31
TOTAL	3019	100,00

Indice de suceptibilidad	Número de predios	Porcentaje
0	32	1,06
2	935	30,97
3	435	14,41
4	1585	52,50
5	20	0,66
6	12	0,40
TOTAL	3019	100,00

LEVANTAMIENTO FOTOGRAFICO	NUMERO
FOTOGRAFIAS EXTERIORES	7.105
FOTOGRAFIAS INTERIORES	834
FOTOGRAFIAS DE DAÑOS	2.740

4.10 INSPECTION OF BUILDINGS AND STRUCTURES

4.10.1 OBJECTIVE:

Identification of the current state of repair of buildings and structures located along the route of the PLMQ

- AREA OF ACTIVITY:
- Buildings and homes located within 50m. on each side of the route: 3,000;
  - facades and common elements of the buildings
  - Interior of some houses

4.11 AFFECTED PUBLIC SERVICES

4.11.1 OBJECTIVE:

Identify urban services that may be affected by the implementation of the PLMQ infrastructure

4.11.2 AREA OF ACTIVITY:

- Stations,
- Ventilation Wells, pump wells, emergency exits
- Tunneling access wells
- Tunnels between screens

To achieve the best results contacts were established and meetings were held with Zonal Administrations in the Quito Metropolitan District, agencies, organizations, companies and service companies that could be affected by the carrying out of works for this project, in order to have the necessary information about the property, rights, services and easements held.

For the preparation of the inventory of buildings and existing services in the areas of influence of the project, field inspections were conducted, while previously collecting all possible information from Public and Private Companies was required, as well as the collaboration of representatives of these companies for field trips and verification of information provided by them.

With this information collected by Metro de Madrid an implementation plan has been developed for replacement of sewerage and drinking water services, which may be temporary or permanent. These replacements will be made prior to the construction of the metro in the relevant sectors in order that these services do not interfere with the construction of the metro.

The Study of buildings and structures, aimed to create an inventory, characterization and classification of buildings and structures in the area of influence of the first line of the Metro de Quito-- 22037.67 m in length.

The character and classification of buildings and structures was inventoried, identifying properties along the metro area of influence, determining levels of risk and damage of each of the structural units, to define the susceptibility index, determining the vertical distance between the foundation of the buildings and the top of the tunnel. As well information on nature and structure type was inventoried, as well as foundation type, distance from the property to the line and its location in relation, the type of material used for the structural elements of the building and common elements were observed, and a photographic record was obtained of the facades and the visible damage.

A system compatible with Android was implemented, which can be queried and is accessible from anywhere in the world, connecting via the Internet. The system has a friendly interface that allows easy access and management of the various modules. It is connected to a database, any type of search or specialist consultation can be made in an agile and precise manner.

With the information gathered in the inventory, classification of buildings and structures, technical sheets were developed for each of these structures, with their photographic record and a location map was prepared, showing the location of the route; also plans were drawn up according to the index levels susceptibility, risk level and level of damage, signalized with red, yellow and green, to facilitate understanding thereof. Additionally, there are maps of: structure type, material structure, foundation type, geometry of the building, number of floors, age, architectural value and identification of use.

4.11.3 COORDINATION WITH AGENCIES

Contact has been maintained with businesses and organizations that might be affected by the works envisaged.

Companies with whom contact has been maintained are:

- Empresa Pública Metropolitana de Agua Potable y Saneamiento (EPMAPS)
- Corporación Nacional de Telecomunicaciones (CNT)
- Empresa Eléctrica de Quito
- Empresa Pública Metropolitana de Movilidad y Obras Públicas (EPMMOP)
- Grupo TV Cable

4.11.4 SERVICES AFFECTED

We have the identification and definition of repositioning should it be necessary, of all the services that could be affected by the execution of the works defined in the project.

From the information obtained the following service networks have been identified:

- Collectors
- Sewerage
- Drinking water
- Electricity
- Telecommunications
- Cable TV
- Traffic signals

As part of the inventory of existing buildings and services, sheets and maps of services organized in the areas of activity are included as follows:

- Stations
- Tunnel between screens

- Workshops and garages
- Wells

4.11.5 RESULTS:

Sheets and maps registering the location of services affected by the infrastructure of the PLMQ are available. The following photograph illustrates one of those casas:

4.12 GEOLOGY AND GEOTECHNICS

4.12.1 INTRODUCTION

The documentation produced forms part of the final design of the first line of the Metro in the city of Quito. At this point it relates specifically to the Geology and Geotechnics of the corridor and constituent structures.

4.12.2 OBJECTIVE:

Knowing the geology and geodynamic features of the land, and obtaining the necessary parameters for the design of various structural elements of the PLMQ application pioneering trials in Ecuador: Pressure metering (presiometría) and Down Holes.

4.12.3 AREA OF ACTIVITY

- Tracing the route of the Metro
- Geotechnical Evaluation through 70 surveys, field tests and laboratory tests.

4.12.4 GEOTECHNICAL RESEARCH METHODOLOGY

1. Review of existing information
2. Execution of boreholes :
   - Drilling: Obtaining evidence
   - Performing SPTs
   - Taking Shelby samples
   - Taking of undisturbed samples (waterproof)
   - Permeability tests
   - Piezometro installation
   - Measure of water table (water)
   - Assays resistivity (Gamma, Spontaneous potential SP, SPR)
   - Pressuremeter tests
3. Lab tests
   - Mechanical characteristics of soils
   - Triaxial tests
   - Chemical analysis of water samples from the boreholes
4. Geophysical tests
   - Reconditioning the well
   - Down Hole Tests
5. Interpretation of the results
   - Correlation analysis
   - Recommendations

Geological and geotechnical knowledge determines the characteristics and ground conditions along the route, in order to get the data needed to define the conditions of excavation, the construction characteristics of the tunnel to be dug, possible protection measures and soil treatment, the possible use of materials removed, and how to define the foundation conditions at station sites and structures.

Work done for the project is available, as are other studies or previous projects in the area, along with references, and project data and work done on materials of the same nature. These determine a general geological framework. There is also a geological sectioning and description of conditions along the route.

There is also a plan with geotechnical research on the geological and geotechnical profile of the route, the correlation of stratigraphic columns of boreholes, survey records, permeability tests, diagrams, Down Hole tests, pressure meter tests, measurements of the water table and passive seismic respectively, the study of quarries and supply plants, laboratory tests conducted on samples taken from the boreholes.

The work has determined the characteristics and geological-geotechnical conditions of the site and surrounding area, to define the conditions of excavation, construction systems, identify thrust terrain and groundwater, as well as define the foundation conditions at the structure sites.

Geology and Geotechnics

The Quito basin is located in the Andean valley, and is deposited with exclusively volcanic material, of the Middle Pleistocene age; predominantly at the north end of the track the Machángara Formation surfaces in profile, the Cangahua Formation and the most recent Carolina formation of volcanic sediment pyro clastic in source generated by the volcano Pichincha. In the South volcanic sediments pyro clastic in origin is distinguished, generated by the volcanic complex Atacazo. Anthropic fillings are also superficially quite widespread in the city especially in the basins of ancient ravines.

The route of the METRO DE QUITO line, is located along the Quito basin in a topographic depression approximately NS in direction, elongated and three to five miles wide. Morphologically, it is divided into two sub - basins: center - north and south, separated by the river Machángara and El Panecillo dome. The basin of Quito is differentiated by the following units, which were defined by:

Machángara Formation presented with two subgroups: Basal Volcanic Sg and Quito Sg.

Basal Volcanic Sg: avalanche deposits, mudflows, pyro clastic flows and lahars, intimately related to lava flows, characterized as heterogeneous, heavily textured, which are the product of eruptions of Rucu Pichincha.

Quito Sg: fluvial deposits and mudflows slightly lower than previous ones more homogeneous and smaller grain size than those included within the Basal Volcanic.

In the sub basin south of Quito, the Quito subgroup, presents primary volcanic deposits including pyro clastic flows, pumice and ash falls which have been called "Volcano-Sedimentary Guamaní Unit, as well as those reported in el Pintado Fluvio lacustrine Unit, which include sedimentary deposits of fluvial and lacustrine environment as fine sandstones and clays.

Cangahua Formation

Consists of altered tuff typically of yellow to brown colors, usually interspersed with falls of ash, pumice, paleosols and sometimes mud flow and alluvial channels, they occur in limestone crusts and manganese oxide, in the middle of the deposit , are layers of fine sand to 50 inches , while the base of the formation, especially on the flanks of the volcanic complex Atacazo - Ninahuilca and Pichincha, colluvial are up to 2 feet thick, formed by blocks of andesite, dacite and pumice within a sandy brown silt matrix

Northbound includes deposits of alluvial fans flowing from the eastern slopes of the Pichincha volcano, to the main drains that reach the sub basins (Rumipamba, Rumihurcu and Grande ravines and mainly in the River Machángara)

La Carolina Deposits

Sediment characterized by packages of silt, clay, medium to coarse sand, interspersed with ash and pumice falls, which are presented in the Alluvial and Lacustrine Palustre subgroups.

Alluvial Sg: numerous lahars, primary volcanic ash and soil levels present in the fans that are the main drainage basin. However, towards the axis of the basin it is closely related to Lacustrine and Palustre deposits, as well as small waterways, (El Ejido, La Carolina, Jipijapa).

Lacustrine Palustre Sg: The Carolina deposits previously mentioned contains a package of silt and clay, interspersed with ash falls, in the records of the perforations in the Carolina and El Ejido traces of paleosols can be seen.

4.12.5 CONCLUSIONS OF THE GEOTECHNICAL INVESTIGATION

- It is entirely feasible to construct a subway in Quito.
- The work of the Metro cross between compact and soft soils. No evidence of rock along the way.
- The southern sector shows soft soils with a high water table, digging with TBM feasible.
- The center area shows consolidated soils, very good condition for digging by traditional methods.
- The northern sector has consolidated soft soils, with average groundwater levels, workable digging with TBM.
- The stations can be built by Cut & Cover

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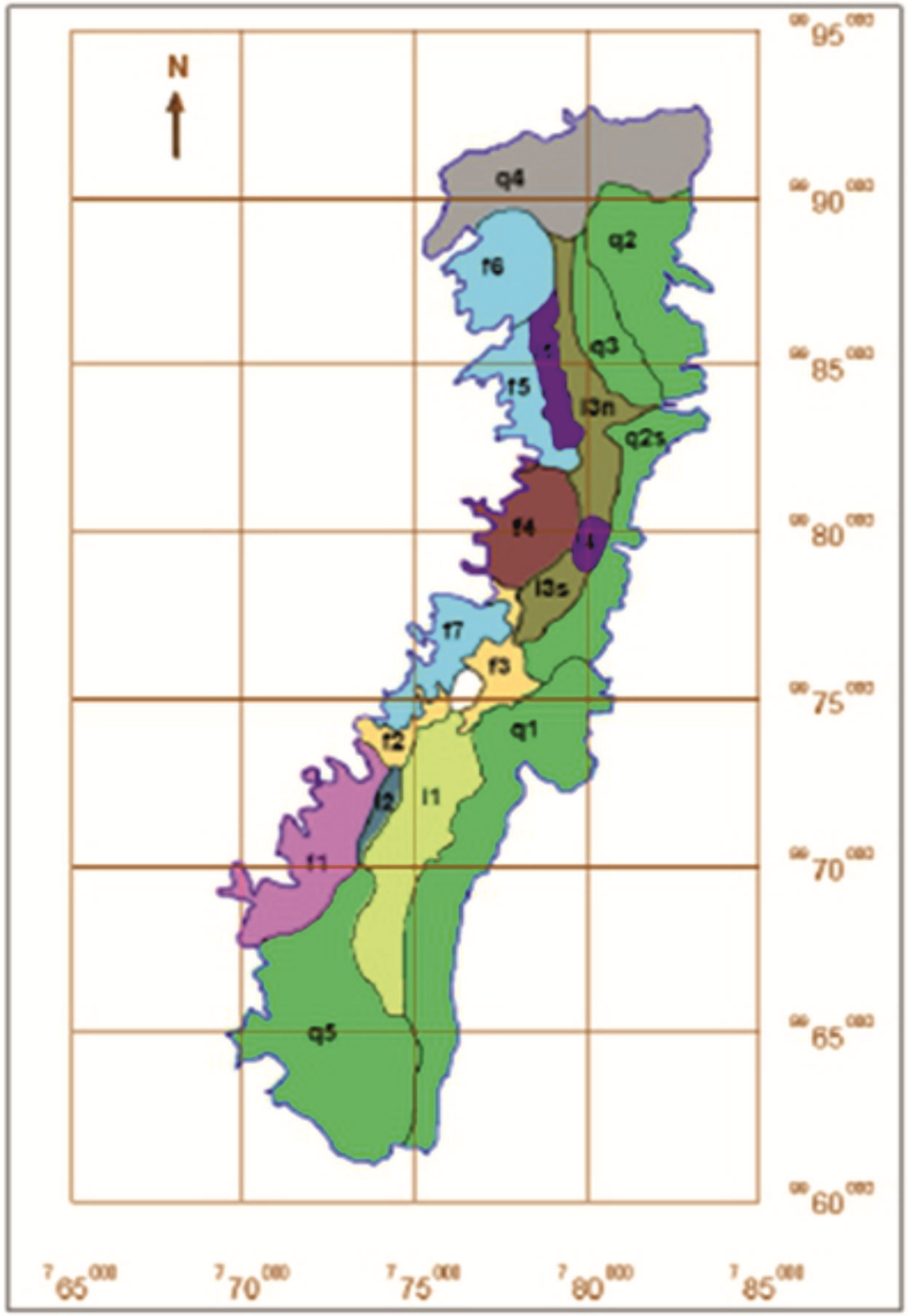
4.13 SEISMIC EFFECTS

4.13.1 INTRODUCTION

We describe the considerations of seismic effects in the design of the first line of the Metro de Quito.

The city of Quito is located in a context of active tectonics due to the subduction of the Nazca plate beneath the South American plate. It is a compression zone N80E with the presence of active faults that give the city a high seismic potential. The existing seismic risk in the city of Quito is the highest in Ecuador. In fact, the city of Quito is located within the Z = V zone of the Seismic Zoning Map of Ecuador whose expected maximum acceleration in rock for the earthquake design is a MAX = 0.40 g.

This high seismic acceleration is amplified by the existing soil quality, especially in the northern part of the city. In this regard, in recent decades classification of soils has been carried out in the city of Quito according to their seismic risk. This can be seen in the following image:



AREAS OF SOIL IN QUITO.

The materials marked with the letter q correspond to volcanic ash tuff formations (cangahua) present on the east side of the city of Quito. The materials marked with the letter l correspond to lacustrine deposits belonging to the former quaternary lake located in the south, center and north of the city of Quito, where there sits the largest part of the population of the city. The materials marked with the letter f correspond to alluvial-colluvial deposits, such as alluvial fans from the eastern slopes of Pichincha. Finally, the sector not marked and white in color corresponds to the dome of the Panecillo, corresponding to a volcanic structure consisting of lavas and welded pyroclastic. Concretely, the route of the PLMQ primarily affects the *l3n, f4, l3s, f3* and *l1*units.

The behavior of a buried structure under seismic action is influenced by three factors: the seismic action itself, geological conditions of the terrain and the design and construction of the structure or tunnel.

4.13.2 CONSIDERATION OF SEISMIC ACTION

To obtain the seismic action considered in the design of the various components that which is described in Capítulo 2-Peligro Sísmico and in Capítulo 3-Riesgo sísmico evaluación y rehabilitación of the Norma Ecuatoriana de la Construcción (NEC-11) and Capítulo 12 del Código Ecuatoriano de la Construcción. Requisitos Generales de Diseño: Peligro sísmico, espectros de diseño y requisitos mínimos de cálculos para diseño sismo resistente (CPE INEN 5) has been followed.

To perform the necessary seismic analysis it is appropriate to start with Sismo de Diseño, which is the earthquake that has a 10% chance of taking place in 50 years, equivalent to a return period of 475 years.

In terms of the importance of the structure, structures designed for Line 1 of Quito are considered as "specialty occupation".

The NEC-11 defines the territory of Ecuador in six seismic zones, characterized by the zone factor Z as on the following map:

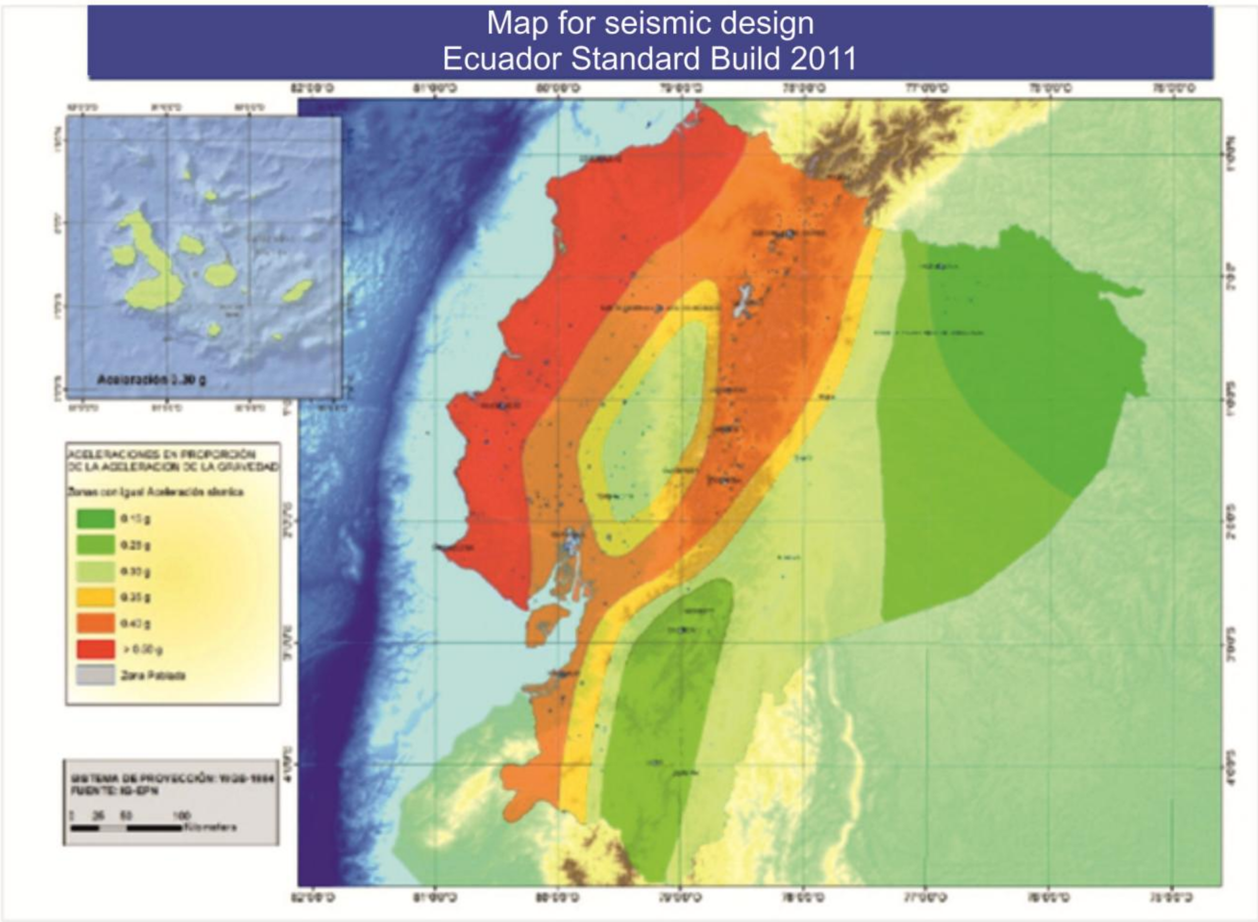


Table 2.1 z factor values as a function of the seismic zone adopted

Zona sísmica	I	II	III	IV	V	VI
Valor factor Z	0.15	0.25	0.30	0.35	0.40	≥ 0.50
Caracterización de la amenaza sísmica	Intermedia	Alta	Alta	Alta	Alta	Muy Alta

In the present case, the city of Quito is located in zone V, high seismic hazard and the value of Z factor is 0.40.

5. CIVIL WORKS PROJECT

5.1 THE ROUTE

The path defined for the first line of the Metro de Quito is underground; it meets the geometric criteria established and the constraints due to issues such as:

- The demand for mobility

- Intermodality of the Integrated Passenger Transport System
- The siting of the stations.
- The geotechnical characteristics of the ground.
- The functional aspects, such as users accessing outside facilities keeping the Metro platforms as shallow as possible.
- The urban structure.
- The existing public services, and
- The actions foreseen in the environment.

The first line of Metro de Quito (PLMQ) runs south to north in the city. It begins with the current Quitumbe bus terminal to the southern end of the old Mariscal Sucre International Airport.

The route of the P.L.M.Q. includes the following sections:

- Branch line access to workshops and garages in Quitumbe with 590.60 m, between the coordinates 9 +409.40 and 10 +000,00 +
- Tunnel line 21.698 Km underground that is between the coordinates 10+000,00 and 31+698,90
- Terminus station El Labrador coordinates between 31+698.90. and 32 +072.56

A code has been adopted for rail traffic, the initial coordinates in Quitumbe Station 10+000 and absolute zero.

The length of the route is 22,663.17 m from the Cocheras until the end of the terminus station El Labrador. Along the length 15 Metro stations have been designed so far and a site for workshops and garages, which also house the Central Control Post of Line, where the correct operation of the line can be controlled. Additionally five reserve areas are planned for future implementation of many other stations, at the time the demand so determines, of which one located in the Plaza del Teatro may be included in the construction currently scheduled.

The working length between the two end stations is 21,698.91 meters, to which must be added the 590.60 meters of Workshops and Depots access branches, and 373.66 meters for the terminus at the El Labrador station.

Of the total length, the 70.99% (16,087.59 m) is planned for construction by TBM, 9.22% (2089.77 m) would be built in the conventional method or by TBM, 8.41% (1905.46 m) will be executed by the method between screens, the rest of the tunnel 0.99% (223.41 m) will be open, and finally, 10.40% (2356.94 m) corresponds to the length of the stations.

The average depth of the line is 22.41 meters, while the stations are located at an average depth of 17.60 meters. The average distance of the stations is 1391.20 meters.

The route runs from the peak of 2909.66 m at Quitumbe station to the lowest, which is located in the La Carolina Park at an elevation of 2752.75 m. These data give a maximum height of 156.91 m for the Line, and the average elevation is at the 2800.73 m.

The names and locations of the stations are designed as follows:

Station Nº	NAME	initial station coordinate	final station coordinate	Central platform coordinate
E-01	QUITUMBE	10+000,000	10+140,770	10+059,350
E-01b	FUTURE STATION (RESERVE 1)			11+303,157
E-02	MORÁN VALVERDE	11+920,352	12+102,270	12+033,247
E-02b	FUTURE STATION (RESERVE 2)			13+106,488
E-03	SOLANDA	14+094,194	14+257,379	14+185,979
E-04	EL CALZADO	15+158,950	15+315,138	15+242,341
E-05	EL RECREO	16+834,012	16+964,094	16+894,797
E-05b	FUTURE STATION (RESERVE 3)			18+107,088
E-06	LA MAGDALENA	18+695,191	18+829,379	18+759,179
E-06b	FUTURE STATION (RESERVE 4)			20+047,373
E-07	SAN FRANCISCO	21+397,154	21+518,054	21+456,354
E-07b	PLAZA DEL TEATRO (RESERVE 5)			22+275,586
E-08	LA ALAMEDA	23+310,633	23+469,233	23+398,083
E-09	EL EJIDO	24+202,887	24+409,087	24+303,187
E-10	UNIVERSIDAD CENTRAL	25+456,246	25+589,187	25+525,265
E-11	LA PRADERA	26+631,158	26+771,658	26+706,108
E-12	LA CAROLINA	27+559,261	27+699,011	27+624,061
E-13	IÑAQUITO	29+085,470	29+222,570	29+160,421

Station Nº	NAME	initial station coordinate	final station coordinate	Central platform coordinate
E-14	JIPIJAPA	30+452,735	30+591,432	30+527,885
E-15	EL LABRADOR	31+557,853	31+698,903	31+626,902

Being an underground project it is necessary to design other elements for the correct functioning of the lines from the point of view of passenger safety and operations. So there are **10 emergency exits**, strategically located between the stations to facilitate the exit of passengers in case of need, there are also **13 ventilation shafts** which together with those existing in the stations themselves allow the living conditions of the infrastructure to meet the comfort standards required; **10 pump wells** are designed for evacuating any possible water that enters the tunnel.

They have also provided for three extraction wells for the TBMs.

The following photographs show the work of the TBMs and the manual methods, as well as an extraction sleeve.

Source Web

5.2 DESIGN PARAMETERS IN PLAN AND ELEVATION

The route parameters adopted for the tunnel line are:

ROUTE TUNNEL PLAN	
Width of the path (measured between active boarders)	1.435 mm
Distance between the axis of the lane	1.505 mm (lane 54E1)
Type of transition curves	Clotoide
Maximum speed	100 Km/h
Maximum superelevation	150 mm
Minimum radius	300 m
Non-compensated maximum acceleration	0,65 m/s2
Maximum acceleration uncompensated traveler	1 m/s2
Maximum superelevation ramp	Normal: 1,5 mm/m Exceptional: 2,0 mm/m
Superelevation deficiency	100 mm
Maximum Superelevation variation in time (mm / s)	Normal: 30 mm/s Exceptional: 50 mm/s
Maximum variation of uncompensated lateral acceleration (m/s3)	0,02 g

ROUTE TUNNEL PLAN	
Minimum length of straight between circular curves (m)	0,4 V
Minimum length of constant curvature alignments (m)	0,4 V
Useful length of platform (straight)	115 m
ROUTE IN ELEVATION OF LINE TUNNEL	
Type of vertical alignment	Parabolic
Slope (maximum)	Maximum: 35 mils (exceptional Machángara River crossing 37 mils) Low: 0 mils (stations) 5 mils (tunnel)
Vertical alignment setting minimum	3.500 (exceptional 2.000 Machángara river crossing)
Maximum permissible acceleration in vertical alignments	Normal: 0,15 Exceptional: 0,30

Route parameters adopted in the garage access tunnel are as follows:

ROUTE PLAN GARAGE ACCESS TUNNEL	
Width of the track (measured between active boarders)	1.435 mm
Distance between axis of the lane	1.505 mm (lane 54E1)
Type of transition curve	Not available
Maximum circulation speed	24 Km/h
Maximum camber	0 mm
Minimum radius	70 m
Uncompensated maximum acceleration	0,65 m/s2
ROUTE IN ELEVATION GARAGE ACCESS TUNNEL	
Type of vertical alignment	Parabolic
Slope (maximum)	Maximum 40 mils
Vertical alignment setting minimum	1.000
Maximum permissible acceleration in vertical alignments	Normal: 0,15 Exceptional: 0,30

5.2.1 STATIONS

As mentioned before, the design of the first subway line in Quito has fifteen stations (15), all underground and with side platforms.

Except Quitumbe station, the start of the line, all stations have at least an intermediate level between the street and the depth of platforms, where the station concourse is set out and circulation to the platforms is distributed.

A station is accessed from the outside street level, through access ports strategically placed to meet the needs of the city. All have at least one PMR enabled entry, and lift access from street to lobby and down to the platforms.

The lengths of the stations are as follows:

STATION	LENGTH (m)
E1. Quitumbe	140,77
E2. Morán Valverde	181,92
E3. Solanda	163,19
E4. El Calzado	156,19
E5. El Recreo	130,08
E6. La Magdalena	134,19
E7. San Francisco	120,90
E8. La Alameda	158,60
E9. El Ejido	206,20
E10. Universidad Central	132,94
E11. La Pradera	140,50
E12. La Carolina	139,75
E13. Iñaquito	137,10
E14. Jipijapa	138,70
E15. El Labrador	141,05
Media	148,14
Maximum	206,20
Minimum	120,90

5.2.2 VENTILATION AND PUMPING WELLS AND EMERGENCY EXITS

Individual wells, necessary for the operation of the projected infrastructure, are distributed along the route with the following criteria:

VENTILATION WELLS:

Are located near the midpoint between two stations. Through a gallery 14 meters long for equipment housing, the tunnel communicates with a vertical shaft at least 32 m2 of free section.

PUMPING WELLS:

They are located at low points of the route or in an area where, if they were not placed, the flow collected in the low point would require the creation of oversized cisterns. Their capacity is designed for a hypothetical 4-hour stop in operation of the pumps.

EMERGENCY EXITS:

Interstation's are arranged when the distance between platform ends is greater than 1,000 m, recommending a distance between them of the order of 500 m. There are located within 100 m of the ventilation shafts and avoid, whenever it has been possible having a route for evacuation of more than 500 m in case of smoke in the tunnel.

As a general rule, where it has been possible, a single output shaft of for emergency functions and the pumping has been integrated so that this economizing also minimizes the surface effects.

In total we have projected the following ventilation shafts, pump shafts and emergency exits:

- 13 ventilation wells
- 7 pumping wells
- 7 emergency exits
- 3 emergency exits and pumping wells

Below is a table showing the location of these singular points.

NAME		Initial Coordinates	Final Coordinates
JET Ventilation	1	9+750,000	
QUITUMBE	**E-01**	**10+000,000**	**10+140,770**
JET Ventilation	2	10+610,000	
JET Ventilation	3	11+020,000	
EXTRACTION Well	1	11+020,000	
EMERGENCY Exit	1	11+390,000	

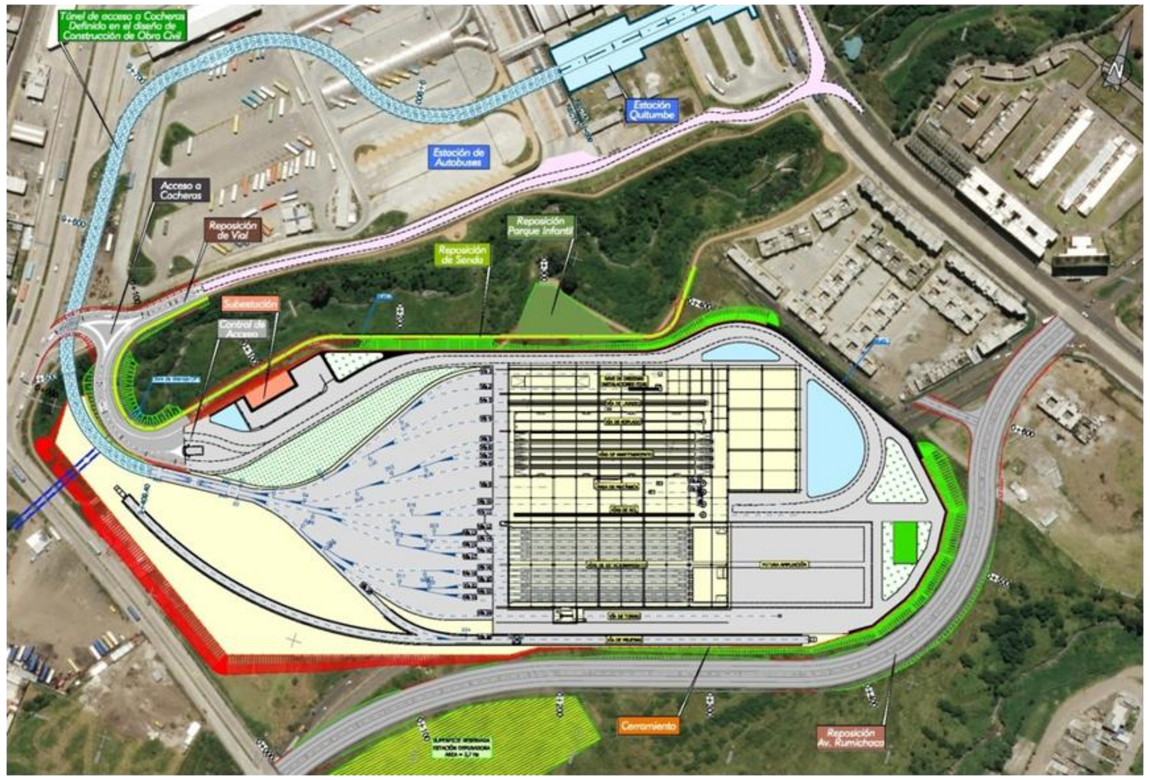
NAME		Initial Coordinates	Final Coordinates
MORÁN VALVERDE	**E-02**	**11+920,350**	**12+102,270**
PUMPING Well	1	11+960,000	
EMERGENCY Exit	2	12+620,000	
VENTILATION Shaft	1	13+020,000	
EMERGENCY Exit	3	13+680,000	
SOLANDA	**E-03**	**14+094,190**	**14+257,380**
PUMPING Well	2	14+250,000	
VENTILATION Shaft	2	14+660,000	
EL CALZADO	**E-04**	**15+158,950**	**15+315,140**
VENTILATION Shaft	3	16+030,000	
EMERGENCY Exit	4	16+220,000	
PUMPING Well	3	16+220,000	
EL RECREO	**E-05**	**16+834,010**	**16+964,090**
VENTILATION Shaft	4	17+470,000	
EMERGENCY Exit	5	18+080,000	
PUMPING Well	4	18+500,000	
LA MAGDALENA	**E-06**	**18+695,190**	**18+829,380**
EMERGENCY Exit	6	19+190,000	
VENTILATION Shaft	5	20+000,000	
EXTRACTION Well	2	20+000,000	

NAME		Initial Coordinates	Final Coordinates
EMERGENCY Exit	7	20+860,000	
24 de Mayo Interchange		21+124,250	21+156,430
Santa Clara Access		21+254,200	21+292,560
PUMPING Well	5	21+290,000	
SAN FRANCISCO	**E-07**	**21+397,150**	**21+518,050**
EMERGENCY Exit	8	22+300,000	
PUMPING Well	6	22+300,000	
EXTRACTION Well	3	22+300,000	
VENTILATION Shaft	6	22+720,000	
LA ALAMEDA	**E-08**	**23+310,630**	**23+469,230**
VENTILATION Shaft	7	23+840,000	
EL EJIDO	**E-09**	**24+202,890**	24+409,090
PUMPING Well	7	24+210,000	
VENTILATION Shaft	8	25+000,000	
UNIVESIDAD CENTRAL	**E-10**	**25+456,250**	**25+589,190**
LA PRADERA	**E-11**	**26+631,160**	**26+771,660**
VENTILATION Shaft	9	26+920,000	
VENTILATION Shaft	10	27+140,000	
LA CAROLINA	**E-12**	**27+559,260**	**27+699,010**
PUMPING Well	8	27+990,000	

NAME		Initial Coordinates	Final Coordinates
EMERGENCY Exit	9	28+330,000	
VENTILATION Shaft	11	28+480,000	
IÑAQUITO	**E-13**	**29+085,470**	**29+222,570**
EMERGENCY Exit	10	29+740,000	
PUMPING Well	9	29+740,000	
VENTILATION Shaft	12	29+840,000	
JIPIJAPA	**E-14**	**30+452,740**	**30+591,430**
VENTILATION Shaft	13	30+950,000	
EL LABRADOR	**E-15**	**31+557,850**	**31+698,900**
PUMPING Well	10	31+800,000	

5.2.3 WORKSHOPS AND GARAGES

The location of the workshops and garages of the first subway line in Quito is conditioned by urban and technical requirements that oblige both their status and their position in the plan. The area of operation of the workshops and garages covers an area of 119,898 m2. The area of occupation is seen in the following figure:



The route is largely influenced by the environment itself. The plot to be occupied is bounded by the Ortega Ravine, the Sanchay Ravine and existing homes both North and South, so space is very tight. Topographically it forms a hillside retaining natural coverage and has levels ranging between +2913 and 2933.

The shape of the plot is also an important determinant, as although it is long, the width is very small, so that the very buildings of the garages have had to adapt to that provision, substantially in a northeast-southwest direction, filling the entire width available.

As for the route plan of the tracks this is determined by the orientation of the garage warehouses.

After crossing the access branch via the Ortega ravine, the bretelle from which two branches run, is available and that allows distribution of the circulation:

- The first of the branches, by successive diversions opens up to the 12 parking tracks, the turn around and the test track.
- The second of the branches, distributes to the four maintenance tracks, to the two routes of long term revision areas, the mechanical area, the wash and dry warehouse, to the loading dock and the track car warehouse.

The railway yard is formed on a platform with a constant slope and elevation of 2924 meters.

The dimension of this platform is conditioned by the following:

- Quitumbe station, the first station on the line, which is projected at an elevation 2909.66 meters.
- Route of the garage access ramp, which connects the station to the railway yard. Both the development in plan and elevation is limited by the available space being the maximum slope of 36.5 mils.
- Ortega Ravine Crossing. The slope of the ramp allows the crossing of the Ortega ravine. The channel bottom elevation is 2921.845 meters and the height of the rail, as mentioned, is the 2924 meters. To save the channel the existing drainage work under Avenida de Huayanay Ñan will be extended so as not to affect the watercourse. The minimum height that allows for the crossing of the ravine is 2924m and thus does not greatly raise the height of the embankments to build on the Esplanade. The possibility of crossing the ravine by tunnel was discarded because it would cross at the same elevation of 2915 and almost all of the platform will be designed to remove the layer under the water table, so as to ensure perfect drainage during the lifetime of the facility. This is considered technically and economically feasible.
- The Bretelle to access the garages is available at the start of the railway yard for which a straight alignment length of 60 meters is set aside.

The layout of the railway yard is conditioned by the center distances between the various routes and minimum distances to the walls, pillars or any element of the structure of warehouses.

The separation of the various routes is achieved, as noted, from the two main routes by implementing successive diversions.

5.3 SUPERSTRUCTURE

The superstructure available for workshops and garages for Metro de Quito is divided into two areas: the rail yards that start at the bretelle at the entrance road to the rail yards located in the PK 9 +409,40 where all switching devices are located and on the other hand the workshops and garages. In the design: the permeability of the system, the economy, the maintenance, the slope and the material of the earthworks has been considered. The different switching devices to be placed in the rail yard are part of superstructure.

5.3.1 RAILWAY YARDS.

This area is characterized by the existence of large number of switching devices and very small radii that cause very low flow rates. For maintenance criteria establishing the need to design a railway superstructure with sleepers, thanks to which allow, if necessary, replacement of a defective device quickly without cutting traffic for long periods of time.

Since the entire tunnel of Quito Metro line 1 is projected to be ballastless track, the existence of a single superstructure zone with a sleeper design causes it to have more restrictive standards, setting as main the criterion the reduction in maintenance. So that no maintenance of the sleeper track is required no more frequently than the rest of the line.

Adopting a shape layer thickness of 60 cm, a layer of sub ballast of 30 centimeters and a minimum thickness of ballast under the underside of the crossbar of 35 centimeters.

The lane is the same as in the rest of the line UIC-54 and the cross-piece is UIC gauge.

5.3.2 WORKSHOP AND GARAGES AREA.

This presents a different superstructure depending on its intended use pathway distinguishing these types:

- Track flush with slab. This type of superstructure is characterized by the rail head flush with the outer slab around it and lowered until the lower bound of the head inside. The rail is anchored to the concrete by the inclusion of a coupon rail 54 Kg / m, 42 inches long, welded to the cross lane each meter.
- Track flush with slab and pit allowing the Wheel to pass, superstructure similar to the previous but with a space for passage of the wheels, the space is created by inserting a metal L.40.40 up to the head of the lane. The slab rests on the slab foundation of the warehouse.
- Track with pit. Routes are arranged with a pit between the rails to facilitate maintenance of underground units. The support between rail and concrete pit structure is made by a metal profile HEB-220; it is placed between a strip of neoprene Trackelast FC-9 of 4.5 mm thickness. Each meter fasteners are placed on both sides of the profile, these fasteners start as a Stedef staple by means of screws attached to the profile instead of the spikes used in the standard sleepers.
- Track on metal. A type of superstructure also used in trenches, where the rail is continuously supported (except in manhole areas) on a profile HEB 240, in turn supported by pillars of HEB 260 type, suitably distributed along the pit.
- Track on rigid blocks. Superstructure adopted for the parking tract, characterized by the placement on the concrete ballastless foundation of the warehouse, the slabs of concrete ballastless track, and a series of rigid concrete blocks embedded in this slab.

These blocks are placed facing each other with a gap between them of 1 meter, embedded in a concrete slab 30 inches thick, which is available on the foundation of the warehouse. The concrete used is FC - 25 MPa.

The following table shows the different types of superstructure to be used in each of the workshop routes

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TRACK	USE	SUPERSTRUCTURE
Track 1	Warehouse of track cars/fixed installations	Lane flush with slabs

TRACK	USE	SUPERSTRUCTURE
Track 2	Warehouse of track cars/fixed installations	Lane flush with slabs and pit
Track 3	Wash Track	Lane flush with slab
Track 4	Drying Track	Track in pit on metal
Track 5	Maintenance Track	Track in pit on metal
Track 6	Maintenance Track	Track in pit on metal
Track 7	Maintenance Track	Track in pit on metal
Track 8	Maintenance Track	Track in pit on metal structure
Track 9	Mechanical area	Lane flush with slab
Track 10	RCL Tracks	Lane flush with slab
Track 11	RCL Tracks	Lane flush with slab
Track 12	Parking track	Track on hard concrete blocks
Track 13	Parking track	Track on hard concrete blocks
Track 14	Parking track	Track on hard concrete blocks
Track 15	Parking track	Track on hard concrete blocks
Track 16	Parking track	Track on hard concrete blocks

5.3.3 SWITCHING DEVICES

Two switching devices are distinguished:

- Bretelle registration DDI-C-UIC54-154-1 / 8.5-CR-3385 for placement on the ballast, this one is located at the beginning of the rail yard.
- Diversions registration DSI-A-UIC54-100-0 0.20-CC-D / I for placement on ballast.

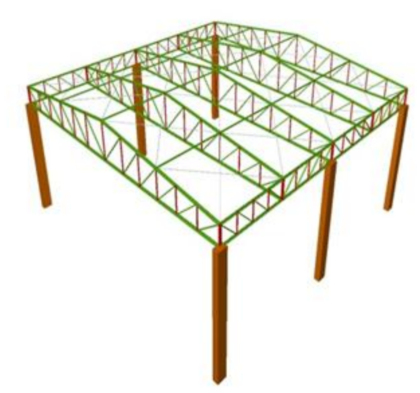
5.4 STRUCTURES

The main structures are the warehouses that will house workshops, garages and offices, electrical substation, building access control, retaining walls and land within the drainage work.

5.4.1 WORKSHOPS AND DEPOTS WAREHOUSE

The warehouse for workshops, garages and offices has a floor area of 27,100 m2 of which 935 m2 correspond to the offices. Due to its size, the warehouse is designed with lightweight independent modules always smaller than 30x30 m.

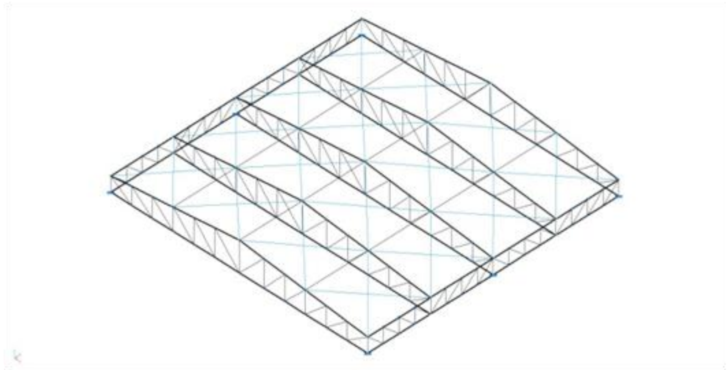
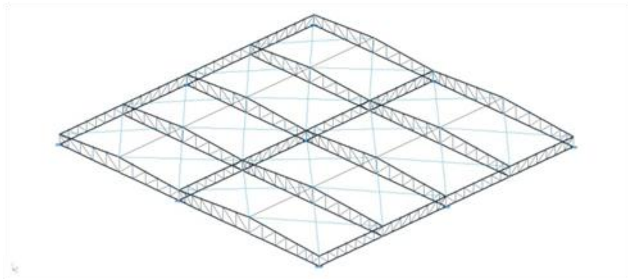
In areas of workshops and garages, these modules are composed of lightweight metal roof trusses supported on reinforced concrete columns with dimensions of 0.60 x1, 00 m.



The roof structure comprises a set of five primary trusses arranged 7.25 m apart in the transverse direction to the axes of the subway tracks, being in charge of giving form to the gable cover of each module. These trusses are joined at their ends by flat trusses. Belts supporting cover panels rest on the main girders. Bracing is provided by San Andrés crosses on the deck plans.

The trusses are made of UPN welded at the ends so their wings form metal drawers, open profiles IPE-220 straps are available each 2.50 m, and the cross braces in San Andres angle profiles consist of L40 .40.4.

The spaces to be covered between metal trusses are 29.70 m, 27.60 m, 22.00 m, 16.00 m and 9.45 m, and there are two groups of modules with double trusses that cover spaces of 16.00 +13.60 m, and 13.00 m +11.30.

The truss modules are supported by concrete columns with metal baseplates.

Columns are grouped into separate modules of dimensions:

- Module 29.70 x 29.00 m with 6 columns
- Module 29.70 x 24.50 m with 6 columns
- Module 27.60 x 29.00 m with 6 columns
- Module 27.60 x 24.50 m final with 6 columns
- Module 22.00 x 29.00 m with 6 columns and crane of 10 t 5 t
- Module 16.00 x 29.00 m with 6 columns and crane of 10 t
- Module 16.00 x 14.50 m with 4 columns and crane of 2 t
- Module 9.45 x 14.50 m with 4 columns of dimensions 0.60 x 0.80 m
- Module (13,60 16,00 m) x 29.00 with 9 columns and crane of 10 t
- Module (13,60 16,00 m) x 24.50 m with 9 columns and crane of 10 t
- Module (11,30 13,00 m) x 29.00 m with 9 columns
- Module (11,30 13,00 m) x 14.50 m with 6 columns

For support of the crane bridges concrete corbels are designed.

The modules are designed with deep foundation pile caps 0.85 m in diameter.

For the formation of the facades of the warehouse they are designed to hold metal substructure facade panels with columns and beams HEB-220-320-220.

Inside the warehouse, maintenance and garages are designed with several metal walkways and platforms for personnel to access the rolling stock for maintenance.

OFFICE MODELS

Inside the craft workshops and depots the office building is located. The building is a regular "L" plan on two floors, a reinforced concrete framed structure with solid slabs and beams (edge-wise).

The dimensions of the main structural elements are:

- The columns of the first floor are square of dimensions 0.50 x 0.40 x 0.50 m and 0.40 m.
- The columns of the second floor are square of dimensions 0.40 x 0.40 m.
- The slab that forms the floor of the first floor is 0.25 m thick.
- The slab that forms the floor of the second floor is 0.30 m thick.
- The slab that forms the floor of the deck is 0.25 m thick.
- The beams of the second floor and the roof are 1.00 m thick.

The building is divided into three separate modules with separating columns and slabs with expansion joints.

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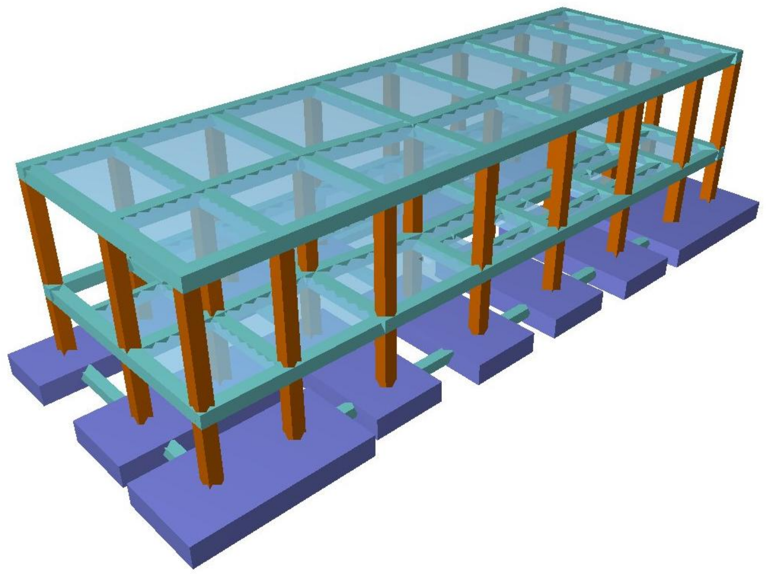
5.4.2 ELECTRIC SUBSTATIONS

The electrical substation is located in the path of the Ortega ravine as are the warehouse, workshops and garages.

It is a rectangular building with two floors of dimensions 11.45 x 32.75 m, of reinforced concrete framed structure with dimensions forged +8.15 m +2.90 m.

The dimensions of the main structural elements are:

- 24 square columns of dimensions 0.60 x 0.60 m.
- Slabs (ground wire) forming the floor of thickness 0.25 m.
- Slabs (ground equipment) that forms the floor of the second floor thickness 0.40 m thick.
- Slabs forming the cover wrought thickness 0.25 m.
- Beams of 0.60 m thick on the second floor and roof.
- Direct foundations and combined footings of 1.00 m thick, braced in two orthogonal directions with tie beams of section 0.50 x0, 50m.



5.4.3 ACCESS CONTROL BUILDING

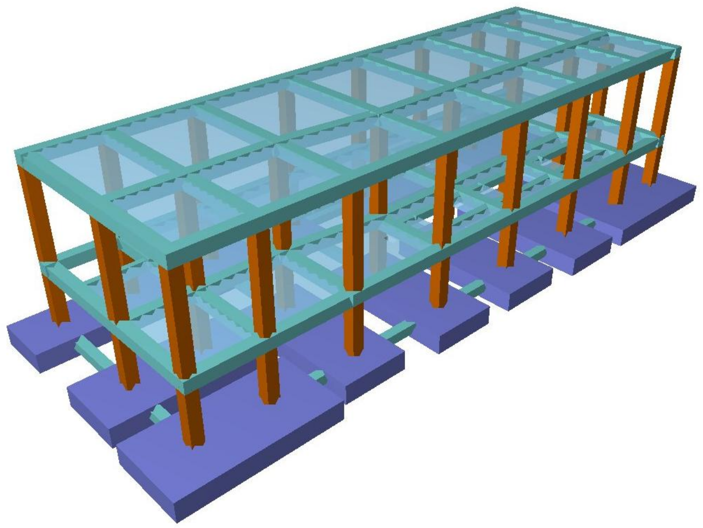
The access control building is exempt from the craft workshops and garages and is located near the entrance to the depot enclosure.

The building is of rectangular dimensions 5.60 x 11.85 m, with the end of the monitoring window cantilever forming a semicircle light.

The structure is reinforced concrete portico with deck slabs at elevation +3.50m.

The dimensions of the main structural elements are:

- 6 square columns of dimensions 0.40 x 0.40 m.
- Slabs forming the floor of the first floor 0.25 m thick.
- Slabs forming the floor of the housing of thickness 0.30 m.
- Beams of 0.60 m thick in the arcades of the cover.
- direct foundation footings of 1.00 m thick, braced in two orthogonal directions with tie beams of section 0,40 x 0,40 m



5.4.4 ACCESS CONTROL STRUCTURES

The access control building is exempt from the craft workshops and garages and is located near the entrance to the reservoir enclosure.

The building of plant rectangular dimensions 5.60 x 11.85 m, with the end of the monitoring window cantilever forming a semicircle light.

The structure is reinforced concrete portico with deck slabs at elevation +3.50 m.

The dimensions of the main structural elements are:

- 6 square columns of dimensions 0.40 x 0.40 m.
- Slabs forming the floor of the first floor 0.25 m thick.
- Slabs forming the floor of the housing of thickness 0.30 m.
- Beams of 0.60 m thick in the arcades of the cover.
- Direct foundation footings of 1.00 m thick, braced in two orthogonal directions with tie beams of section 0,40 x 0,40 m

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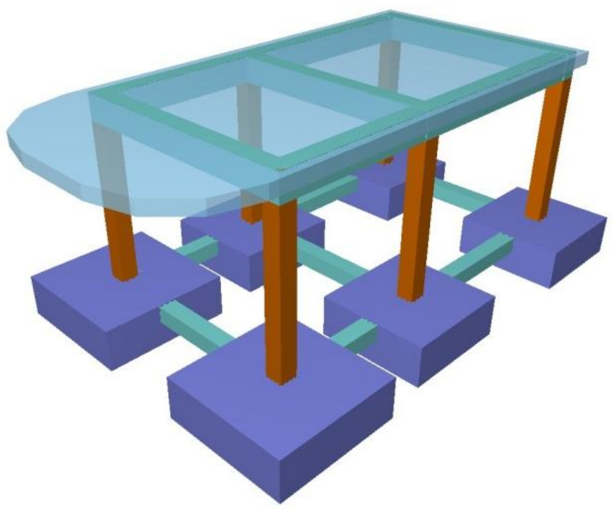
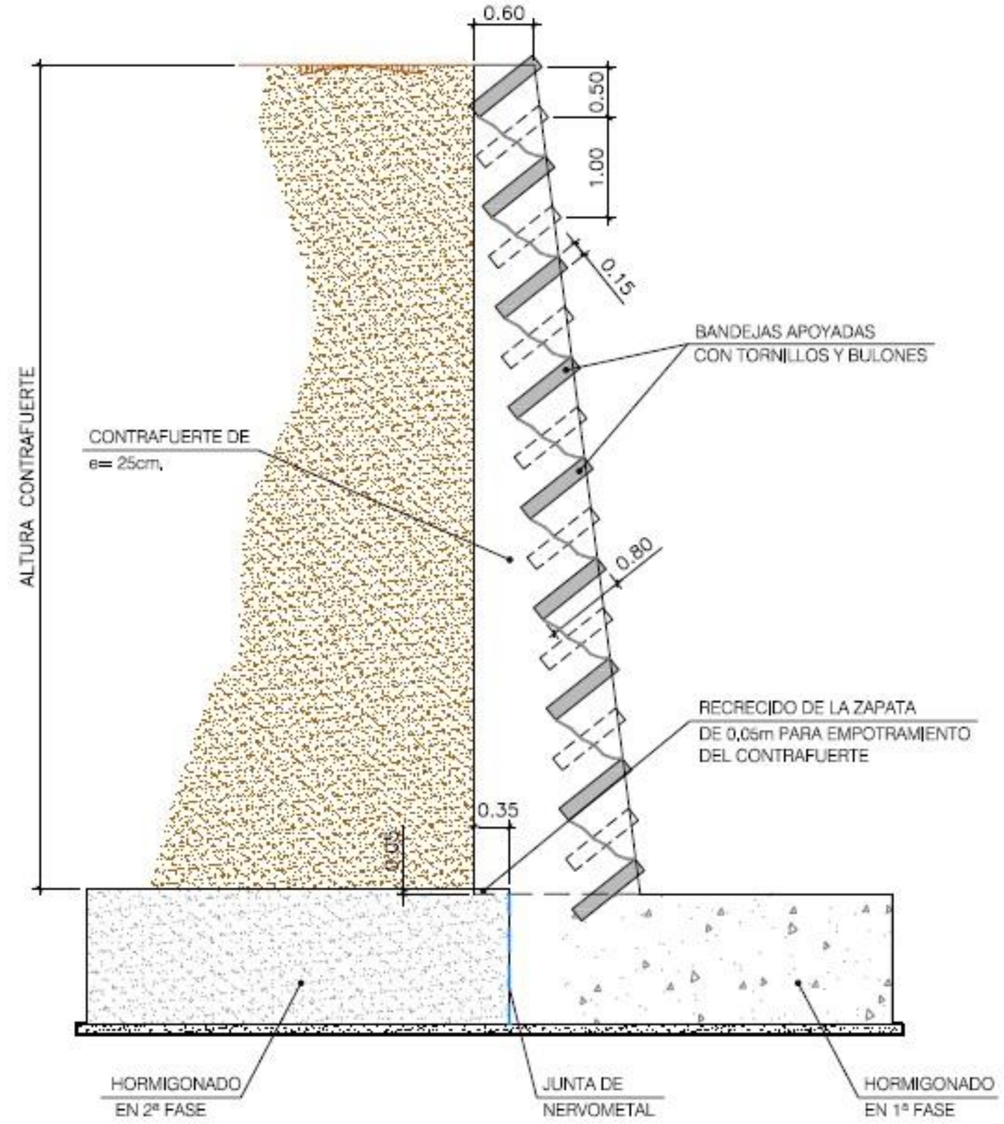


5.4.5 RETAINING WALLS

In the project we have designed two earth embankments, like those seen in the upcoming images.

The one called wall 1 is located next to the village and Inca Trail and is designed to contain the spill lands generated by the extension of the fill material necessary to place the tank excavation to +2924 m elevation. It is a planter type wall of precast concrete 146.80 m long and 7 m above the elevation of the land. The design of the pieces is very simple and consists of buttresses thickness of 0.25 m 2.45 m each connected by rectangular trays of 0.80 x 2.20 m. The buttresses support a reinforced concrete strip footing in situ of 8.00 m wide and 1.30 m thick.



What is known as Wall 2 lies along the path that runs parallel to the Ortega ravine. This is a classic Cantilever concrete wall length 104.25 m.

We have designed three different sections adapted to calculate the height of land to be contained:

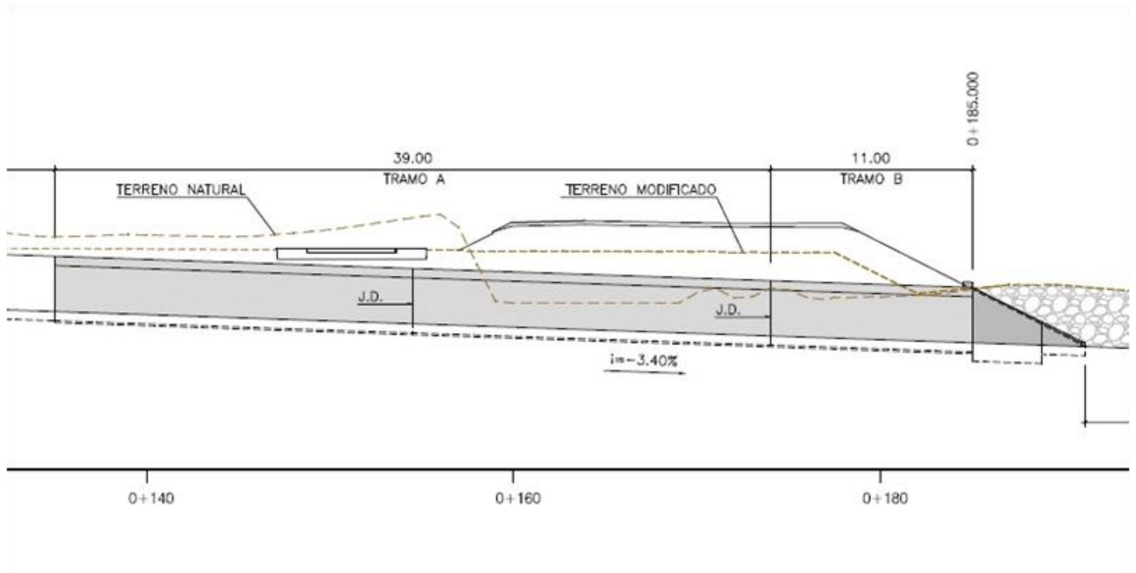
Section	Max. Height of land.	Elevation thickness	Shoe width	Shoe thickness	Length
Type 1	1,20 m	0,30 m	2,05 m	0,50 m	18,90 m
Type 2	2,00 m	0,30 m	3,30 m	0,60 m	80,35 m
Type 3	3,00 m	0,30 m	4,00 m	1,00 m	5,00 m

5.4.6 FRAMEWORK FOR DRAINAGE WORKS OF1

In the project, in order to expand the existing drainage work next to the entrance to the reservoir, a frame or box has been designed of 50 m in length and free interior dimensions 3.00 x2, 50 m.

Two sections types have been calculated based on the thickness of the land over the lintel:

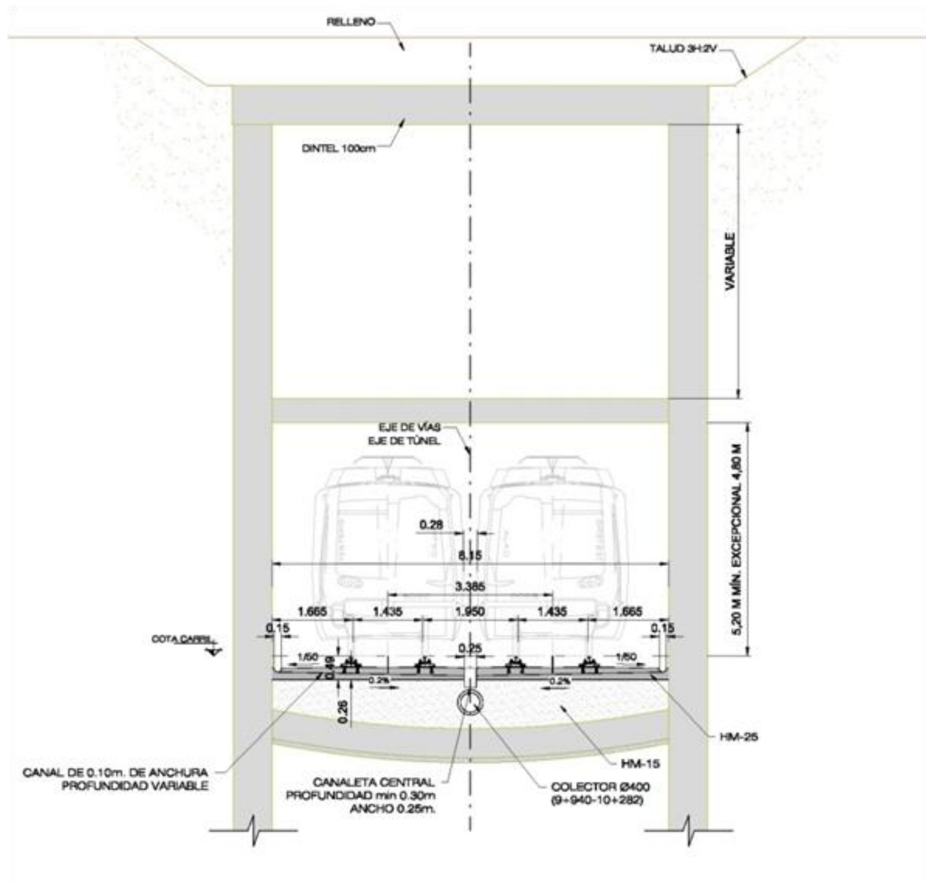
Section	Gable Thickness	Lintel thickness	Shoe width	Shoe thickness	Length
Stretch A	0,30 m	0,50 m	5,70 m	0,50 m	39,00 m
Stretch B	0,35 m	0,50 m	7,80 m	0,60 m	11,00 m



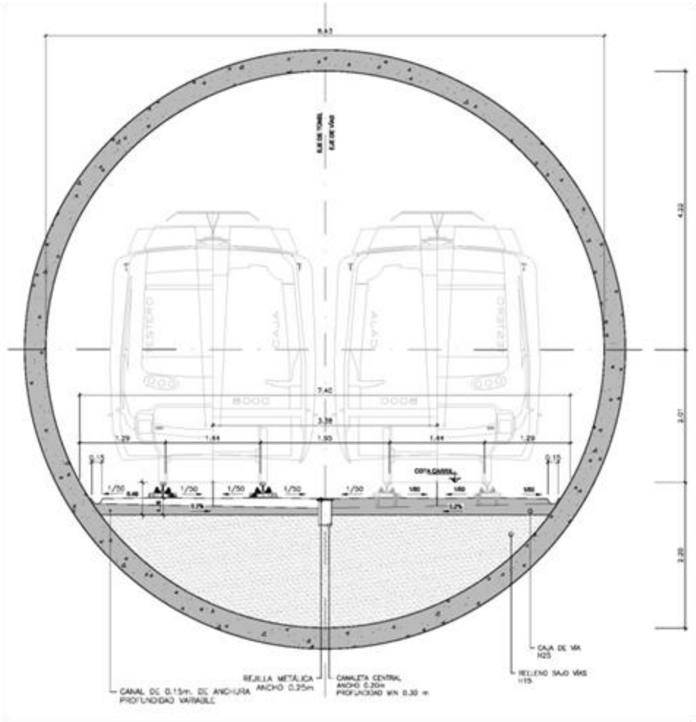
5.4.7 LINE TUNNEL

The defined construction systems for tunnel construction are:

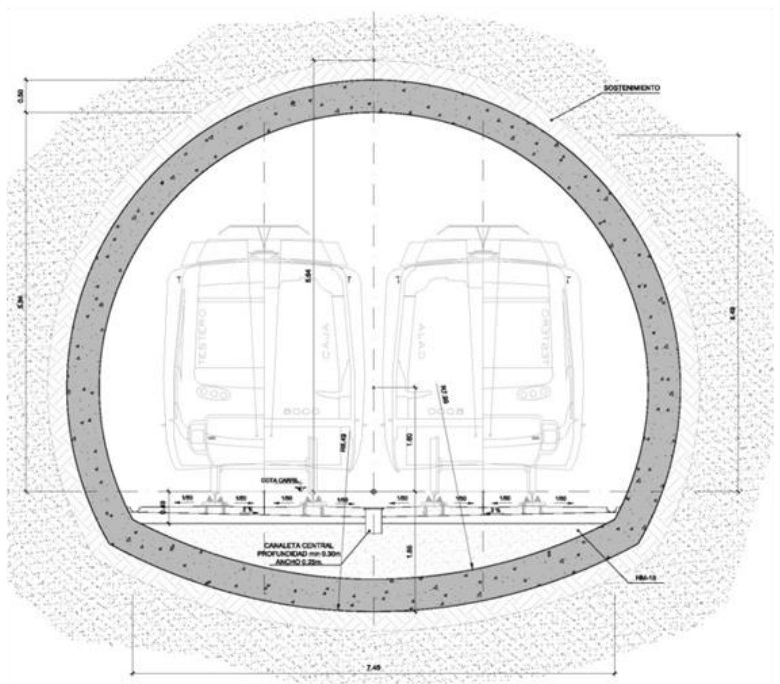
- **Tunnel between screens**. The tunnel sections executed between screens have been designed with a horizontal clearance of 8.15 m and 5.20 m minimum vertical dimension measured from railhead (exceptionally 4,80 m). This system is implemented for part of the access tunnel to the Quitumbe depot and the tunnel line between the Quitumbe station and shaft located in the PK 11 +020 and the tunnel line between Morán Valverde station and PK 12 +400.

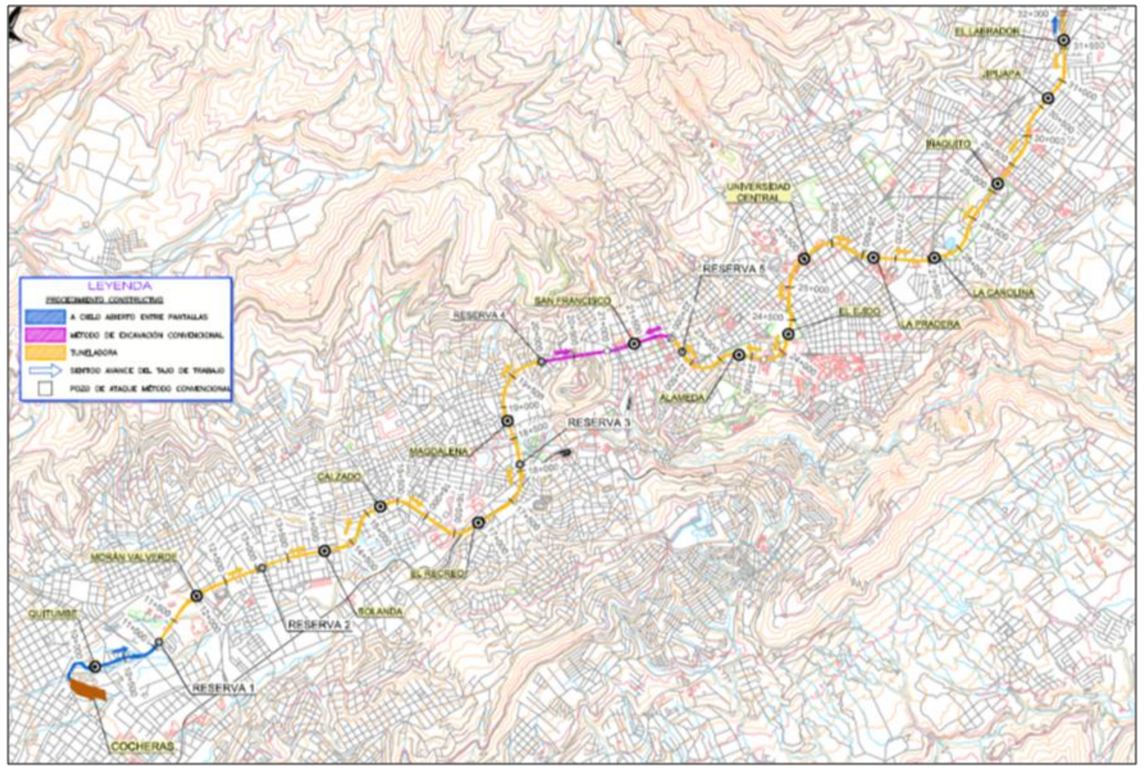


- **EPB type TBM**. The tunnel boring machine has been set out as having a diameter: of 9.37 m, and free section: 8.43 m. It is planned to use three tranches by TBM. Two stretches depart from Solanda station the first to the extraction well located in the PK 11 +020 and the second toward the extraction well at PK 20 +000. The third tranche of TBM goes from El Labrador station to the extraction well located in the PK 22 +300 (located in the Plaza del Teatro between San Francisco and Alameda stations).



- **Tunnel dug by sequential methods**. 5.84 m interior dimension measured from the rail head to the underside of the dome and a width of 8.45 m measured via box level. This construction system is used from the extraction well located in the PK 20 +000 (between the La Magdalena and San Francisco stations) to the extraction well PK 22 +300 (located between San Francisco and Alameda stations).





5.5 ELECTROMECHANICAL FACILITIES

5.5.1 INTRODUCTION

Facilities included in the proposed structures are:

Electrical

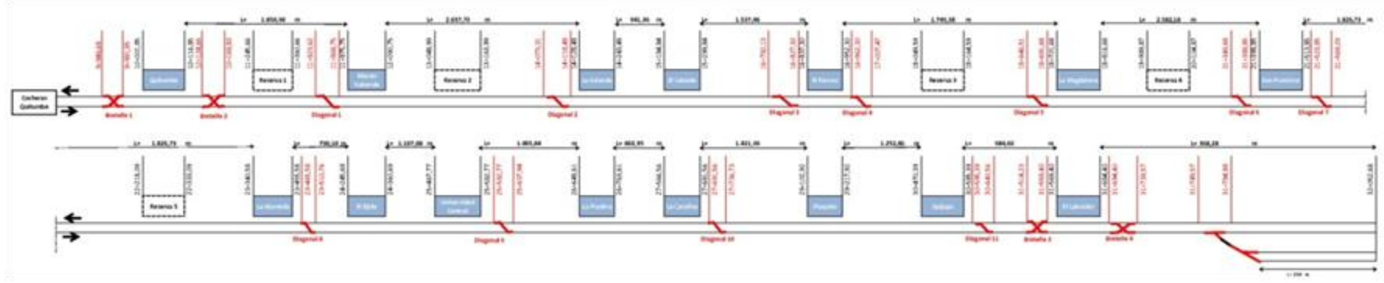
- Lighting: stations, tunnels and wells (emergency exits and pumping wells). Three separate types are defines:
  - Normal lighting.
  - Aid lighting.
  - Emergency lighting.
- Installing force. The power installation consists mainly of a network of power points (sockets, three phase and single phase) distributed in stations, tunnels and wells (emergency exits and pumping wells).
- Installing ground. Installation of ground is done through a single ground (general land mesh) at each station

Mechanical

- Plumbing: supplying drinking water to the station.
- Sanitation stations both sewage and storm water.
- Drainage pumps in the tunnel.
- Fecal Pumps in the stations.
- Ventilation.
- Fire protection network (dry column boxes)
- Ventilation / extraction network.
- Opening device for gate to the outside.

5.5.2 RAIL TRACK EQUIPMENT

In total four bretelles (double diagonal) are projected, along with 11 diagonal and 2 deviations according to the following scheme



5.6 INSTALLATION PROJECTS

In the definition of the railway facilities necessary for the Line 1 of the Quito de Metro technologically advanced systems are proposed, with criteria of minimizing energy consumption and philosophies of availability, reliability and security in line with a metropolitan transportation system.

When opting for various technology solutions, the peculiar location of the city of Quito and the risk of existing seismic activity has been taken into account; applying detection solutions and active or passive actions aimed at the protection of users and facilities.

The proposed route for the First Line of the Metro de Quito is developed entirely in underground, so that damages or permanent occupation by facilities have minimal environmental effect. In the case of lift installations, it is necessary to have an outlet on the surface for the equipment minimizing the gap between the level of the street and lobby. To minimize the visual impact of these items, they will be made of glass. In the case of ventilation suction is completed with finishes flush with the ground and disposing silencing elements in the wells to minimize noise and vibration.

5.7 DESCRIPTION OF THE DIFFERENT SYSTEMS COMPRISING THE FACILITIES PROJECTS:

5.7.1 RAILWAY SIGNALING

a) Introduction

This project has as its objective the supply, installation and subsequent implementation of the railway signaling system, Automatic Train Control (ATC) and Automatic Train Supervision (ATS) for the First Line of the Metro de Quito, all this in terms of fixed facilities and for onboard equipment.

Subsystems are defined as being in charge of safety of routes, locating vehicles throughout the route and ensuring the safety of circulation, and all prepared for monitoring and management from the Central Control Post (PCC).

With the OBJECTIVE of increasing the flexibility of operation, under normal or malfunction conditions in the fixed installations and / or the rolling stock, the line will be equipped with satellite devices to track change maneuvers (diagonal) distributed along of the line or equipment to maneuver traffic in all directions at terminals (bretelles).

Considering the characteristics of future growth, it is provided that the line be furnished with a semi-automatic railway operation system, GOA type 2 (according to EN 62290-1) incorporating an Automatic Train Operation (ATO) mode that performs the functions of driving and stopping at the station from a exiting order set by the driver.

b) General Characteristics of Project

The system OBJECTIVE of the project is to be open to various technologies that meet the functional requirements, that they are better suited to the characteristics of the line infrastructure, operating range, composition of the trains, environmental conditions, speed, regulated circulations and operation of the line. The following three subsystems will be included:

- Backup signaling subsystem online and workshops. Comprised of interlocks and track equipment, it will be responsible for ensuring safety in the performance, control and monitoring of routes and locate vehicles both online and in the depot. A total of five main interlocks have been defined for the control of facilities (four for the line and one to control the depot). Each line interlock will cover an average length of 5.5 km and 5 stations, taking into account the expected future increase in the number of stations. The main Interlocks located on the line in complement with necessary auxiliary interlocks, based on the controllers of Objectives to suit the characteristics of the proposed system (signaling equipment will be installed in rooms and tunnel walls located on channel 1).
- A.T.C. Subsystem (Automatic Train Control). This subsystem will be installed on the assembly line, and will be based on equipment:
    - A.T.P. via-train with data streaming (unidirectional or bidirectional depending on the selected technology) which will be responsible for ensuring the safety of the circulation, preventing incidents occurring due to scope or speeding through permanent control of train speed.
    - A.T.O. via-train, enabling Automatic Train Operation in semiautomatic mode.

    - The A.T.C. equipment also to be installed in the depot (test track and four interior tracks) to facilitate maintenance and testing of the trains, both statically and dynamically.
- A.T.S. Subsystem (Automatic Train Supervision). Subsystem is responsible for monitoring and managing from the PCC (Central Control Post) the overall operation of the signaling system and ATC will consist of:
    - C.T.C. Module (Centralized Traffic Control) to manage the command, control and system monitoring and tracking of trains along the line, alarm monitoring, event playback, etc..
    - Control module, through which the backup-signaling and in combination with the gears in inter-stations transmitted via ATO, allows the management of the operation, regulating the operation intervals and optimizing energy consumption.

The project will be developed based on a proven system and service in other railways "in heavy metro lines", it is reliable, incorporating support tools for proper maintenance, it is flexible and easily adaptable to future extensions of "trains and stations" as well as incorporating new features.

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5.7.2 ELECTRICAL SUBSTATIONS

The OBJECTIVE of this project is the supply, installation and subsequent implementation of systems of traction power substations for First Line of the Metro de Quito bound for the entire path of the line and the Quitumbe depot.

a) General Characteristics of Project

Traction power substations facilities are responsible for meeting the traction needs of the different electric sectors of the catenary on the line and depot. The power supply offered will have the adequate reliability and security conditions that are necessary in a metropolitan transportation service.

b) Scope

The project scope is the definition, supply and installation of all elements of the traction power substations system for First Line of the Metro de Quito and its integration into operating systems.

Line 1 of the Metro de Quito will have a total length of 22 km, between the stations of Quitumbe and El Labrador. The definition and evaluation of the works to be performed for all facilities was based on the following parameters:

- Line route.
- Signaling System.
- Rolling Stock Features.
- Operating conditions laid down for the initial and final stages.
- Traction supply voltage for the line to 1500 Vdc.
- Dimensioning S-1, i.e. in the case of a traction substation being out of service, the side substations must be electrically connected so that the electrical portion affected will still be serving in normal operation, maintaining the trains' interval.

    - Dimensioning N-1, i.e., ensuring continuity of supply with the same requirements, in case of failure of a utility company substation, so the affected electrical segment continues to provide service in normal operation, maintaining the trains' interval.
    - Substation configured in parallel.
    - Limitation of voltage drops in the line according to UNE-EN 50163 for catenary voltage and EN 50122 for the voltage rail - land.
    - Results of the simulation study of various scenarios, initial and final, normal and S-1, proposed to deal with the distribution and location of electrical substations. In response to the above design conditions, the following criteria for sizing of facilities has been defined:
    - Number and location of substations along the line.
    - Power installed in substations.
    - Network of HV cables to interconnect substations.
    - Power Supply from the electricity supply company, to meet expected consumption.

According to the simulation studies carried out, the solution for the traction supply for the line and depot for different operating scenarios is as follows:

- Initial scenario expected operating for 16 MRSSRM trains:
    - Traction supply line 1: to 1500 Vcc and in parallel, from 11substations located at:
        1. Quitumbe Depot
        2. Station 2 (Morán Valverde)
        3. Station 3 (Solanda)
        4. Station 5 (El Recreo)
        5. Station 6 (La Magdalena)

6. Station 7 (San Francisco)
7. Station 8 (La Alameda)
8. Station 10 (Universidad Central)
9. Station 12 (La Carolina)
10. Station 14 (Jipijapa)
11. Station 15 (El Labrador)

– Traction supply from Quitumbe depot to 1500 Vcc, from the substation located in the depot.

- Final scenario of the planned exploitation, for 27 MRSSRM trains:

– Traction supply line 1: 1500 to Vcc and in parallel, from two additional substations located in:

12. Station 12 (El Calzado)
13. Station 13 (La Pradera)

The scope of this project includes activities related to the supply, installation and commissioning of the facilities of traction power substations of 1500 Vdc, corresponding to the initial stage of expected operation of line 1.

Consequently, the actions to be taken are:

- Installing equipment for 11 Electrical Substations required for initial stage of operation, to power Line 1 and the depot, with a voltage of 1500 VDC traction.
- Installing a Network of HV cables at 22.8 KV for interconnection between Electrical Substations.
- Installation Metering Management System, necessary to implement the measure traction energy and ancillary services on line 1.
- Installing Energy Control Point located in the Central Control Post, located in the Quitumbe depot to allow monitoring and remote control of power facilities (traction power substations, catenary connectors and transformers) all activities of supply, installation, testing and commissioning of all the elements and facilities are considered to be included in this project, as well as all expenses related to inspections, authorizations and permits that are mandatory, enforceable under applicable law in Ecuador, as well as all activities of any kind, needed for system implementation and delivery in satisfactory operating condition.

5.7.3 ENERGY DISTRIBUTION

The goal of this Project is to carry out as many actions as necessary for the execution of energy distribution facilities in the stations, tunnels and depots.

a) General features of the Project

Energy distribution facilities are responsible for meeting the need for electric feeds to the many services of the stations, tunnels and depot. The supply of electric energy offered will have the pertinent reliability conditions and guarantee necessary in a Metropolitan transport service.

b) Scope

The scope encompasses the provision, installation and commissioning of the energy distribution facilities that will feed 22-km of line's route, fifteen (15) stations and the depot:

Quitumbe depot
Quitumbe
Morán Valverde
Solanda
El Calzado
El Recreo
La Magdalena
San Francisco
La Alameda
El Ejido
Universidad Central
La Pradera
La Carolina

Iñaquito

Jipijapa

El Labrador

In order to link lighting systems and electric outlets to the specific architectural features of the sites, the lighting installations and general electric outlets – both in stations and tunnels – are covered in the pertinent Civil Works Construction Design Projects and, thus, are out of the scope of this project.

The design is based on energy distribution in high voltage of 22,8kV distributed in line, with six electricity connection points of the primary distribution network of traction substations that grants ensures service and maintenance ease. The system is conceived in n-1, i.e. its functioning is not affected in the event of a possible lack of supply of one of the supply points of the primary network.

The energy distribution facilities are in charge of meeting the Low voltage electric feed needs of the different elements that constitute the fixed facilities integrated into the stations, tunnels and depot of the Metropolitan network. For this, said facilities are broken into segments in two greater areas, those for supply and transformation into High voltage and its subsequent distribution and reception of Low voltage electric supply by the different receptors.

High voltage

The high voltage distribution line departs from the Transformation Center that receives the feed from the primary network, forming a line that goes through all Transformation Centers where it goes in and out of each one of them.

The main elements are:

Normal High voltage supply distribution network. Feed line in high voltage to 22.8 kV will be comprised by a tri-polar Aluminum cable 3 x 3/0 AWG 15/25 kV that runs through all the transformation centers of the stations, tunnels and deposit. The union section between the traction sub-stations and the transformation centers will be done, in general, with cable of similar characteristics but of a superior section of 3 x 250 MCM 15/25 kV.

Transformation Centers. Facilities that change electric energy from the high voltage network from 22.8 kV into low voltage into use power (220/127 V) to feed the various services and/or facilities that depend from each center.

The high voltage distribution system is commanded from the Central Control Post, which allows permanent supervision of the system and, if necessary, the immediate reorganization of the boundaries and its load balance.

Low voltage

Low voltage feed (I+N/127V y III/220 V) obtained from the transformers is distributed to the fixed facilities of the stations, tunnels and depot through the Low voltage (CGBT) General Chart.

The main elements that comprise low voltage facilities are:

Low voltage General Charts. The setup of Low voltage (CGBT) General Charts is planned with a low voltage assigned of (I+N/127 y III/220 V). This setup incorporates the feeding circuits of the different services of the installation from which they are dependent.

Strength circuits. To feed the different electric sub-charts that will feed machines (escalators, elevators, fans, etc.) and technical rooms (communications, interlock, etc.).

5.7.4 ELECTRIFICATION

The purpose of this Project is to supply, installation and subsequent implantation of the Electrification System for the First Line of the Metro de Quito intended for the entire route of the Line and the Quitumbe depot.

a) General features of the Project

The Electrification system includes the following sub-systems/elements:

The air contact line: is the set of elements with which the pantograph interacts to capture the required traction current. It includes contact conductors, air conductors to increase the section, the electric connections between them and the necessary structures for its mechanical support.

Feeding system:

Feeding cable: Configure both the positive and the negative transport line and its role is for traction energy – which is amended in the sub-stations – to be available in the air line and go back from the lane to the rectifier

Bridging connectors: are equipment that allow modifying the length of the electric sectors of the catenary; this allows configuring the feed of sub-stations in the most adequate manner at each time.

An Electrification System is established for the Quitumbe Depot with tramway thread in the rail yard and inside the cars. For the test track the plan is to setup a conventional compensated catenary.

b) Scope

The scope of the Project is the definition, supply and installation of all the elements that comprise the Electrification System for the First Line of the Metro de Quito and their integration into the exploitation systems.

A solution for Line 1 is defined based in the rigid catenary PAC MM-04. This circumstance does not invalidate that another rigid catenary solution might be installed so it does not entail a reduction in the capitation quality with the pantograph and whose conductor section is the same or higher than the cited profile.

For the Quitumbe Depot the solution defined is based on the tramway thread. In this solution we use elements gathered from international standards, commercial elements and tailored solutions easy to manufacture.

The scope of this Project includes the following actions:

First Line of the Metro de Quito

Supply, installation and operation of contact air line for 1500 Vcc rigid catenary type, profile PAC MM-04 for 22 Km of double line and 15 stations, including support structures in the different tunnel sections, stations and viaduct, suspension isolators, aluminum profile, contact thread and bridge feeders between sections.

Supply, installation and commissioning of 22 load opening connectors the sectorization of the First Line of the Metro de Quito.

Supply, installation and commissioning of positive and negative feeder cables to transport energy from 11 sub-stations to the air line.

Quitumbe Depot

Supply, installation and commissioning of contact air line for 1500 Vcc tramway thread type at the link of the depot with the line, in the shunting rail yard and in the inside tracks that need to be electrified.

Supply, installation and commissioning of the contact air line for 1500 Vcc compensated conventional catenary type in the test track.

Supply, installation and commissioning of 4 load opening connectors to feed each electric package.

Supply, installation and commissioning of 7 negative connectors and their control and of the associated pantograph maintenance runway

Supply, installation and commissioning of positive and negative feeder cables.

All supply, setup, testing and element and facility commissioning activities are considered to be included in the Project, as well as all the expenses inherent to inspections, authorizations and mandatory permits under current Ecuadorian law, as well as all those activities of any kind necessary for the implantation of the System to be contracted and its delivery in satisfactory working conditions.

5.7.5 CONTROL AND TRANSPORT TICKET SALES

a) Introduction

The stations' architectural design follows a format in which one or two accesses converge in a hallway from where the different travelers' flows located in the station are distributed. In said hallway are located the different equipment typical of a Metro exploitation, including those intended for access control and equipment to sell transport tickets, both manned (commonly known as "ticket offices"), as well as automated sale equipment (or "METTAs"). After the hallway are the escalators and elevators necessary to get from the hallway to the platforms, which are always located laterally.

In the case of the stations San Francisco, La Alameda and El Ejido, these will have a second access hallway, to enable alternate ways towards the platform distribution network.

b) General features of the Project

The purpose of this Project is the supply, setup and subsequent implantation of the control systems and sale of tickets for the First Line of the Metro de Quito directed to the newly constructed hallways that belong to the stations of that line.

This Project defines the implantation of a control system and ticket sales with 100% contact-less technology, where simple tickets are sold in token-like (long-lasting, resistant plastic elements with microchip) supporting devices and multi-travel tickets are sold in both cases in a format of plastic cards with an interface pursuant to standard ISO 14443 types A & B.

Having this type of structure as basis, the supply for this Project encompasses toll equipment to control station access through a mechanic blockage system of 120º rotation tripods, commonly known as *tourniquets*.

For accessibility of users with reduced mobility, the ticket control system establishes the supply of swing doors of standardized width that have contact-less processors to enable controlled access to the facilities by this type of users.

While the step blockage system defined along this Project is the tourniquet type, other technical solutions proposed by the potential bidders will not be dismissed, if these are based on swing doors or fan-like types, which allow open and obstacle-free access to users when they are contracted into the device. In this case, the elements intended to access for users with reduced mobility will be integrated into the device through equipment of similar features of a standardized special width.

The established ticket control system is a closed system, so all equipment intended to ticket control will have a ticket processor both at the entrance and at the exit of the pay zone.

The sale of transport tickets is characterized for being a procedure in which most of the weight will be supported by a system of terminals to recharge cards and sell tokens; located in ticket offices these will allow charging and recharging cards, balance consultations, etc.

This assisted sales system will be supported by automatic sales equipment in those stations where the anticipated travelers' demand suggests using them.

To execute the processes to personalize season tickets the system will have – in emblematic sites throughout the network – assisted sales offices that will have specific features and processes to print and characterize supports – always with contact-less interfaces.

Likewise, this Project specifies supplying balance consultation terminals, elements located in stations' hallways; available to users to read tickets, showing on screen the balance and the validity of the tickets saved in the card.

Within the processes intended for the implementation of the First Line of the Metro de Quito, studies have been conducted to forecast the present and future flow of passengers in the corridor that links the neighborhoods Quitumbe and El Labrador, the route of the new line. The study conducted in the document **"Modelo de movilidad y demanda en DMQ (Demanda Metro de Quito)" (***Mobility Model and Demand in the Metropolitan District of Quito***)** provides the estimated daily load per sections and the anticipated movement in stations under two potential reorganization scenarios of the city's transportation system.

The calculation for the need of circulation and sales equipment was made based on the calculation defined in the aforementioned document as "Phase B", since this is the scenario that estimates the greater demand of travelers using the First Line of the Metro de Quito.

The calculation combines both the flow expectation by stations, as well as the expected number of passengers per section, and more specifically, the calculation of the daily flow of passengers that enter and exit each station.

a) Scope

The scope of the Project is the definition, supply and installation of equipment to control traveler tolls and ticket machines necessary for the implementation of control systems and transport ticket sales for the First Line of the Metro de Quito.

This project defines a solution based on Tokens for the occasional one-way trip and a long-lasting plastic card, both with contact-less interface pursuant to standard ISO 14443, types A and B.

The scope of equipment for this basic Project encompasses the following supply:

95 tourniquet type Access equipment for two-way toll control, with contact-less ticket processors ISO 14443, types A and B for the entrance and exit flow of passengers and **18 extreme control devices (MCE)** for battery ending

18 doors adapted for PMR user pass through, with two-way user control with these features with contact-less ticket processors ISO 14443, types A and B for the entrance and exit flow of passengers.

18 Consultation Terminals to inquire about available balance and validity dates of transport tickets.

25 sales offices that will be set up in ticket offices or Local Control Posts ("**PCL**" for its initials in Spanish) – these will enable sales of tokens and recharge of contact-less long-lasting cards ISO 14443 type A and B.

8 automated sales equipment (METTA) to be installed in the hallways of those stations with greater traveler demand and they will allow the sale and automatic recharge of tokens and contact-less long-lasting cards ISO 14443 type A and B; these will accept the following payment options: coins, bills and electronic payment.

3 posts to personalize season tickets to allow personalization of contact-less long-lasting cards ISO 14443 type A and B in strategic network sites.

18 computers to telemanage Toll and Sales Systems ("T.P.V." for its initials in Spanish**)** for the integration and management of equipment intended for ticket sales control at the station level.

3 Remote Station Servers to capture data received from all stations and its integration into the system to manage and control toll and ticket sale equipment at the level of the Centralized Control Post, including software and hardware development in addition to its implantation at both levels.

In general, equipment should meet mechanical and electric strength features, a low noise level, be of modular architecture and be easy to operate, easy to maintain and to expand and modify the software. The data should be kept in the event of any absence or occasional variation of voltage in the feeding network, in order to ensure the finalization of the operation underway. Communications from the equipment to the TPV computer at the station should be done through the local network – ETHERNET – in order to minimize error probabilities in digital communication due to external noises.

5.7.6 ESCALATORS AND ELEVATORS

The Project's objective is to supply, setup and subsequent implantation of ELEVATORS AND ESCALATORS in the stations of the First Line of the Metro de Quito and an elevator in the building of the Depot's offices.

a) General features of the Project

The anticipated installations are as follows:

Installation of 1,000 Kg/13 people or 630 Kg/8 people (class I) elevators, based on the estimated use of the station, that link the access paths at the street level with the hallways and/or platforms of the stations that are part of the scope with the following implantation criterion:

- **1,000 Kg elevators in the stations Quitumbe, Recreo, Magdalena, San Francisco, El Ejido and El Labrador.**

- **630 Kg elevators in the stations Morán Valverde, Solanda, El Calzado, La Alameda, Universidad Central, La Pradera, La Carolina, Iñaquito and Jipijapa and in the Depot office building.**

Auxiliary Works to be done in elevator pits and holes.

Installation of escalators that link Access paths, at street level with hallways and/or platforms of the stations that are part of the scope of the Project and that are defined under the item "General Basic Data". **The design criterion will be one escalator per level (going upwards)**; while in the stations Universidad Central and Jipijapa one level per platform will be entirely for pedestrians, from the intermediate platform levels. In regards to the aforementioned criterion, the following stations **will be the exception**:

Quitumbe will have downward escalators from the hallway to the platforms.

El Recreo will have downward escalators from the hallway to the platforms.

La Magdalena will have downward escalators from the intermediate levels to the hallway and from there to the platforms.

San Francisco all levels will have a second downward escalator except from the level between floors to the platforms.

El Labrador will have downward escalators from the two intermediate levels to the hallway and from there to the platforms.

Auxiliary Works to be done in the rooms where control equipment will be located and in escalators' pits.

Installation of pipes to detect and extinguish fires along the inside of the escalators.

Electric supply connection points.

b) Scope

The following shall be considered included in this project as works to be completed: the supply, setup and subsequent installation of elevators and escalators in the pertinent holes or pits, and equipment in engine rooms, where they exist, as well as testing, bearings, approvals and completion of various elevators and escalators, with electrical, mechanical and decoration installation.

Also included in this project are the other works necessary for the completion and decoration of elevators and escalators, related rooms and associated auctions and joints between them and the walls of the hallways, galleries, canyons or platforms, affected by the works, as well as all ancillary works necessary for the implementation of the above, such as pipes for the passage of cables or pulleys, guides and hook fixings, chases, replacement of walls and flooring to their previous condition, etc.

It also includes the supply and setup of electrical conductors from the control panel of the machines (technical room) to the tractors groups (pits).

Finally the project also includes all the work required to run the tests and test-run before commissioning, corrective maintenance and conservation in good condition of the facility, including labor and necessary tests during the implementation period and necessary authorizations for use and operation.

This project does not include the supply and setup of the electrical protection module of elevator and escalator lines, of electric power drivers from the low voltage box at the transformation room of the station to the control and maneuvering panel (technical room), the automatic switching of the emergency electricity supply connection point, located at the entrance of the station, to the low voltage box of the transformation room.

Not included in this project are the necessary equipment for the transmission of signals to the Stations' Local Control Posts (PCL) and Centralized Control Post (PCC), which is the subject of other specific projects. However, it does include the supply and installation of pipelines, both for detection and for firefighting, that run through the escalators' accommodation pits for their connection to the fire protection system of the station, which will be the subject of a specific project.

5.7.7 FIRE PROTECTION

The purpose of this Project is supply, setup and subsequent installation of Fire Protection Systems in the First Line of the Metro de Quito.

a) General features of the Project

The objectives that cover Fire Protection facilities are as follows:

Detect fires in an incipient phase in order to be able to face the fire before it reaches great magnitude and it is easy to control. Likewise, have the basic elements to transmit alarms and to give notice of these.

Extinguish fires based on their magnitude and type.

Create basic support facilities for firefighter intervention.

Place signs in exits and evacuation routes, as well as means to extinguish the fire. Fire safety goals. To this end, the following facilities will be required:

Stations:

- Automated fire detection systems in specific areas and those particularly at risk.
- Setup a manual pushbutton network and fire alarms.
- Setup manual means to extinguish fire (fire extinguishers).
- Special installations for automated fire extinguishing through water mist and detection through aspiration in the holes under the escalators.
- Dry column installation for exclusive firefighters' use (in station pinions).
- Installation of signs for evacuation routes through posters and guiding lines, as well as means to extinguish the fire and alarms.

Tunnels:

- Dry column installation for exclusive firefighters' use (in ventilation pits and emergency exits).
- Installation of exit route signage through posters.

Quitumbe Depot, offices and Centralized Control Post:

- Automated fire detection systems in specific areas and those particularly at risk.
- Setup a manual pushbutton network and fire alarms.
- Setup manual means to extinguish fire (fire extinguishers and fire extinguishing cars).
- Installation of pumping systems and control panels in pump room, and all its wiring and accessories. This includes the construction of water supply storage tanks to act as a reserve specific for extinction systems
- Installation of external hydrants, internal hydrants and equipped water connection points.
- Installation of automatic sprinkler network in specific areas.
- Installation of extinguishing system based on mist water in the communications room/CPD through autonomous group.
- Installation of evacuation route signs and means to extinguish fire through posters.

b) Scope

This Project defines the Works related to the installation and commissioning of Fire Protection Systems to be implemented in the line under consideration.

The installation of Fire Protection will be implemented in all the stations (15) and the pertinent inter-station tunnels. On the other hand, the Quitumbe Depot will have the PCI system that includes the maintenance wing, workshops, stores, offices and Centralized Control Post (PCC).

The most significant actions to be completed are:

In Station

Detection systems

- Installation of analogue Station Central PCI and associated equipment (detectors, push-buttons, etc...).
- Installation of communications loop and control/activation modules.
- Installation of aspiration detection system in escalators.
- Configuration and integration of all elements at the PCI Station Central (CRA).

Fire extinguishing systems

- Installation of autonomous pressurization group and water mist pumping, selector valves, pipes and accessory elements for escalators.
- Installation of dry column connects through conductors - pipes the feeds from the street with water supply connection points in pinions in the platforms.
- Installation of fire extinguishers in areas where passengers stand and station rooms.

Photoluminiscent signage

- Beacons and signage of platform edges.
- Beacons and signage in canyons through long plates and exit signs.
- Beacons in stairways.
- Beacons of station exits.
- Beacons of obstacles and means of extinction

In tunnel

Photoluminiscent signage

- Signage of evacuation routes and emergency exits at the inter-station through posters.

Dry column

- Installation of the dry column, connecting through conduction - pipes from street outlets located near the tunnel, in stainless steel enclosures for use by firefighters.

In Quitumbe Depot, offices and Centralized Control Post (PCC)

Detection systems

- Installation of analogue detection central (CRA) and associated equipment (detectors, push-buttons, sirens, etc...).
- Installation of communications loop and control/activation modules.
- Configuration and integration of all elements in the analogue detection central (CRA).
- Supervision post and PCI control.

Fire extinguishing systems

- Installation of pumping systems and control panels in pump room, and all cabling and related accessories.
- Installation of water storage tanks (two semi-deposits).
- Installation of external hydrants.
- Installation of internal hydrants.
- Installation of equipped fire outlets (BIEs).
- Installation of automated sprinkler network in specific areas.
- Installation of fire extinguishing system based on mist water in communications room/CPD through autonomous group.
- Installation of manual fire extinguishers and fire extinguishing cars.

Photoluminiscent signage

- Signage of evacuation routes through photoluminiscent signs.
- Signage of detectors and extinguishers.

5.7.8 VENTILATION

a) Introduction

This Project's objectives include the supply, setup and subsequent installation of the VENTILATION systems for the First Line of the Metro de Quito. The following installations are within this project's scope:

Tunnel and station ventilation.

Pressurization of the tunnels' emergency escapes.

Air conditioning of the central hallway of the San Francisco Station.

b) General features of the Project

Under the generic concept of "ventilation," in the stations and tunnels of the METRO DE QUITO, the objectives that that should be fulfilled in conditions of normal use are essentially the following:

Renovation of the system's interior environment, extracting the foul air (carbon monoxide, smells, etc.) and introducing fresh air from the exterior; provided that the air that is captured (generally at road level) complies with minimum purification requirements.

Control of the system's thermal load produced by trains, people and other heat-generating elements (lighting, Transformation Centers, motors, air-to-air climatization equipment, etc.).

Control of the air currents and pressure variations produced by the piston effect and caused by the train's passing.

Additionally, there are other "ventilation system" objectives that under certain conditions may apply to emergency situations such as tunnel and station accessibility through extraction and compensation-emission pits as well as the extraction of smoke (originating from a fire) or of dangerous atmospheres (flammable gas or toxic fume leaks). While the installations have been designed for conditions of normal use, not specifically configured for emergency situations, the tunnel ventilators will be designed to handle tunnel speeds of 1.3 meters a second, a speed considered to be sufficient to take away smoke caused by a fire at its initial stage.

In order to install a ventilation system, taking into account that there is a basic infrastructure that will be considered in the Civil Works Project, it is essential to perform the following:

Auxiliary civil work

Waterproofing and drainage of the galleries.

Frame formation.

Support structures

Construction of brickwork and reinforcements.

Maintenance equipment. Protection enclosures.

Mechanical installations.

Supply and setup of ventilators and diffusers.

Supply and setup of tilts (one-way motorized dampers).

Acoustic treatments of transition depots.

Supply and setup of dissipative silencers.

Construction of directional turbine blades.

Electric and control installations.

Supply and setup of the control and protection panel.

Grounding installations.

Wiring system and cabling.

Lighting installation.

Supply and setup of probes.

c) Scope

The scope of this project is the definition, supply and installation, testing and commissioning of the equipment necessary to install the following in the First Line of the Metro de Quito:

Tunnel and station ventilation.

Pressurization of the tunnels' emergency escapes.

Air conditioning of the central hallway of the San Francisco Station.

These installations are to be integrated into the railway's infrastructure projected for the Civil Work Project and, similarly, for the management and use of the systems by the Metro de Quito. The project should consider all of the specification points in addition to any contributing supplementary information; within which proposed solutions should be considered.

The ventilation system is located throughout two clearly different areas: the stations and the tunnels.

In order to develop the ventilation installations it is necessary to have the proper infrastructure. This infrastructure consists of the construction of pits that allow air to flow in and out of the system according to the design needs and creation of annexing rooms or galleries for the storage of mechanical, electrical and control equipment. For the proper functioning of the system, the following pits should be included:

Station infrastructure

Emission pits (I): these pits are located along the stations. Depending on the station's system of construction, they may be separate from the compensation pits or incorporated into them. In any case, they will be connected to the exterior with a room where mechanical equipment will be located.

Compensation pits (C): there are generally two per station, preferably located at the station entrance and exit gates.

Infrastructure of closed tunnels between stations (without outside access). We will refer to tunnels without direct outside contact and that connect two stations as "closed tunnels." Within this typology we have the following installation:

- ***Extraction pits in two-way simple tunnels (E):*** generally located near the halfway point of the different stretches of closed tunnels between stations. They will have a gallery where mechanical equipment will be stored.

Infrastructure of partially and open tunnels (with outside access). We will refer to tunnels that connect two stations with outside access by way of one or two portals as "partially open" and "open," respectively. When necessary, ventilation in the tunnels will occur through stream ventilation (JETs) and on an infrastructural level, it will only be necessary to widen the tunnel which will allow for the installation of the ventilators as displayed in the corresponding control and protection chart. Only in the case of open tunnels will it not be necessary to create compensation pits.

5.7.9 TELECOMMUNICATIONS

a) Introduction

The purpose of this Project is to supply, set up and subsequent implantation of the telecommunication systems for the la First Line of the Metro de Quito, both within the scope of stations and tunnels, as well as the necessary equipment in the Depot and in the Central Control Post (PCC) in charge of providing support for voice and data transmission of the different sub-systems. Fiber optic based, it includes several sub-systems (data, radiotelephones, telephones, teleindicators) to cover several operational needs.

The Telecommunications network provides the basic infrastructure necessary for the inter-connection of the different elements and, evidently, its reliability has a direct implication in the availability of the other systems; thus, the basic design criterion for the telecommunications network must be reliability and availability guarantee.

b) General features of the Project

The Communications Network has been structured taking into account the features of the services to be provided and the anticipated data flow.

From the perspective of the nature of the data to be transmitted, in the case of the Metro de Quito there would be services based on IP communications. Most services provided will fit within this category:

- Closed Circuit TV (CCTV)
- Telephony
- Interphone System
- PA System
- Station Control
- Remote control of Power Substations
- Signage and ATS (Automatic Train System)
- Radiotelephony TETRA

As it has been mentioned, the main design criterion for Metro de Quito's Communication Networks must be service availability, taking into account its critical level for railroad exploitation. In order to be able to provide basic services to users, i.e. keep the trains running, there are two (2) key services, namely:

- Signage and ATS
- Radiotelephony TETRA

Not having these services available at any given point would force to stop the trains for safety reasons until said phone blockage has been identified. The proposed solution entails the use of a multi-service transport network unified as communications network: Communications Network IP, based on Gigabit Ethernet technology on fiber optics, where all services based on IP services will connect.

The Communications Network IP's architecture is essentially comprised of three hierarchy levels that use a fiber optic infrastructure:

- Backbone network or CORE.
- Distribution network.
- Access network.

The following types of fiber optic cables will be laid out:

- Cable line. Includes two (2) single-mode 64 optical fiber cables, one laid out for each tunnel gable across the line, with entry and exit in the communication rooms of each of the stations and depot. The project provides for a sufficient number of connectors. Cable connections should allow uniting the various elements of the backbone network as indicated in the plans included in the plans document. The number of fibers welded and/or connected is reflected in the measurements.
- Station cable. Includes one multimode 8 optical fibers cable from the optical splitter of the communications rooms to a number of remote station units (hallways, etc.). At stations that have substation, it includes a mixed optical fiber cable (8 FO multi-mode + 8 FO single-mode) and those that have an interlock will have a mixed fiber optic cable (16 FO multi-mode + 16 FO single-mode) from optical splitters of the communications rooms to the substations and/or corresponding interlocks.

All services and functions where communications are required in the scope of the station are centralized. Thus, there is a need for potent and hierarchical telecommunications network that facilitates access and centralization of all present and future services in a station. The communications room is set up as the hub from where all communications cables associated with the line and station enter and depart.

This project includes all station wiring, centralized in the Communications Room; it should follow the philosophy of structured cabling systems, so that the different component elements comply with applicable regulations, both in terms of materials and connection. In this way we ensure physical links with features that enable reliable communication between different devices or systems, as well as support the growth (in speed and bandwidth) required by the rapid development of telecommunication systems.

The telephony solution proposed in the project allows implementing a telephony system based on Voice technology Over IP (VoIP) with all the characteristics of a high-end classical PABX network. The system is based on the use of a central server, or IP PBX, which provides call switching facilities and advanced services (Centrex), i.e. all the capabilities of a typical PABX, but with the advantages of VoIP solutions.

The Digital Trunking Radiotelephony System to be implemented according to the project will comply fully with the TETRA standard, allowing the transmission of voice and data in various forms provided by this standard (status messages, short data, and data in package mode).

The TETRA Radiotelephony System will use radiant infrastructure to be installed in the Line (tunnels and stations) included in this project.

The Traveler Information System will enable the management and presentation of information in the different teleindicator panels at the stations, allowing real-time updating of information of all panels.

Traveler Information System management is done from the Central Control Post, and has equipment distributed throughout the stations.

The following will be located at the PCC:

Central Server System

Front End Communications (FEC) with the Stations

Control and Supervision posts from where this service is controlled.

Each station will have:

Teleindicator panels.

Local Control Equipment.

To ensure the availability of systems, it is essential to have real-time accurate information on the situation of the different equipment and subsystems and have configuration management tools that allow making any changes remotely.

The project includes a Platform for Network Management Systems based on the integration of different elements to achieve the highest level of control over the systems and services installed; specifically, it is comprised of:

General purpose Alarms and Events Manager SNMP

Configurations Managers, specific for each element

Status and Traffic Monitoring Systems

Service Quality Management System

Incident Management System

It also includes the Chronometry system that allows the determination, conservation and distribution of time references in all locations of the Metro de Quito network.

There will be a master clock installed in the PCC; it will be piece of equipment responsible for distributing the time signal to all equipment of the Communications Network, of the Tetra Radiotelephony, of the Traveler Information System and other systems and servers that require it through of the time synchronization equipment. This master clock is synchronized through a GPS connection.

The GPS (Global Positioning System) provides time and positioning information with global coverage. UTC time Information (Coordinated Universal Time) permanently transmitted by satellites, is converted to local time by a simple adjustment made by the master clock.

The distribution of the clock signal to the rest of the equipment scattered throughout the stations and sites will be made through the IP Communications Network using for this the Network Time Protocol (NTP).

Time Synchronization equipment shall be installed connected to distribution layer network equipment. This approach allows for a hierarchical structure where time synchronization equipment take the exact time from the master clock from the PCC and spread it to other computers whose communications depend hierarchically on them.

c) Scope

The following systems are included within the scope of this project:

Communications Network.

Station Ethernet Network.

Telephony System.

Radiotelephony System TETRA.

Traveler Information System.

Communications Room Equipment (CC).

Electric feed system.

Auxiliary equipment.

In general, the equipment should comply with these features: mechanical and electrical strength, low noise level, modular architecture and easy operation, of easy maintenance and software expansion and modification.

5.7.10 STATION CONTROL

a) Introduction

This project integrates the supervision and control of several installations, placing the centralized control station at the foyer level in the office used for the manual sale of tickets (Ticket office), referred to as the Local Control Post (PCL).

The Station Control System (SCE) must be based on a commercial SCADA packet with minimal technical properties. The SCE will be the system to provide operational support of the station installations and their maintenance.

This system includes the supervision and control of the station's electromechanical installations (escalators, elevators, gates, ventilation, pump installations, emergency exits, and pressurization zones of the tunnel emergency escapes) as well as performing the presentation and coordination with other systems: essentially the CCTV, PA system and Interphone system.

b) General features of the Project

In order to achieve the operational objectives declared above, the SCE must be the entity that integrates with the Station Subsystems, establishing the most standard data transportation protocol communication system possible that the subsystem allows.

The CCTV system will integrate with the Station Control System (SCE), allowing for a coordinated operation with the other systems.

Specifically, through the SCE, cameras will be able to focus automatically on certain situations at each station (an Interphone call, a problem with an escalator, an elevator alarm, etc.). Similarly, upon the occurrence of these incidences, through the SCE and from the Central Control Post (PCC), the cameras will be able to attach to announcement screens upon demand.

The Interphone system will be used to communicate with the Station Control System (SCE) with the purpose of informing the arrival of an Interphone call and allow for the automatic control of the related TVCC camera, on the corresponding monitor.

This interconnection will also allow for the generation of historical information on events related to the local use of the system such as phone calls made, phone call response, etc.

In order to achieve the operational objectives declared above, the SCE must be the entity that integrates with the Station Subsystems.

In order to achieve the operational objectives declared above, the SCE must be the entity that integrates with the Station Subsystems, establishing with each one, the most standard data transportation protocol communication system possible that the subsystem allows.

c) Scope

The system is considered to be distributive, which uses different programmable machines to control and supervise the associated and instituted station installations. Different categories of machines exist according to the installations they control and supervise; all of which operate out of a TCP/IP communication protocol.

The following installations, in principle, become control, remote control and supervisory tasks:

CCTV system.

AP System.

Interphone System

Escalators.

Elevators.

Ventilation (Station and Tunnel)

Gates.

Pump equipment.

Electricity:

- Tunnel lighting.
- Station lighting.

Emergency exits.

Pressurization zones of the tunnel emergency escapes.

This control structure allows for the state of operation of the mentioned installations to be known in each station, displaying the alarms and incidences or changes in the standards of normal operation, as well as allowing for the provision of opportune commands in order to modify the state of operation.

Supervision and control tasks may be performed from any of the site locations, Local Control Posts (PCL) or Central Control Posts (PCC), as long as the installations are not on a fixed mode.

The principle components of this system are:

A central unit, based on a standardized, modular and scalable industrial PC of hardware architecture of 64 available bits that will unify, on a single monitor and control board, the monitoring of the following systems:

- Control system of electromechanical installations (escalators, elevators, gates, emergency exits, etc.)
- Station communication systems (CCTV, AP system and Interphone system)

Programmable machines or remote units (UR)

The communication network

5.7.11 CENTRAL CONTROL POST

a) Introduction

In order to operate the First Line of the Metro de Quito, not only all systems must be installed and operating, but also these must work in an effective, coordinated and supervised manner.

This supervision and control is done in a centralized manner at the Central Control Post, where all systems might be managed and controlled in a centralized manner and where any type of incident that might arise while metro services are being provided can be managed quickly and efficiently.

b) General features of the Project

The purpose of this project is to supply, set up and subsequent installation of the Central Control Post (hereinafter PCC for its initials in Spanish) for full operation of all systems and installations used for the operation of the First Line of the Metro de Quito.

c) Scope

The Project's scope includes all the Works and supplies necessary for full operation and exploitation from the PCC to control, supervise and centralized management of all systems of the First Line of the Metro de Quito, so the following concepts are part of the project's purpose:

Auxiliary installations in the PCC area.

- Adaptation and acclimatization of the engine room (equipment).
- Adaptation and acclimatization of the control room.

Since the PCC is located within the Quitumbe Depot, any other auxiliary system will be set up within the pertinent installation projects, and will share infrastructure with the Depot (for instance lighting, fire protection systems, access control, integrated safety management, etc.)

Specific PCC installations.

- Operator posts (Trains, Energy, Facility Control and Supervisor).
- Maintenance post.
- Auxiliary posts.
- Videowall.
- Visualization screens for the CCTV system.
- Auxiliary operation system for the PCC.
- IP network distribution (exploitation network, office and telephone).

Integration of applications for Control Systems. The project will include the integration of the various applications within control platforms of the Central Control Post, the provision of the specific applications for each of the control and /or centralization systems, its servers and associated licenses are included in the specific projects for each System.

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6. ENVIRONMENTAL IMPACTS IDENTIFICATION AND ASSESSMENT

The methodology used in this Environmental and Socio Cultural Impact Assessment to identify and evaluate the impacts is based on matrix methods of identification and evaluation of impacts (Leopold Method) but adapted to the present study and taking into account Ecuadorian law regarding the identification and evaluation of impacts, the methodology used in the Preliminary EIS and consultant team's extensive experience in this field.

The overall rating of impacts is presented in the Environmental Impact Matrix, which corresponds to Annex 1 of this Executive Summary

The environmental factors that might be affected by the Project assessed are the following:

FACTORS	
ABIOTIC	AIR (climatic change, air quality, noise)
	WATER (superficial and underground)
	SOIL
	GEOLOGICAL-GEOMORPHOLOGICAL
BIOTIC	FLORA
	FAUNA
	ECOSYSTEMS
SOCIOCULTURAL	SOCIAL (Well-being, health and safety, education, employment, transport and mobility, tourism)
	CULTURAL (Cityscape and Cultural heritage (ethnological, architectural, archaeological, immaterial assets)

The Project's actions that might cause positive or negative impacts on the aforementioned factors are the following:

PROJECT PHASES	ACTIONS
CONSTRUCTION	PREPARATION (Excavation, vegetation remotion, transport, etc.) (climatic change, air quality, noise)
	TUNNEL CONSTRUCTION
	STATION CONSTRUCTION
	DEPOT CONSTRUCTION
	AUXILIARY ACTIVITIES (Waste, traffic cuts, billboards, supply, etc.)
OPERATION AND MAINTENANCE	OPERATION (Line functioning, depot and stations' operation, hiring)
	MAINTENANCE (staff hiring, materials and service demand, testing and inspection processes, work maintenance, conservation)
	AUXILIARY ACTIVITIES (Waste, staff hiring)
CLOSING	REHABILITATION (Striking of auxiliary structures, reconditioning of storage areas, waste management, equipment and machinery removal)

Environmental impacts are the effects that the Project's actions will have on environmental factors, present in the city of Quito. Following the possible impacts identified are briefly described:

PARTICULATE EMISSIONS

To calculate emissions of particulate matter and to evaluate fugitive dust emissions arising from the activities of earthmoving and transit of machinery, emission factors obtained from the document "AP-42. Compilation of Air Pollutant Broadcast Factors "of the EPA (Environmental Protection Agency) of the United States of America were used.

The values of measurements of particulate matter in Quito are higher average values than those permitted in existing sectoral legislation, so it is anticipated that the emission of particulate matter during the construction phase will worsen the current situation as excavation, demolition and transportation of surplus materials and debris from demolitions, will result in the measurement rates to be higher.

In the operation and maintenance phase, the values that can be expected are similar to the current as actions that generate emissions of dust will have finished. They may even be lower than current levels, given that motor vehicles are major emitters of diesel particles, and as mentioned above the aim is to reduce the number of vehicles circulating in the city

Construction with heavy equipment is a source of dust emission that can have a substantial temporary impact on local air quality. Major earthworks are carried out with methods that permit the underground excavation of material with a TBM or the traditional method. Along a shorter length, according to the data, the cut and cover method or open pit methods can be used. In all cases, the tunnel material is taken out to the surface with carriages or by mechanical means. Once outside it is loaded on to the trucks to move material to the dumps or collection and reuse sites.

Accordingly, potential emissions of dust will in this case be mainly when loading the trucks and transporting the material. There is the possibility of temporary unpaved roads in the work area and as well as for accessing the heaps and collection sites. In these roads, the transit of heavy machines may also result in dust emission.

Finally, applying the formula yields a Weighted Environmental Index Value for the construction phase which is a medium negative value, and for the operation and closure phases which is low negative. That conclusion is consistent with the experiences observed in the works listed above, in which the effect on the environment, both in terms of the atmosphere and the health of the population due to particle emissions has not been a major factor due to the ease of the implementation of mitigation measures.

GAS EMISSIONS

As reflected in the Socio Economic Feasibility Study included in the Feasibility Study for the first line of the Metro de Quito, in the city Quito vehicular traffic is responsible for 65% of emissions of nitrogen oxides (NOx), 28% of emissions of volatile organic compounds (VOCs), 98% of the emissions of carbon monoxide (CO), 44% of the emissions of sulfur dioxide (SO2) and 15% of the particle material smaller than 10 microns. Therefore, any decrease in traffic in Quito will be significant, as it will contribute substantially to reducing the emission of greenhouse gases into the atmosphere. Therefore, the expected influence on these aspects as regards the metro will be positive.

In the construction phase and the lack of increase in traffic resulting from the use of machinery for the work may increase the emission of greenhouse gases, although this increase will not be significant, since the machinery involved in the project will be minimal relative to the total number of vehicles traveling in the DMQ per day.

In the operation and maintenance phase it is expected that there will be a significant reduction in emissions, because the metro is a clean transport system as it uses electricity to operate. Therefore, the operation of the metro will not only affect the air quality of Quito, but contribute to its improvement by reducing traffic. Given these statements, it is anticipated that the impact of the operation and maintenance phase, which is the most important as it will be the longest, will be positive.

In the case of the construction phase the impact will be the opposite of the operating phase. This negative impact is due to the loading and transport of machinery needed for the implementation of the evacuation the land resulting from the excavation.

Finally, applying the formula, a low and negative Weighted Environmental Index Value is obtained in the construction and closing stages due to the small increase in the number of vehicles that will occur due to the execution of the works, and high positive value is obtained for the operation stage, due to the significant reduction in the number of vehicles resulting from the Metro, which generates lower emissions of greenhouse gases. That conclusion is consistent with the experiences observed in the works listed above, in which the effects on the environment due to gas emission during the operation period have been positive due to the reduction in CO2 emissions.

ACUSTIC EMISSIONS

Noise is one of the most uncomfortable impacts that will be generated while this project is being developed. Its likeliest incidence will be perceived during the construction and the abandon and closing phases, mainly while excavating and demolishing and transporting materials, fragments and soil in general. In these cases, the impact will last a certain amount of time, and it will only exist during these actions. In any case, its importance and magnitude must be evaluated and mitigation measures must be taken.

Keeping in mind that most of the work will take place under the ground, either with a TBM or by the traditional Madrid method; the ground itself will play its part for diminishing and even absorbing the possible noise. The same situation will occur while the soil is being exploited, in which this element will keep noise from getting into the surface and disturbing the citizens.

This is how the different emissions of sound levels will be evaluated during the work´s phases:

In the construction phase, due to the fact that the excavation machine works under the ground, most of the noise will be absorbed by soil. According to several events during the construction of Metro systems in Spanish cities, the sound generated by TBMs working under considerable depth is practically imperceptible to the ears of citizens, with levels under 10dbs or any other measure of noise that might affect the human being.

On the other hand, all heavy machinery working above ground (delivering and transporting materials) will generate considerable amounts of noise, and therefore potential harm to people.

As indicated in previous chapters and paragraphs, and as a consequence of the volume generated by the transportation of material outside the work area, a total amount of 552 round-trip journeys a day to evacuate the excavation material, which is why, along with these 1104 trips, there will be an evaluation of possible additional noise to be generated in this phase. It must be kept in mind as well that, in an 8 hour period, 69 vehicles would go one way and 69 would go the other way.

There are several mathematic methods that help estimate the level of noise caused by a highway activity keeping in mind basic variants (gradient, type of pavement, traffic, speed, percentage of heavy machinery, etc.) and also to its relative position according to the noise reception point.

To evaluate such levels, national and international regulations and documents have been considered, such as the Attachment 5A of Ministerial Agreement 155- Standard for Noise Level Prevention and Control in Port Facilities, Ports and Terminals (Anexo 5A del Acuerdo Ministerial 155: Norma para la Prevención y Control de Niveles de Ruido en Recintos Portuarios, Puertos y Terminales Portuarias) and the ISO 1999 Certification Normative; and the *"Guide du bruit des transports terrestres"* del Ministère de l´Equipement, Centre d´études des transports urbains.

If there is an average speed of 40km/h (one very conservative speed), a two-way road, and 69 vehicles in each way as time intensity, a continuous noise level of over 50dB(A) is to be obtained.

Subsequently, adding these 50dB(A) to the current amount of noise in our environment (some 80 dB), there would be a new total amount of 80,004 dB(A), which means that the increment of traffic due to construction works has very little impact to the increment of the present facts.

A special mention to the ventilation systems that are required for the perforation of tunnels, since they can generate actual noise levels of 80dB(A), which added to the current levels of noise, between 70 and 90 dB(A), would establish an amount between 80,41 and 90,41 dB, something very similar to the current standards.

Regarding the Operation and Maintenance phase, it will be necessary to evaluate, as a first element, the level of noise made by the metro within its own circulation. For this purpose, the noise will be calculated as if it was not under the ground but on the surface, and this will be corrected with the intention of evaluating what part of the noise generated is capable of going through the ground and reaching the surface. This noise will also be contrasted with the one whose emission is interrupted as a consequence of diminishing the normal traffic with the mentioned purpose of evaluation. Coming up, the evaluation of the noise generated by the metro while its circulation.

The sound levels of a metro passing by at 15 meters of distance of the road are estimated around 65,06dB(A), a standard similar to the one measured on Barcelona´s Trambaix. This value, in terms of an underground metro, will be effectively absorbed by the ground itself in its majority.

This is why the maximum level of sound, as a result of a train passing by, will be estimated in 65,6dB(A), and the continuous sound level, equivalent to an estimated traffic of some 150 trains, will be of 47,23dB(A). All this, under the assumption that the circulation takes place above ground, which means that this noise belongs to the inner tunnels and inner stations. Evidently, the soil will play the substantial role of absorbing noise in terms of acoustic emissions to the outside. According to previous experiences, the outer noise is almost imperceptible to people. The increment expected to exceed de current noise levels, in this case, can be less than 10dB(A) in the outside, and as a result, the response from the population to this event is to be considered almost null.

Specifically noise may occur as a result of ventilation systems in tunnels and stations. These emissions will be similar to those calculated for the construction phase. Therefore, just in specific times, emissions may occur about 80 dB noise abroad that will add to the traffic noise levels estimated at about 80 dB so the total noise in the ventilation areas that will be of 83 dB are very similar to today.

The following will evaluate the noise no longer emitted due to the reduction of traffic as the operation of the meter begins.

By simplifying terms for evaluation, considering average circulation speed of 40 km / h, streets of two lanes in each direction, and intensity appropriate time, an equivalent continuous noise level above 65 dB (A) is obtained, which would make the current noise levels of about 80 dB decrease slightly (79 dB), increasing levels being caused by the operation of the metro almost imperceptible (79.00000055 dB).

It can be concluded that the noise levels outside the metro, due to the high traffic intensity, will remain high during its operation, but this does not contribute neither to their increase nor to their decline. However, other measures must be taken, and not related to the metro operation, designed to reduce noise levels in the streets of Quito since they are above the WHO recommendations.

And in the end, by applying the formulation, an Environmental Value Weighted Index of low and negative value in the closing stages of construction is obtained, due to the small amount of noise that can go outside as a consequence of, mainly, building materials and soil transportation, and high and positive in the operation phase due to the reduction of private vehicles to be produced as an effect of the implementation of the metro, something that will contribute to reduce noise levels in the area. This conclusion is consistent with the experiences observed in underground works of other great cities of the world, in which the effects on the environment caused by noise emissions during the operation has been positive due to the reduction of road traffic, and slightly negative in construction and closure phases because of the slight increase of noise that could be transmitted to the outside as a result of the works or transport of materials.

In conclusion regarding this impact, it is possible to say that this is a negative impact on the construction phase, keeping in mind a value of the environment, as well as a highly positive impact in the operation and maintenance phase, and a negative one in terms of the closing phase. This consideration is strictly local, absolutely temporary for the phases of construction and closure, and permanent for the operating phase, and it is reversible in construction and closing phases. This impact allows preventive and corrective measures for mitigation.

VIBRATIONS

During the construction and operation phases of the subway system, there will be impacts due to vibrations. During the design stage of the subway system measures for reduction and control of them have been accounted for so that they don't affect building or the environment in general. Such measures are described in chapter 11 Environmental

Management Plans of the Environmental Impact Study document. Vibrations depend, among other factors, on the soil's mechanical characteristics and the speed and weight of the trains, the Metro de Quito Company, has specific studies on the aforementioned topics.

Based on the soil natural vibrations study performed by TRX Consulting company and on the detailed study made on the layout, it has been defined a current vibration baseline that the City of Quito's soil already has, and several sections of the tunnel have been detected where it is considered necessary to use very high attenuation systems for natural vibrations (traffic and others) and as prevention against vibrations and noise during the construction and operation of the FLMQ (First Line of the Metro de Quito)

In TRX Consulting Company's study for Metro de Quito there are established several zones of possible impact to buildings due to their sensibility to the transmission of vibrations. These are:

- Unidad Educativa del Sur PK 14+610
- Street 6 El Calzado (200 meters north of El Calzado station) PK 15+645
- Manabi and Guayaquil Streets PK22+026
- Universidad Central Station PK 25+490
- La Pradera Station 26+910

In other experiences on similar projects in Europe, the effects on people have been limited.

Starting from the Natural Vibration Studies that the Metro de Quito Company has performed, the resulting conclusion is that the sampled vibrations, are those currently present in the city, and that they stem from the level of traffic the city currently has and in some points of the sampling due to activities such as construction work.

The Metro de Quito Company has on the Subway Design Studies and additionally on specific studies, where it is presented a group of activities to mitigate and control the possible impacts that could happen in the project's different phases. It is also planned a vibration monitoring program that could be generated in the construction and operation of the subway.

As a final conclusion in reference to this impact, it is possible to state that although there is an impact in the construction and operation stages, it will be mitigated with measures already incorporated in the final design of the First Line of the Metro de Quito.

SOIL CONTAMINATION

The main aspects to take into consideration for an evaluation are: machinery required for the operation, vehicular intensity like trucks a civilian traffic around the work zone as well as parked in auxiliary areas, required oil changes, grease and lubricant use for machinery, established conditions in garages and workshops (soil insulation, equipment cleaning, sewer systems for contaminating substances, rubble disposal (both in gathering and reuse) and materials to be transported to these areas (volume and nature of the materials transported and discarded)

As mentioned before, it has been estimated that about 1.104 work vehicles (trucks) a day, making around 552 trips inbound and as many outbound, for approximately 36 months, being 20 months the estimated time for soil removal (or 14.400 work hours if done every day and the equipment is working non-stop). The oil change in trucks, cranes and other vehicles is used to be calculated in work hours (or kilometers traveled) depending on the equipment. It is the manufacturer the one that determines in the service manuals when it has to be performed estimating based on work hours (the vehicles usually have timers incorporated). It is unknown what kind of truck the construction company will use to transport the material. But taking a large capacity 10-wheeler truck as an example that has to have an oil change every 2.000 working hours, it would require at least 7 oil changes during the project. If it is estimated in 10 liters the oil tank capacity, it would be a total of 72 oil liters used per vehicle. This oil volume has to be thoroughly changed, in proper zones and allocated in areas specifically designed for its reuse or disposal, as stipulated in Ecuadorian law, to avoid soil contamination. Some of the sources for used oils include:

- Heavy construction equipment engines, trucks and vehicles.
- Generator and compressor engines
- Hydraulic and transmission systems of the aforementioned vehicles.

The following considerations have been accounted for:

Leaks and spillage: in the project area there may be fuel leaks and spills (gas for vehicles, trucks and heavy equipment). The leaks and spills can happen at the loading and discharge of the product, at transport and storage of the fuel and in the storage area during the oil change or refueling (it could happen mainly at the workshops and in the oil and grease rooms at the auxiliary facilities of the work site). A good sewer system with grease traps included should prevent the leak of spilled fuel. This way, leak and spillage contamination to soil and water bodies outside the work zone will also be prevented. At any rate, the best practices should be ensured when the time comes for oil and grease changes and waste disposal.

Waste: the recipients and deposits for non-biodegradable solid residue will be placed in the work areas and operations center, so that proper waste disposal is encouraged and not littering. When an oil change is needed, the used oil shall be gathered and temporarily stored in appropriate containers at the work site until it can be retrieved by the contractor and its disposal scheduled at the proper facility. If 55 gallon tanks are used, these will have to be transported and disposed of properly. All minor maintenance activities should be performed in specialized areas that have insulating covers so that soil contamination is avoided.

In case of accidental leakage: all work crew should have the basic elements to prevent fuel leakage. It is also important that the storage site has the appropriate conditions to prevent ground leakage. On the case of a spill, the work crew should stop it creating barriers or canals surrounding it. Once it has been stopped the crew should proceed to gather the product with a material like sand, which should be at hand. The gathered residue should be treated as dangerous waste and the manner and final disposal will be specified in the Dangerous Waste Disposal Management manual.

GEOLOGICAL RESOURCE CONSUMPTION

No plans to open new mines exploitation are expected for the operation and closure of the project evaluated.

Geological resources from mines in operation, therefore, will be used; resources with the appropriate licenses and environmental evaluations, showing as well that their environmental impact is admissible and that there is no need to make a specific evaluation in this study.

CHANGES IN THE GENERATION OF SURFACE RUNOFF

This evaluation focuses on the actions of the project that can produce a substantial change in the generation of surface runoff. It shows the actions that will cause soil protection from humidity, and therefore will increase the runoff coefficient of the affected area. Any other action that may have an impact on the generation of surface runoff is estimated to produce non-significant effects since they do not change the current runoff coefficient substantially and will not, therefore, produce significant increases in circulating flows and volumes by drainage shafts.

For garages and workshops, as previously seen, the only area in which it is expected to have a significant impact on modifying the generation of surface runoff, the estimated need for land is of approximately 5 hectares, of which 1.5 hectares will be used for the implementation of the road.

In the specific terms of the modification of the surface runoff generation, the intensity is considered to be low for all cases, since most of the areas through which the metro runs are sealed and the metro goes underground. The extension, for the same reason, is considered to be low, despite being a work of 22 kilometers long, keeping in mind that the future situation will not change much in comparison to the current one. The duration of the works is not too extensive in time compared to the useful period of the metro, so its value has been lessened. The reversibility is considered low in all cases. The risk of occurrence is considered high in all phases.

In the end, the formulation helps determine a low and negative estimation of the weighted environmental index in the construction phase and low positive one in the closing stage. This conclusion is consistent with the experiences observed in underground works of other great cities of the world, in which the changes in surface runoff have been insignificant, showing better results in the final stages of closing after the rehabilitation of previous drain areas.

This impact is negative and average in the construction phase and positive and average in the closing phase, in terms of recovering the actual conditions of runoff generation.

SURFACE WATER CONTAMINATION

The analysis of superficial runoff water made for this work and the data collected from other sources indicate high sorts of pollution mainly due to the same direct discharges of sewage waters of Quito. It must also be mentioned that natural water in the area already contains high levels of iron and arsenic as a result of the alteration and subsequent dissolution of some of the minerals that form the volcanic rocks that form the substrate of Quito.

The turbidity of the water right now is also high due to the high amount of erosion on hillsides and to wastewater discharge.

This impact will be significant in all three phases of the project if there are uncontrolled dumping of pollutants. Due to the characteristics of the project, the substances that can cause major problems if there were uncontrolled disposal would be hydrocarbons (fuel, oils, fats) since they can ruin water quality at very low concentrations.

Finally, applying the formulation, we obtain average and negative environmental weighted index values in all phases. This conclusion is consistent with the experiences observed in underground works of other great cities of the world, where surface water contamination usually occurs due to the emission of particulate material in the excavation process, but as general rule are usually insignificant.

The surface water contamination impact can occur in any of the three phases of the project. It is a negative impact for both average and for its minimization current laws for the storage and handling of pollutants and other corrective measures must be applied and taken.

DRAIN EFFECT

Some authors point out that in underground work there can be what they call "drain effect". This phenomenon would occur in the case that, by building the tunnel, this process did not accomplish totally waterproof or impermeable results, which means that water was able to run inside the tunnel, a “drain effect”. When this occurs, the piezometric level decreases in the proximities of the tunnel.

For most of the trace line tunnel it has been provided the use of an EPB TBM (work with closed front and maintained soil pressure in the chamber by means of a screw excavated products evacuation). This type of machine has been proven by years of use to prevent the entry of water from the front as from the end of the shield area. In this zone, there is a sort of "brush" that prevents water from entering inside the shield, resulting in the inability to work in proper conditions.

The other point where water could enter is the final lining itself, which consists of a ring of prefabricated sections which are joined and shape it. Since being prefabricated, it shows the quality of concrete, with high strength, to be very good and therefore impermeable. The weakest point is set in the joining points; however it is not possible to get water through them since they are waterproof.

Another system used for the construction of the tunnel is mining by conventional procedures, and the execution procedure is the one of sequential excavation (SEM). In this case, the front is open, the ground is being held and coating is being made as the process continues. This method is used in areas where the groundwater level is lower than the excavation quota, and thus with no effect, so again the drain effect is discarded.

The last method used for the construction of the line is the method called “between covers”, in this case it is necessary to lower the water level within the covers during the construction phase, which causes only minimal declines abroad and in no case a drain effect.

In the Metro project in Quito, this effect cannot occur primarily due to construction method used, which can be found in the Design Study of the First Metro Line for Quito, whose specific measures to mitigate and control this impact are in Chapter 11 “Environmental Management Plan of the Present Study”.

SCREEN EFFECT

According to the design of the first metro line in Quito, it can be assured that this effect does not occur in any point of it. Indeed, in the entire route excepting the first 700 meters the designed tunnel is a quasi-circular or circular section that clearly cannot disrupt the normal flow of water.

A modeling of the area has been done in one of the stations designed to check the area´s hydrogeological behavior. This study is incorporated into the final construction design for Quito´s metro.

In the initial zone, the design contemplates the execution of the method called tunneling between covers, therefore it might be possible to see this phenomenon take place, but there would have no effects because the variation ranges would be similar to those produced by the stationary variation.

There can be seen, in the figure on the next page, how water flow direction, marked by red arrows, is substantially parallel to the path, so the barrier effect cannot occur. The covers have a depth ranging between 14 and 18 meters and rely on the formation of Cangahua, formed in this zone of sand and gravel, and therefore permeable so, even though the cross flow went outside the trace, there would not occur any barrier effect.

In addition, a modeling of the area of one of the designed stations in order to check the area´s hydrogeological behavior; the result again confirmed the absence of any barrier effect on the line.

After analyzing the hydrogeological behavior modeling conducted by the Metro de Quito Company, it is concluded that there is no existence of the barrier effect on the Line.

GROUNDWATER CONTAMINATION

In the case of pollution of underground water, a high intensity has been considered in all phases due to the effect that it could occur as a result of contamination. The extension has been considered high in all stages, for the same reason, the effect on important aquifer zones. The duration of the works is not too extensive in time compared to the useful period of the metro, so its value has been lessened. The reversibility is considered average in all cases. The risk of occurrence is considered average as well, for the type of work involved.

Finally, applying the formulation, we obtain average and negative environmental weighted index values for all phases. This conclusion is consistent with the experiences observed in underground works of other great cities of the world, where the groundwater contamination is probable and likely.

The impact groundwater contamination can occur in any of the three phases of the project. It is a negative impact with an average degree, and for its minimization measures will have to be implemented, including standards for the storage and handling of pollutants and other corrective measures.

EFFECT ON BIOLOGICAL COMMUNITIES

To determine the rating scale of intensity, it is considered high intensity if the impact causes the loss of endemic or threatened species or if the percentage of area with permanent condition is greater than 5% of the total area of parkland; an average intensity if it causes a loss of common species that can be recovered by simple and inexpensive mitigation or if the percentage of area with permanent condition is between 2% and 5% of the total area of greenery and there is low-loss on species that can be recovered with help from man or if the percentage of area with permanent condition is less than 2% of the total area of parkland.

The consulting team has resolved to rate intensity as low-impact, as species are common and easily recovering, and the permanent affected area is less than 2% from the total area of parkland.

Furthermore, the extension is considered specific as it only affects a certain area where the structure is affected. Regarding the duration, it has been rated as average because the impact is presented for the duration of activity and ends when it finishes, afterwards corrective measures can be taken. In the case of a permanent effect, compensatory measures for recreating green spaces can be taken.

The risk of occurrence is low impact, and with all the mitigation measures to be taken, it decreases even more if they are well applied. Reversibility is also considered low because the impact is reversible in the short term.

With all these considerations and applying the formulation, a negative environmental weighted index value is obtained, which, for construction phase, turns into a low negative value.

In conclusion, regarding this impact, it is possible to say that this is a negative impact assessed as low, acting mainly in the construction phase, of low valuation, of a specific, temporary type and reversible in the short term. This impact supports preventive and corrective measures for mitigation. Regarding green area with permanent condition, it is considered to be very small compared to that in the urban area of Quito, however apply a compensatory measure to recover the same or greater surface area elsewhere in Quito can be applied.

EFFECTS ON URBAN MOBILITY AND ACCESSIBILITY

This section will assess the positive impact generated in the operation phase of the metro system during its operation. It is kept in mind that, as mentioned in the identification of impacts, mobility will be negatively affected in the construction and closing phases, and although the damage to the mobility of the population is not considered very important, it will also be assessed as a negative impact. Specifically, the location of the stations and the design of the trace have been conceived from the standpoint of not causing significant effects on the mobility of the city during the construction period.

The socioeconomic levels of macro zones mainly important are the average (69.2% of households) followed by low (23.6% of households). As for the number of vehicles in the city, the study reveals the following mobility data, always lower than the statistics of the competent authority, CORPAIRE, Corporation for Improving Air Quality in Quito, belonging to the Ministry of Mobility of the Metropolitan District of Quito.

Household Research says that there are about 303,116 commercial vehicles available for personal mobility DMQ residents. The number of vehicles per inhabitant varies depending on the area of the city, being higher in the north, reaching 0.20 light vehicles / capita, and less in the Quitumbe area - urban south, with a value of 0.09 vehicles light / capita, in relation to the total population of the DMQ.

The average working day includes approximately 4,271,565 trips to and from a destination and a specific reason for them. 85% is made in motorized means, of which 73% are made by public transportation and 27% by private transportation. The bus is the conventional way for most people, constituting 63.5% of trips by public transportation.

According to the estimates made in other sections of this Environmental Impact Assessment, the number of trips to be made by trucks moving materials to be deposited is 1104. This represents an additional circulation intensity of 552 heavy machinery units per day in each of the directions of movement (outward / return). Let us consider the influence will this increase in traffic flow intensity of Quito.

According to the Highway Capacity Manual of the United States Transportation Research Board Manual, in circulation analysis and planning in urban and suburban arteries, in the absence of specific data from gauging, perfect saturation intensity can be considered from 1,900 light vehicles / green hour / lane. In the present case, taking a relationship red / total cycle of traffic lights on the concerned road of 1/5, the saturation time is 1,520 net resultant light vehicles / hour / lane.

To change transport trucks to the equivalent light vehicle, a conversion factor recommended by the Road Research Laboratory of Great Britain is used, which advocates a conversion factor, in the case of urban roads and heavy trucks, light vehicles of 2.5 / heavy truck. Therefore, light vehicles, equivalent to the 552 trucks operating in each direction are established as 1380. If we consider a working day of 8 hours daily, land transportation to the tailings produced an increase in the intensity of traffic on the road along which light of 173 vehicles / hour.

For 2-lane road, this extra traffic accounts for 5.7% of the saturation intensity (3,040 light vehicles / hour). If the roads have three lanes, 3.8% (4,560 light vehicles / hour), and if they have 4 lanes, 2.8% (6080 light vehicles / hour). As it can be seen, this traffic represents a very small proportion of the saturation in the three cases. Additionally, it must be considered that not all vehicles are on the same road, as they have provided various tips, and also can be programmed multiple paths to a single dump.

Given the above, it can be considered that the movement of trucks from construction works between work zones will not have a significant impact on traffic conditions in the city of Quito.

At present, the situation faced by Quito is structural in nature and is the result of decades of implementation of a model of growth based on the expansion of the urban landscape to the north and south and the eastern valleys, causing a low-density land use, with an unequal geographical distribution of services that, from the point of view of mobility, involves concentration and travel destinations radial to the Historic Center of Quito and hyper center as well.

The current status of mobility in Quito, as already mentioned, is not good, there is evidence that the capacity of the roads in the areas where the work will be implemented right now is already outdated, so the little increase of heavy traffic will not be a significant problem added since collapse problems already exist. Below are data showing traffic congestion in the Municipality.

To calculate the magnitude, it is required 3 variables, intensity, extension and duration. The intensity of this impact is calculated based on two variables:

Time saved with the first subway line in Quito, compared to other motorized transport: According matrix travel times Technical Feasibility Study, the allotted time for travel from La Ofelia to Quitumbe is 42.3 minutes, when compared to the average time used to travel a similar distance as the EDM11, private transport, a similar course was considered from Carcelén to the historic center and from there to Quitumbe, the average time needed to traverse is 100, 8 minutes, representing a 57.24% time saving compared with the metro to the private car.

On another hand, the public transportation system consists of 172 Quito conventional public transport lines operated by 2698 urban buses and 46 lines operated by 676 interparochial buses that provide service to the areas located on the outsides of the city and surrounding valleys. It also has 3 lines of BRT mass transit, trolleybus, the Ecovía and then south, south east and North Central corridors. The following figure shows how the Mass Transit in DMQ will be integrated.

A trip on the trolley in Quito, during rush hour, can take an hour and a half from the North Terminal to Quitumbe station, similar to travel by subway Quitumbe Labrador. Assuming an average time, the duration of this trolley ride is 40 minutes; if extrapolated, the estimated duration of the underground journey of the entire the first line project, from

Quitumbe to El Labrador, would be 33,4 minutes - time savings with respect to transportation trolley system would be 21%.

Considering that 27% of journeys are made 4,271,565 on average on a weekday, were made in private transport, and 73% are made by public transport, we will apply the specific weight of each of the values for calculating the average time saving. The result would be 30.8% time saving on average, using the metro compared to current conventional transport on a weekday.

Another variable needed to calculate the intensity of this impact is the percentage of population that is expected to benefit from the new transportation system. According to EMD11 Quito's population is about 2,370,884 inhabitants, and the population of the 4 macrozones to travel the subway system for a total of 1,426,402 inhabitants, that is 60.16%, thus the intensity this impact is calculated as the percentage of time saved in relation to the current situation and percentage of the population as a potential beneficiary of the savings.

In the specific case of the effect to urban mobility and accessibility, it is considered that due to the digging of tunnels and surface works taking place, there will be outages and detour traffic and pedestrian streets, however there will be no high intensity of this impact in the construction phases, that is not considered to be very significant, mainly because despite the works that are expected to perform at the surface, they can only take place on roads in 3 stations (Jipijapa, Iñaquito and the Carolina) and the streets where this will take place have double lane, so that even if one of them is cut, the other vehicles will have an alternative to circulate. It is true that this will cause slower traffic, but the damage is minimized. In the operating phase is considered one of the most important positive impacts.

Being a positive impact that is produced in the operation phase, it will require no preventive, corrective or compensatory measures.

This work will promote the achievement of some of the objectives of the "Special Plan of the Historic Centre of Quito" (part of the "Strategic Plan 2025 Quito) - to consolidate the urban structure and the value added symbolic spaces and citizen gatherings.

INCREASING OF EMPLOYMENT AND ECONOMIC ACTIVITY

The number of direct jobs is expected to be a total of 2,200 total in the construction phase (approximately until 2015), jobs that are temporary, and 1155 through 2045 in the operation phase.

The percentage of increasing employment thus relative to the current working population is 0.28% of jobs with a duration of about 3 months, and 0.15% of steady jobs, relative to the working population, if one considers the average employment growth in the DMQ.

According to the National Statistical Institute of Ecuador and with reference to the quarterly growth rates of Quito in the last year, it is calculated an average of 1.175% of employment growth. To calculate the intensity of this variable, job creation of the new project will be kept in mind in relation to a growth rate of 1.175%. According to this information, it has been calculated an increasing in the percentage of employment growth during the first 3 years of 23.8%; even if temporary, in relation to last year in Quito, and to operate the metro, the increasing of permanent jobs percentage in the growth rate is 12.7%.

Being positive impacts, these will not require preventive, corrective or compensatory measures. In addition, in this study there are no measures to enhance the benefits of these impacts involved, but in relation to work if international standards indicate that arise as a mandatory requirement for the contractor and / or developer of the project, as part of the standards of the International Labour Organization, ILO. In this regard will ensure compliance with the ILO Declaration on Fundamental Principles and Rights at Work, which expresses the commitment of both governments and business and workers to uphold basic human values, in Specifically for our project will be special emphasis on the control of recruitment to avoid by any means, that the following situations

 Forced Labour.

 Child labor.

 Discrimination in employment and occupation.

IMPROVEMENT OF THE QUALITY OF LIFE OF THE POPULATION OF QUITO

As already discussed, the installation of a new transport system, like the Metro, will enable people to travel with comfort and reliability. This line of communications also connects other public transportation systems in the city, making the transport network more integrated and useful. Better communication and transportation in a city make it more appealing, has a useful picture of modernity and causing it to build more homes and while most people can access them. This growth of the city will encourage the local economy directly in short and medium terms, the demand labor for construction, and a long-term effect of the development of new industrial and service activities in the municipality. This promotes the improvement of the quality of life of the population.

On another hand, there are issues related to poverty, education, security, health, etc., which are difficult to quantify in this study because they are affected indirectly. According to the results of the Developed Mobility Study, the conclusions of the survey reveal that the movement reasons are studies (32.5%), work (31.1%), personal reasons (24.3%), shopping (4.4 %) and medical reasons (3.1%). In this sense it can be concluded that a general improvement in the city mobility will positively affect by improving access to schools, as well as other health and cultural centers, etc. Also, an increasing of the quality of life in turn promotes improve quality of life of the poorest people in the city. Although the layout of the first Metro line does not connect Quito suburbs, it does connect the lines with this peripheral transport backbone of the city, providing access to historic downtown and the financial and commercial zones of Quito.

In the construction phase, the impacts are average-negative; the population will suffer discomfort of various kinds, although the proportion of the population will be small and the duration of impact as well.

For the operational phase, this impact has been assessed as highly positive, as calculated by the Environmental Index value. Being a positive impact, it does not require preventive, corrective or compensatory measures.

Following proper standards, this project will secure respect for human rights in all sectors and areas that may see altered, as established in the Charter of Fundamental Rights of the European Union and international best practices; by integrating The EIB Statement of Environmental and Social Principles and Standards, 2009, this project will boost this respect even in other activities that may arise. An example of this can be seen in the guidelines established for contracting in the construction and operation of the meter, in the previous section, for which will ensure compliance with the requirements of the International Labour Organization, ILO.

INVOLVEMENT OF CULTURAL HERITAGE

Studies demonstrate the existence of deposits altered in all areas studied.

At stations El Ejido and San Francisco, there was found Aboriginal and colonial archaeological evidence, interspersed and fragmented; these evidences are minimal Quitumbe - Garages. In all other Stations and Special Areas, there was no archaeological material registered.

The information generated in this study should be kept in mind during the construction phase of the works, and should be monitored any archaeological issue.

In regards to heritage buildings, since 1989, the Rescue Fund FONSAL, made the protection, consolidation, enhancement and restoration of all churches and many heritage buildings of the CHQ. Currently, the Metropolitan Institute of Heritage, through the plan "Pon a Punto tu Casa", interventions made structures and roofs of private houses inventoried within the boundaries and buffer zones of the CHQ.

The study of buildings and services affected in the area of influence of the PLMQ, made by Metro de Madrid, reveals a universe of 733 buildings in the historic center of Quito between San Diego and Alameda, from which only eleven have structural problems, and eight of these are abandoned houses and two heritage buildings.

- Sensitive heritage buildings are:
- The religious complex of La Concepción, with an estimated 10% of the south bay with moderate structural damage. It is noted that the Metropolitan Institute of Heritage has been intervening in the process of strengthening and restoration of this complex.
- Colegio San Luis Gonzaga located in Benalcázar Street, next to the church of La Compañía de Jesús, which was chosen as building prototype to study engineering and heritage buildings alongside the study indicated, still in progress.

San Lazaro Hospital, Bahía Street, Ambato and García Moreno streets, a building partially unoccupied and that is being intervened in its strengthening and recovery.

Studies are underway in buildings with specific pathologies affecting structures.

From the experiences of collectors built in the historic center of Quito by the EPMAPS, such as manifold "El Tejar-Mejia-La Marin, which intersects the historic center, and was implemented with the traditional method, there was no effect to the buildings and heritage structures, so this method to be applied in the construction of the tunnel for the subway, on the stretch that crosses the CHQ, is considered to be the most appropriate because it does not produce, either vibrations or negative impacts on structures and heritage buildings.

On the evidence presented, it is established that the construction methods to be applied in the Historic Center, both stations to the tunnel, this is Cut and Cover and Conventional, respectively, are the most appropriate given the particular conditions of the sector, thereby ensuring minimum vibration and impact.

With the evidence found in the Plaza de San Francisco, this impact is rated as low and negative in the construction and closing phases, and this assessment may be modified once the works are running.

In the operating phase, this impact can be seen as positive, and will be assessed, according to calculations made and reflected in the tables above, as average, and this assessment may vary at the time in the operation. This impact is considered positive in the operating phase for the following reasons:

- In the historic center, the elimination or reduction of surface transportation systems will facilitate transportation of pedestrians downtown and the visibility of Buildings
- It decreases the effect on materials by pollution from the burning of fossil fuels
- The Metro Plan supports the pedestrianization of the historic center as it aims to discourage the use of private vehicles.
- Increasing of creation of enclosed public spaces and new cultural spaces.
- Positive impact to intangible cultural heritage (preventive respect of intangible cultural heritage)
- Promotion of social and cultural activities, helping to meet Goal 7 marked on the National Plan for Good Living, or Development Plan of the Republic of Ecuador: Build and strengthen intercultural public spaces and common meeting.

LANDSCAPE IMPACTS

The fragility of the landscape is defined as its ability to accommodate the changes produced by a specific action without losing its value or landscape character and, therefore, depends on the inherent characteristics of the landscape and the performance characteristics around it. They are inversely related, since a landscape with a high fragility has a limited capacity to accommodate and absorb changes produced in it.

It is now imperative to determine the vulnerability of the action perimeter, its ability to accommodate changes in accordance with the landscape features of their own, regardless of any intended activity.

Therefore the importance of landscape impacts is mild, except in the case of works affecting surface historic center in which the importance is moderate due to the uniqueness of the area and there must exist every commitment in the correct integration of the work surface and underground workings careful not to affect heritage assets of high interest.

These are usually mild or moderate impacts; the impact is direct and has long-term duration. The impacts have negative reference except those involving restoration works.

Fundamentally, landscape impacts will be generated in the construction and closure phases. In the operating phase of the planned infrastructure will be integrated into the environment since it is mostly underground and surface will only be visible in the station entrances. As for the dump, it is to be restored so that the work completed will also be integrated into the landscape. The garage is located in a suburban landscape so once construction is completed buildings will also be integrated in their environment.

It must be highlighted that the sensitivity of the historic center of the city declared a World Heritage Site and a high equity so landscape impacts could affect that value.

The importance of landscape impacts on all three phases and for each of the landscape units affected is mild, except for the historic center of Quito that is moderate.

In the case of the historic center of Quito, during the works, there must be scrupulously care to avoid irreversible deterioration of cultural heritage during construction. The design of the works visible from the surface will be integrated into the environment to avoid visual impact of high interest on cultural heritage present.

EFFECTS ON HEALTH BY GENERATING ELECTROMAGNETIC FIELDS

While this impact is not considered significant, and has not been selected among the preliminary valuation, whether to proceed to a description in order to report on it, because the themes of generation of electromagnetic fields and their application for health can cause some alarm.

As indicated below, this impact is not significant or there is no evidence that electromagnetic fields at levels that will be generated in the metro, causing adverse health effects.

The power supply for mass transportation as rail or metro is performed by power lines.

Both power lines that supply power for the operation of the metro, such as engines and traction equipment for trains, can generate electric and magnetic fields, although as noted in previous sections, are those for power lines that supply the most significant amounts of energy.

In regards to power supply lines, the electric field decreases rapidly by increasing distance to the conductors and are shielded against almost any material walls, trees, soil, etc. Therefore, as a general rule being that line segments are buried in urban, there is no affectation to the surface.

According to this, the Spanish UNE 215001-2004 - "Standard methods for the measurement of electric and magnetic fields of industrial frequency produced by high voltage power lines," states the following:

"If power lines underground of high voltage, the electric field is completely shielded by terrain, drivers will also be shielded and grounded, so that the electric field that is created is null and there should not be taken any measure ".

In regard to the magnetic field, there are greater difficulties for shielding, but its value decreases rapidly with distance.

The values are well below the maximum of 100 mT, recommended by the Council of the European Union.

As indicated in the website of the World Health Organization, the trains have one or more locomotives that are separate from the passenger cars. Accordingly, the primary source to which passengers are exposed is the power supply rail.

In the passenger cars for long distance trains, magnetic fields of several hundred mT might appear near the ground and with lower intensities (tens of mT) in other parts of the compartment. Electric fields can reach intensities of 300 V / m.

The engines and traction equipment for trains and trams are normally located under the floor of the passenger cars. At ground level, the intensities of magnetic fields can reach levels of up to tens of mT on the floor parts positioned just above the engine. The field intensity decreases drastically with distance to the ground, so that exposure of the base of the passengers is much lower.

According to WHO, in recent years, public authorities in various countries have made numerous measurements in order to study the levels of electromagnetic fields in the everyday environment. None of these studies concluded that the measured levels can cause adverse health effects.

The German Federal Office for Radiation Safety (Bundesamt für Strahlenschutz, BfS) recently measured the daily exposure to magnetic fields of about 2,000 people in various occupations and degrees of exposure in public places. All the people involved took personal dosimeters for 24 hours. Exposure levels measured showed a large variation, but the average daily exposure was 0.10 mT. This value is a thousand times lower than the limit for the population of 100 uT and 200 times less than the exposure limit for workers of 500 uT. In addition, exposure levels were registered by the inhabitants of the town centers, and they indicated that there are no major differences in this regard between rural life and urban life. Even exposure of people living in the vicinity of power lines high voltage differs little from the average exposure of the population.

Each country sets its own national standards for EMF exposure. However, most of these national standards are based on the recommendations of the International Commission on Non-Ionizing Radiation Protection (ICNIRP). This nongovernmental organization formally acknowledged by WHO, evaluates the results of scientific studies worldwide. Based on a thorough analysis of all scientific publications, the ICNIRP produces guidelines which set recommended exposure limits. These guidelines are reviewed periodically and, if necessary, updated.

The values of the electromagnetic fields generated as a result of the operation of the metro or its electricity supply needed for its implementation are in all cases less than the maximum recommended by the WHO, therefore there is no risk to human health individuals.

Furthermore, as indicated in the WHO website, based on the overall results of all investigations, it cannot be inferred that electromagnetic fields cause long-term effects on health, such as cancer. National and international standards set and update based on the latest scientific knowledge, in order to protect against the mentioned health effects.

6.1 CONCLUSION OF THE IMPACT ASSESSMENT

In order to conclude this study it is necessary to take into account the impact assessment results. Due to the discovery of several negative impacts, all of them require prevention or mitigation measures. Otherwise, its duration or magnitude is not equal to the duration or magnitude of the great benefits of the first line of the Metro de Quito planned by the Metropolitan District of Quito (DMQ).

Firstly, the construction impacts of this great infrastructure, the noise pollution to the public, the above average emission of gas and particles, the vibration amount greater than what is produced daily, or the damage that greater emission levels of gas contaminants and particles may have on the environment; are expected to reduce to current levels once in operation and are no more than normal interruptions of any public work. The design phase, including the preparations for construction, will create similar inconveniences due to geological studies. Underground surveys have been executed for these studies as well as for the archeological study, however to a much smaller degree than the actual Project. Also some blocks or detours mainly for pedestrians but also for traffic and noise, as well as gases and particles associated with the machinery and the survey itself have been considered as inconveniences, however we should restate that they have not been considered to be significant, which is why they do not have a quantitative assessment of this study.

The following lists the priorities and justifies the positive and beneficial impacts this Project will bring, including those that while they may be listed as negative impacts, we consider to be reasonable and general benefits of this Project:

- A noticeable improvement in the quality of life of the residents of Quito.
- It promotes urban integration and organization and consequent land development.
  - Increased comfort, reliability and decreased commute times.
  - Improved access to places of interest; whether they are related to work, commerce or tourism.
  - The development of urban areas surrounding the Project, improvements to the Historic Center and the assessment of archeological resources. Improvements in tourism.
  - The creation of increased public spaces such as new social and cultural spaces.
  - Increased urban accessibility and mobility in the DMQ, improved access to educational, health and social centers.
  - Due to the DMQ's Integrated Transit System, this is the metro's articulating base, the socioeconomic inclusion of marginal sectors and the integration of the urban area.
- Less superficial vehicular traffic on main roads, allowing for the decrease of traffic congestion, combustion gas contamination and sound, as well as commute times.
  - Increased labor production.
  - Reduced gas imports due to the fact that the new metro system will use electric energy and because the total number of vehicles will decrease.
  - Air quality improvement of Quito, contributing to the reduction of greenhouse gas emissions and the mitigation of climate change.
  - Improved public health due to the reduced number of accidents and less environmental contamination.
- Job creation: Needed throughout all of the project's phases, which will be quality and stable employment. Job diversification: The construction as well as the operation of this service will provide a higher number of direct employment; nevertheless, indirect employment will also increase due to the population's economic development and growth.
- Development of a new culture of citizenship and of a positive attitude towards quality public service.
- Increased commercial and economic activity.
- Population increase in the direct area of contact, which will promote social development. Indirectly, integrated and mass transport helps to avoid economic and social segregation and to decrease poverty rates.

- Technical development and transfer of knowledge. It is considered to be beneficial both for Ecuador and Europe to share knowledge on railway technology. There is a direct transfer of technology from Europe due to the participation of companies from Spain.
- Improved use of natural resources such as petroleum products, due to the substitution of fossil fuel energy for electric energy. Additionally pollution due to combustion gas emissions is reduced.
- Two of the characteristics that make the Metro transportation system more efficient are the use of energy and space. Studies performed by administrations from other countries show that the space used by metro systems is less than that used by buses, and much less in the case of vehicles. In regards to energy use, with the same amount of energy used for one passenger, the Metro covers more distance than the bus and more than double the distance of a vehicle.

There is the risk that soil contamination may occur due to accidents or oil, grease, or fuel spills. The impact, however, is considered to be insignificant due to the fact that important precautionary measures are being taken and that waste products will be adequately managed. Accident and lubricant spills or other contaminants due to current vehicle traffic must also be taken into consideration. This level or risk of contamination may be slightly higher than normal during the metro's construction phase, however it is expected to drop to levels lower than current levels during the operation phase due to the fact that there will be less vehicles circulating on the roads and therefore fewer occurrences of accidents and floor contamination.

The surface and underground risk for water contamination is comparable to the risk of soil contamination. All measures necessary to avoid this contamination according to current law will be taken throughout the construction phase. This contamination will never be greater than any project of a similar magnitude, which is why these possible damages are very unlikely. The issue of surface and underground water may be modified; however as mentioned earlier, an intensive hydrologic-hydraulic study will be performed in order to identify and understand the exact characteristics of the surrounding water levels. The projects will be carried out with the most minimum changes possible and always taking every mitigation measure that exists in order to avoid changes in the existing structures or surface run-off that may cause or increase the possibility of a flood.

With regard to the biological communities that may be negatively affected, the impact will be low and isolated due to the fact that these biological communities are located in parks and do not serve as a biological extension nor richness of great importance. This impact is also connected to the construction projects, which will be temporary. Once these projects have ended, all parks and their flora and fauna will be restored, always with the intention of improving the natural condition of these areas in comparison to their current state. Nevertheless, protective measures will be used in areas that do require it.

Regarding social impacts, both positive and negative impacts have been found. The main positive impacts of the Project are: improved urban mobility and accessibility, improved quality of life, increased employment, more dynamic urban economic activity, saving time, saving energy, reduced costs of vehicle operations, less atmospheric contamination, contribution to reverse climate change, less accidents and noise-reduction. In contrast, the social impacts that from some points of view could be considered as negative are: temporary disturbances to citizens due to project construction and the purchase of six pieces of land. The temporary disturbance impacts can be mitigated by measures for environmental control, safety and citizens' cooperation throughout the Project's construction phase. Regarding the purchase of the six pieces of land, the purchase process went smoothly and there was no social conflict as a fair price for the landowners was established. It is important to mention that the land purchases were not inhabited in accordance to the establishments of the first line of the Metro of Quito Project, which state that it will not generate resentment of any kind.

Cultural patrimony, more specifically the archeological remains that one expects to find in a project like this, are considered to be of great importance which is why all existing measures for their protection will be applied, also taking in account current laws. It is also important to highlight that it is a good opportunity to discover, restore, and exhibit those findings; as it is anticipated that they are to be put on display in the areas where they are found like at the site of construction of the San Francisco Station, for example. In other examples include the case of the new transfer station at the *Puerta del Sol* in Madrid, Spain, which has restored and exhibited the remains of the foundations of the Church of Our Lady of Good Success to passengers. This is a good opportunity to value and demonstrate to the public and to tourists, part of the Inca city that lies under the Historic Center of Quito.

Necessary preventative measures will of course be applied to this last impact in order for the highly valuable buildings and monuments located in the center of the city, declared as a World Heritage Site by UNESCO in 1978, not to appear damaged. This also corresponds, in part, to the previously assessed negative visual impacts. Again, these impacts will only occur during the construction and closing phase of this project, which are considered to be temporary. During the Metro's operation phase, the infrastructure is expected to be integrated into its surroundings since it is mostly underground; and on ground-level only the Metro's entrances will be visible which are to be integrated into the urban aesthetic as much as possible. Upon commencing operations, the metro system will allow for a greater number of visitors to observe this important cultural patrimony, which again leads to another economic and social advantage of the project.

Mobility is also one of the most noticeable positive direct impacts of this project. In this sense, it is important to emphasize that currently, the development of the Sustainable Mobility Plan of the Historic Center of Quito is in process, which seeks to give value to public spaces through the establishment of pedestrian streets in the Historic Center of Quito. This is why it is necessary to solve accessibility problems, placing a priority on public transportation rather than private, to which the execution of the first line of the Metro de Quito will significantly contribute and will complement all other existing forms of public transportation in fulfilling the desired mobility and accessibility objectives.

The metros of Santiago (Chile), Bogotá and Santo Domingo and the studies performed for the metro that is in construction in Panama City can serve as perfect examples in predicting the expected success of the construction of the first line of the Metro de Quito; not to mention the experiences of Metro Madrid, which has designed the project.

For these and for the aforementioned reasons it is clear that this project will mark a before and after in the development of Quito and its residents and consequently, in the economic and social advancement of the country.

7. ENVIRONMENTAL MANAGEMENT PLAN

This Environmental Management Plan (PMA) outlines the procedures and guidelines to be implemented in order to limit the activities that may potentially affect the environment and society. The implementation of these procedures and guidelines will help to minimize negative environmental impacts that may arise throughout the different stages of the project.

The following environmental management plans are different in each of the project phases, which are: design, construction, operation and maintenance, and closing.

The environmental management plans are the following:

- Plan for the Prevention and Mitigation of Impacts
  - Plan to avoid climate change
  - Plan for the prevention and reduction of air contamination, noise and vibrations
  - Plan for the prevention and mitigation of soil contamination
  - Geology and geomorphology prevention and mitigation plan
  - Plan for the prevention and mitigation of water contamination
  - Plan for the prevention and mitigation of biological contamination
  - Plan for the prevention and mitigation of mobility deterioration and urban accessibility
  - Plan for the prevention and mitigation of damages to cultural patrimony
  - Plan for the prevention and control of landscape impacts
- Industrial Safety and Occupational Health Plan
- Emergencies and Emergency Response Plan
- Community Relations Plan
- Environmental Training Plan
- Waste Management Plan
- Plan for the Restoration of Affected Areas
- Closing and Abandonment Plan
- Maintenance Plan
- Monitoring and Follow-up Plan

7.1 CONSTRUCTION PHASE

7.1.1 PLAN FOR THE PREVENTION AND MIDIGATION OF IMPACTS

PLAN TO PREVENT CLIMATE CHANGE

The measures that apply to this phase in order to prevent and mitigate climate change are:

- The internal combustion motors of electric trains and engines must be perfectly calibrated according to the technical specifications of the manufacturers in order to minimize gas and CO_2 fossil fuel consumption. In addition, with the objective of maintaining the trains in perfect condition and operation, necessary maintenance must be performed.
- The preferred use of extremely energy-efficient motors.
- For any type of artificial lighting that may be necessary during the construction phase, energy efficient lighting will be used.
- Escalators will be equipped with a stop system for when they are not being used and will start automatically upon the presence of a passenger.

PLAN FOR THE PREVENTION AND REDUCTION OF AIR CONTAMINATION, NOISE AND VIBRATIONS

Control measures for air contamination due to particulate matter

One of the most important impacts related to the construction phase is the generation of particulate matter as a consequence of land excavations as well as a result of demolitions and transportation of the remaining excavation material and debris. There is also a risk involved in the transportation of cement, sand and lime debris, among others, as a result of construction activity.

In order to prevent or minimize the contamination of particulate matter in the air, the following measures will be applied:

- Establish standards for the maintenance and collection of debris in work zones, access roads, quarries, storage areas, affected areas, etc.
- Establish appropriate areas for the storage, merging and loading of construction materials. They should be located in areas where the soil is compatible with such activities. Nearby residential areas should be avoided in particular.
- Provide enclosures that physically and visually separate the activities that take place within.
- Implement the periodic use of water in construction zones in order to prevent the production of particulate matter due to wind.
- Cleaning and maintenance of vehicles that transport materials in order to prevent their wheels or other parts bringing mud to other areas and, which upon drying, may dirty its surroundings due to the wind.
- During the dry season, maintain exposed work areas wet, in order to minimize the spread of particulate matter.
- Cover and secure the stored materials and instruments used to transport soil in order to prevent the wind and the rain carrying them away.

Other activities to be implemented are provided in detail in the PMA.

Control measures for gas emissions air contamination

The most important impacts related to gas emissions as a result of the operation of construction equipment and machines throughout the construction phase are considered to be positive upon opening the first line of the Metro de Quito because it will contribute to vehicle traffic-reduction.

The following measures will be implemented in order to prevent or minimize air contamination due to gas emissions:

- Perform proper maintenance of all construction and transportation equipment in order to maximize their fuel efficiency and minimize the emission of contaminants.
- Establish a documentation process requiring contractors as well as sub-contractors to adhere to maintenance revisions of construction vehicles and equipment established in the legal provisions.
- Automotive and equipment contractors and service providers shall provide monthly reports of vehicle maintenance including their mechanical and physical state and the units' industrial safety elements.
- Establish a schedule for the operation of construction equipment, as well as preferred routes for transportation vehicles in order to minimize, where possible, the operation time of emissions.
- Attach a system of oxidation catalysts that will reduce the emission of CO_2, HC and particulates (PM10) to the diesel vehicle and equipment filters used in construction (when applicable).
- Design an Environmental Monitoring Plan (PMA) for all project areas to be addressed bimonthly in order to control the atmospheric contamination by gas emissions.
- For the purpose of preventing explosions and for the safety of workers (industrial safety), implement a plan to measure Volatile Organic Compounds (VOC) allowing for the detection of the presence of gases prior to advancing in underground projects and throughout the work of these projects.

Noise control measures

The greatest impacts regarding the generation of noise, during the construction phase, are related to machine and equipment use as well as other common construction activities that tend to temporarily increase noise levels.

The following measures should be taken in order to minimize the effects of sound produced throughout the construction phase:

- Establish time restraints for the projects, avoid working at night and avoid the noisiest activities, such as the use of jackhammers, during inconvenient times.
- Soundproof equipment and stationary areas where possible. Install silencers in escape tubes and noise dampers systems.
- Authorized service technicians will approve equipment use in regard to permissible noise levels, machine sound emissions, project equipment and motor vehicles.
- The performance sound screening in more sensitive environmental areas.
- Abide by all governmental standards, regulations and ordinances regarding the management of noise levels for any work related to the contract.
- Other activities to be implementer are detailed in the PMA.

Vibration control measures

The activities particular to the construction of the Metro include: the removal and demolition of structures, the continual movement of heavy equipment, the use of equipment and machines to perform excavations and drillings, movement of the drill head in the tunneling machine, as well as the Metro's infrastructure installation. These activities may cause ground vibrations. The principle measures that must be adopted and implemented in order to prevent or mitigate these vibrations are the following:

- When possible, all vibration-inducing elements (motors, servomotors, valves, etc.) will be uses on top of anti-vibration plates. Their distance from inhabited areas, and/or infrastructures and other structures that may be affected will be taken into consideration.
- Develop an optimal selection plan and use of the tunneling machine's drill heads, adapting it to the types of land (rocky, soil) as they pass through each of the tunnel's segments. This will be determined from the observations and findings that are performed throughout the excavation process and the results of the monitoring of vibrations in the surrounding areas and structures, with the objective of minimizing the generation of vibrations. The use of the tunneling machine is to be optimized in regard to the type of land it is drilling. For example, in regard to the rotation speed, considering the maximum axis length of the drill head (stroke) prior to retracting and relocating its supports in order to prevent eccentric rotation, etc.
- A permanent vibration-monitoring program will be established throughout the metro line, focusing on the sections to be developed in the tunnel and in the most vulnerable areas, such as historical buildings or buildings within the proximity of the metro line.
- Conduct structural integrity inspections of critical structures (pre and post-construction).
- Inform the public that live and work with in the proximity of the project. When necessary, the possible effects of the vibrations, control measures, precautionary measures will be provided, as well as the avenues of communication available to the general public.
- Notify the surrounding public when removal and excavation work is to be performed.

PLAN FOR THE PREVENTION AND MITIGATION OF SOIL CONTAMINATION

Preventative measures

Due to the slight risk that soil contamination may occur, a series of preventative measures have been established:

- Auxiliary activities will take place in areas with low environmental impacts and possible accidents may therefore be easily detected.
- Surveillance measures will be implemented in order to prevent uncontrolled oil or contaminant substance spills.
- Waste disposal will be performed according to current law and the petition for required authorizations will be requested when necessary.
- Specific areas will be established for the storage of fuel, lubricants, and toxic or dangerous products in which adequate measures to prevent leaks will be applied, in conformance with applicable laws.
- Appropriate tools will be located in areas identified as high-risk and in areas near to drainage systems in order to assure their easy access if necessary (shovels, buckets and absorbing materials).
- The best practices will be applied to oil and grease changes, the washing of machines and waste management, in accordance with the guidelines established both in the waste management Plan and in the training and education activities. Adequate storage in appropriate containers and removal by the authorized manager will be implemented.
- The appropriate use of waste or disposal sites that have the capacity to store generated waste and prevent soil contamination with leachates will be established. When possible, areas that have been used previously and have the capacity for such purposes will be used.

Corrective measures

The measures to be taken include:

- In the case of an accidental spill, workers are to detain and surround the spill using canals or containing barriers.
- The collection of the substance (grease, oil, lubricant, etc.) will be done using an absorbent material such as sawdust, sand, or a special cloth material. These materials will be considered as hazardous waste and their treatment and final disposal will be collected in the management of separate hazardous waste according to the waste management Plan.
- Disposal sites must be capable to handle the deposit of specific waste such as debris, soil, or rocks.
- Contractors are to obtain the appropriate administrative authorization from the project sites, workshops, concrete factories, etc. that could use unauthorized materials in the project. The contractor is not permitted to use such materials without submitting the appropriate authorization to the project's legal department and without their approval. The costs for obtaining such authorizations correspond to the contractor.

Compensation measures

The **Environmental Quality Regulation of soil and remediation criteria for contaminated soils (Book VI, Annex 2)**, does not include economic compensation in the case of soil contamination. It does, however, indicate the obligation to apply remediation procedures, the monitoring of remediation actions in order to meet the objectives or expectations established in the regulation, and to provide written notice to the Environmental Control Agency of applicable data. In light of this, compensatory measures will not be included here, however the correct application of the corrective measures mentioned above and established in the regulation, will.

GEOLOGY AND GEOMORPHOLOGY PREVENTION AND MITIGATION PLAN

The quarries that will be used throughout the project will undergo legal authorization and will have undergone an environmental evaluation process. These quarries must conform to the approved management plans current with the acting authority.

PLAN FOR THE PREVENTION AND MITIGATION OF WATER CONTAMINATION

Corrective measures

- All temporary and permanent installations will have diversion systems for surface runoff, which will be removed through existing drain collectors or hubs throughout the zone.
- Before the runoff is discharged, the waste collection site is to be equipped with surface water removal systems. These systems will be capable of diverting and leading the runoff waters collected in the waste site, as well as the exterior runoff waters, to the nearest drain.
- The equipment depot and workshop areas will be equipped with a tiered drainage system for the areas so that the flow caused by the area's waterproofing does not increase the risk for a flood or overflow the capacity of the drains used for its final discharge.
- In the case that fuel types are needed that are not sold at gas stations, the respective permits must be provided by the Ecuadorian environmental authorities. The temporary storage site must abide by the NT INEN 2266 as well as other regulations in the storage, transportation and management of hazardous substances.
- Hazardous materials (oils, greases, hazardous residue, etc.) will be stored in covered areas, equipped with protection from the sun and will not have contact with the outside environment. These areas provide the convenience of being equipped with a spill and leak collection system with a waterproof disposal unit for the collection of any possible waste that may be generated. The temporary storage of these types of materials must comply with the current environmental safety regulations.
- The equipment depot will have installations for the elimination of grease and oil from the waste water as well as the waste from the washing of trains in order for the water to incorporate into the urban processing system upon its discharge into the sewer system. If these installations cannot connect to the sewer system, it will be equipped with a waste water purification system appropriate for the properties of the waste water generated (water used to clean the trains, oils, greases, cleaners, etc.).
- In the case of drainage problems, the tunnel walls beneath the aquifer will be waterproofed.
- With regard to the screen or barrier effect at the entrance zone, the execution of the tunnel design will use the method titled "between screen," therefore evidencing the possibility of this phenomenon. It would not, however, have any negative affect since its variations would be comparable to the ranges similar to those produced by seasonal changes.

Complementary measures

Some complementary mitigation measures are to be incorporated in the improbable situation that the screen effect occurs, that is, if the water continues to flow above the infrastructure. In this case:

- The level of the roof slabs will be lowered and the provision of a filter material will be placed on top of them.

If the water proceeds to flow under the infrastructure, the following will be able to be determined:

- The opening of flood gates (hydraulic communication systems between both sides of the screen openings in the screen walls located under the inverted arch).
- The management of water transfers between the exterior wall surfaces.
- Water catchment and transfer system, from one end of the artificial tunnel to the other, by way of pumps, siphons and irrigation wells.

PLAN FOR THE PREVENTION AND MITIGATION OF BIOLOGICAL CONTAMINATION

Currently, the Metro de Quito maintains a site inventory of the forests that could be affected by activities performed throughout different stages of the project. This document is attached in Annex 14 of the Environmental Impact Study.

Preventative measures

- Protection through markings: with regard to trees of great importance that are not directly affected by the operation line and are relatively distant, with the use of plastic ribbon, a marking system will be used to delineate those protected areas in order to prevent the trespassing of the project's workers and equipment.
- Individual protections: Individual protection measures will be necessary for saddle trees, to which treated pine boards will be attached. These boards will serve the purpose of protecting the trees against accidental contact with equipment. This may be necessary in the isolated cases of small forests that are not directly affected by, but are very close to, the operation lines. The trees from El Ejido Park are the principal trees of concern as they are considered to be cultural patrimony.
- Transplants: Transplants will occur with those large living trees located in the areas of the construction sites that are either isolated or part of a collection of trees, and which are under favorable conditions for transplant. When the trees are of a great size, the transplant will be performed with special transplantation equipment that can sequentially extract, transport and plant the tree, in addition to digging the destination hole for transplant. In the construction of the Metro, it will be verified that only trees that are absolutely

necessary for its construction will be cut down. It will also be verified that they will be transferred to a supportive environment in a public area. The rescue and relocation of flora in auxiliary areas that have important ecological vegetation, that are of financial importance, or whose populations are threatened, will also be performed. When trees are cut down flora rescue workers are to be located at those sites in order to collect plants of interest. The rescue of flora will be performed in constant coordination with the applicable environmental authority.

PLAN FOR THE PREVENTION AND MITIGATION OF MOBILITY AND URBAN ACCESSIBILITY

Preventative measure to be applied throughout the construction and project phase

The following measures will take place for the purpose of reducing the impact of road obstructions, or the barrier effect, for traffic as well as for pedestrians:

- The management plan should integrate routes, schedules and procedures in order to ensure the minimum impact to city traffic.

  a) A basic traffic lane is to be established to ensure that there will not be blockades or alterations.

  b) The plan for traffic detours, obstructed or altered lanes, and their duration time is to be defined clearly. This plan will also include the areas that are to be temporarily used by pedestrians.

  c) The bus, Trolley, and other transportation systems will be restructured to avoid the project zones, keeping in consideration the similarity to and proximity of the normal route.

  d) Signage and instruction for pedestrians will also be installed for the purpose of creating the least amount of inconveniences possible.

  e) When possible, the project work will always take place during the times that least affects pedestrians and traffic, such as at nighttime, given that sound is not an issue.

  f) Signal and establish the routes to be used by heavy machinery.

PLAN FOR THE PREVENTION AND MITIGATION OF DAMAGES TO CULTURAL PATRIMONY

Preventative measures

The following actions will be taken with regard to the archeological components of the project:

- Perform archeological monitoring: This measure will be executed parallel to the removal of soils of the infrastructure projects. Archeological monitoring will occur to recover any archeological evidence or information still remaining in the ground floor after having performed exploratory surveys and retrieval.

- Regarding Historic Center buildings declared as a World Heritage Site of humanity or simply of great historical and cultural value, the following preventative measure will be applied during the construction phase in order to protect urban and architectural patrimony.

- When construction begins, monitoring tests will be performed in non-critical zones in order to confirm or discard the possibility of superficial vibrations. This will allow, according to the case, the coordination of actions with the IMP for the implementation of specific protections at critical points prior to the tunnel excavations.

- Those sites within greater proximity of the project's direct influence that are considered to be of patrimonial interest, will be inspected before and during the tunnel's excavation process with the purpose of verifying the site's state and monitoring the existence of vibrations. If deemed necessary, protection measures will be coordinated with the IMP.

- Elastomer protection will be installed in sensitive zones in the Historic Center in order to reduce vibrations, however many or whichever kind that may be.

Corrective and compensation measures:

If archeological discoveries are made throughout the archeological control and monitoring of this project phase, a conservation proposal will be developed based on an interdisciplinary study of the mobile archeological findings, and future findings, in the Archeology Project of the Metro de Quito. The Management Plan of Cultural Property will also be involved. Similarly, if archeological discoveries are made during this phase its social value will be considered too, as defined in the design phase of this plan.

A slide, collapse or tumble of an identified nearby building could partially or completely ruin its foundation and/or structure. The following is recommended in that case:

- The contractor is to comply with the requirements defined by the regulating authorities, according to the type of drilling performed and to the distance from residential and structural areas, including historical monuments and patrimonial resources. The contractor is to also comply with all local and international standards regarding to vibrations caused by construction processes.

If necessary, a Restoration or Reconstruction Plan should be developed for those historic monuments or patrimonial resources that may have been affected by the construction.

PLAN FOR THE PREVENTION AND CONTROL OF LANDSCAPE IMPACTS

The measures to be applied during the construction phase include:

- Only perform the necessary removal of shrubs in the green areas where structures of the first line of the Metro de Quito are to be installed.
- Restore green areas affected by project construction.
- Propose and consider the possibility of new green zones in the areas affected by the project.
- Restore and replace vegetation of the waste deposit areas upon termination of the project. The restored waste area could be used as a green space, area for sports, etc.
- Take advantage of the station access areas to establish parks and gardens which offer environments that reduces the visual impact of the Metro installations.
- The surface level areas of construction will be equipped with surrounding fences that act as visual barriers near the areas most frequented by individuals. Local artists may decorate these fences with the object of improving its integration into the landscape.
- Walkways, outdoor displays, and structures that allow the observance of the present cultural patrimony will be constructed in the San Francisco Plaza and in stations that are near testimonies of cultural patrimony throughout the project.
- The Metro entrances will be designed to integrate into the urban and architectural environment in which they are located.

7.1.2 INDUSTRIAL SAFETY AND OCCUPATIONAL HEALTH PLAN

Within the organizational structure of the Metropolitan Public Corporation Metro de Quito is a Social Responsibility Unit which consists of three departments of the General Office: 1) Safety and Occupational Health, 2) Environmental Protection, 3) Social Action; in addition to Department Assistance. With regard to the field of Safety and Occupational Health, this Unit has identified three essential lines of action of common interest.

1) Construction Phase Project Management and Control.- Considered being of vital importance for the prevention and protection of the workers, contractors, and general public. The control is to start from the beginning of construction with the expectation of developing an administration system within this line of action for its implementation throughout project construction.

2) Safety and Occupational Health Management.- Based on the implementation of the previous point, this department consists of the consolidation of a structure for documentation that serves as a base for the administration of safety and occupational health resources.

3) Interaction with Citizens.- Interest in the community's well-being and a healthy relationship with the community are considered to be part of the construction phase. From an integrated point of view, the external communication with regulatory organizations, with residents, and with interested parties should be structured according to minimum standards of action and should be in compliance with the responsible implantation of safety measures.

At minimum, to support an efficient management of the organization, the three lines of action should be placed in the context of legal compliance and applicable technical specifications.

A general description of the implementation of the Safety and Occupational Health Plan:

Commitment of the Office.- the Office's commitment is an initial step of the challenge of introducing regulations in the different construction phase activities.

Project planning and organization.- Initially, a chain of command will be established regarding responsibilities and authority of the project supervision. Responsibilities and obligations and the line of command of the construction phase (from the management of contractors, subcontractors and general employees to the abidance of legal stipulations) will be described.

Identification of risks.- During the construction phase, Safety and Occupational health has been chosen as a base for management. Here, the different types of risk factors such as physical, chemical, mechanical, ergonomic, psychosocial, biological and related prevention measures are described. Additionally, an outline related to its assessment for quality management is to be applied (Annex 16 of EIA). Potential risks due to grave accidents such as fires, explosions, floods or seismic activity are also described.

Development of documentation.- The elaboration of easy access to documents and control mechanisms is fundamental for communication and safety during the construction phase and the facilitation of their immediate application. These documents also serve as a learning mechanism for new staff. Documentation is designed to be accessed by and applied to all workers. The following mention control risk identification documents:

- Work executed by electric networks
- Operation of heavy machinery
- Projects involving lifting machines
- Excavations and trenches
- Welding
- Underground excavations
- Use of personal equipment protection

- Signage procedures
- Fire protection and prevention
- Preventative medications
- The transport of injured and sick individuals
- Medical examinations
- Regulations for pregnant women and vulnerable populations
- Verification indicators and measures

Emergencies and emergency response.- In implementation of the Emergency Plan, the principal responsibilities will be assigned to the Project Manager, Project Supervisor, Areas Supervisors, the Department of Health, Safety, Environment and Community, and contracting agencies. These responsibilities and obligations are described at length in the document. Specific regulations include the duty to:

Train each employee to recognize and prevent situations that could be risky.

Train required employees on how to react in the case of an emergency.

Ensure that employees abide by the respective national and international regulations.

Train required employees on the nature of the dangers involved, the necessary precautions to be taken and the use of mandatory protection and emergency equipment.

These regulations are found within the basic action policies and priorities.

The structure of the emergency and emergency response plan is organized into the following components:

- Spill prevention and retention measures
- Emergency response measures
- Safety provisions
- Definition of responsibilities
- Emergency action plans
- Equipment and material for the control of emergencies
- Trainings and simulation drills
- Revision and update of the plan
- Injury classification criteria

The plan's organization requires procedures such as information and action instruments that are part of the safety provisions as indicated below:

- General action procedure for emergencies
- Action procedure for fuel or lubricant spills
- Action procedure for near-fire incidents
- Action procedure for fires
- Action procedure for occupational accidents
- Action procedure for chemical substance accidents
- Action procedure for accidents with a biological risk
- Action procedure for the collapse of the crown of the excavation front
- Action procedure for the flooding of the excavation front of the tunnel
- Action procedure for an explosion
- Action procedure for the sudden change of the infrastructure during underground excavation
- Action procedure for the loss of electricity supply in underground excavations
- Action procedure in the case of an encounter of contaminated soil
- Action procedure for natural disasters: earthquakes

Continual follow-up and improvement.- The relevance of documentation as well as its application will be evaluated through initial inspections and an internal audit. This will generate preventative and corrective actions of aspects that are not in conformance with the system, thus not allowing its optimal use.

7.1.3 COMMUNITY RELATIONS PLAN

OBJECTIVES

The objectives of the Community Relations Plan are i.) To implement a process for a permanent and inclusive relationship among different parties throughout all phases of the project, establishing an the relationship early in order to create a positive environment between the different parties; ii.) Promote a participatory process related to the Metro which is part of the Integrated Mass Transit System; iii.) Achieve a good relationship with social parties based on essential and intangible aspects such as trust, mutual respect and understanding; iv.) Establish a dialogue with the community in order to prevent situations of conflict throughout the construction and operation of the Metro.

SCOPES

Political: Spread information on the commitment of the local government, the Municipality of Quito, of the execution of this important project. Provide information to key players, councilors, parish associations, neighborhood leaders and to presidents of affected neighborhoods.

Technical: Provide information on the technical aspects of the project, on benefits to citizens, and on the improvement of mobility in the city as well as general benefits.

Citizen: Provide detailed information to the neighborhoods affected by the project, issue timely notices, and execute workshops with affected neighborhoods in which agreements and commitments are established. Encourage the empowerment of proposals and strategies.

ACTIONS

According to each of the scopes, specific actions and their respective results are to take place.

It is important to work in all of these areas, to milestones in the development of the project, and to begin the project aspect of citizen empowerment as soon as possible.

Macro-level mass campaigns and specific circulation of information, workshops, events and other BTL strategies are proponed to be incorporated.

PHASES:

- **Initial:** speak to the benefits of the project and distribute mass information on it
- **Middle:** perform specific actions with specific groups, focusing on the key players and affected areas.
- **Final:** reinforcement of the proposal and support of the project development.

In each of these phases, coordination with the head company of the project will take place in order to establish actions in agreement with the project's progress and the implementation needs of the project.

7.1.4 ENVIRONMENTAL TRAINING PLAN

The idea of the environmental training plan, in addition to the implementation of workshops, is to establish and offer a continual and integral training program so that the staff involved, especially the managers and supervisors, has a greater understanding of the environmental aspects related to decision making. As a result, managers and supervisors may involve staff specialized in environmental issues as fundamental parts of the team. Training the team of staff will serve to clarify any confusion or to apply acquired knowledge at necessary moments of the project, whether that is the construction, operation and maintenance or closing phase. Specifically, the public will be more aware and informed of the area affected by the project.

Give a face to the **project staff**, whether they are contracted by the construction company, are subcontractors or are service providers. In this case, three important issues are at hand for the proper development of construction activities, operations and management. They include:

- Occupational safety, an issue previously discussed in the **Industrial Safety and Occupational Health Plan.**
- Emergency procedures, as developed in the **Emergency and Emergency Response Plan**.
- The **Waste Management Plan** will be included in this issue and **is outlined in the following section,** which already contains a specific training plan. Environmental protection also requires the incorporation of the knowledge that is described in the structure and content section.

With regard to **the local population and other interested parties** affected by the project, social and ecological groups, or neighborhood associations; informative talks on the following are scheduled:

- Information is to be provided on the measures that will be applied to minimize negative effects, always mentioning that these impacts will only occur during the project's construction phase and that once the Metro is in operation, the levels of these contaminants will decrease substantially, improving the city's air quality from its current state.
- Explain the limitations that are a result of the new infrastructure or the problems that may occur in the future, with regard to the operation of the road infrastructure. This is also in regard to the education and information of the project's environmental benefits and the behavior that is appropriate in the use of this form of transportation. The public should understand these changes compared to other transportation systems, such as the type of energy that is used, the waste that it produces, etc.

Since this plan will be progressive, more so in the project's operation phase, the talks included in the Environmental Training Plan will vary depending on need and on personnel contracts. Nevertheless, the number of people expected to be contracted is high in the construction phase, at almost 2,200 people.

- Existing risks
- Treatment of hazardous and recyclable waste
- Project signage

COURSE	WORKERS		PUBLIC, AFFECTED AND INTERESTED PARTIES - DURATION	COMMENTS
	GENERAL TRAINING - DURATION (INITIAL/ RECYCLING)	SPECIFIC TRAINING – DURATION (INITIAL/RECYCLING)		
Erosion and sediment control	30 min / 5 min Annually	30 min / 5 min Annually	In the general training workshops, a short explanation of these phenomena will be provided	
Hydrocarbon and chemical spill control	30 min / 5 min Annually	30 min / 5 min Annually		

COURSE	WORKERS		PUBLIC, AFFECTED AND INTERESTED PARTIES - DURATION	COMMENTS
	GENERAL TRAINING - DURATION (INITIAL/ RECYCLING)	SPECIFIC TRAINING – DURATION (INITIAL/RECYCLING)		
Sanitary, hazardous and non-hazardous waste management	30 min / 10 min Annually at minimum	1 hour / 10 min In this case, recycling will occur quarterly	10 min This will occur as often as the general talks that are given during the construction phase	Included and budgeted for in the waste management plan
Existing risks: spills, slides, and floods	30 min / 5 min Annually	30 min / 5 min Annually		Technical knowledge is needed to understand and absorb this content. In order to avoid confusion, the general public will not be informed.
Flood, swelling and overflow risks	30 min / 5 min Annually	30 min / 5 min Annually		
Safety and health	Safety: 2 hours annually Health: medical care, 2 hours annually	Safety: 3 hours annually Health: medical care, 2 hours annually	The necessary information will be available to users and affected and interested parties at all times as indicated by the corresponding laws.	Budgeted for in the Work Safety and Occupational Health Plan Pamphlets and posters will be displayed in the train stations as a reminder of the mandatory signage.
Emergencies and emergency response	2 hours Annually	3 hours Annually	The necessary information will be available to users and affected and interested parties at all times as indicated by the corresponding laws.	Budgeted for in the Emergency and Emergency Response Plan Pamphlets and posters will be displayed in the train stations as a reminder of the mandatory signage.
Air, water and soil contamination.	1 hour / 10 min Annually	1 hour / 10 min Annually	1-2 hour talks (4 total, a priori) Frequency: initial 2 hour workshop + 1 hour workshop during the 3rd month	
Cultural, historical and archeological resources	15 min only once at project start	30 min only once at project start		If there is reason to include new topics, they will be included under annual recycling.
Extraction of natural resources	15 min / 5 min Annually	30 min / 5 min Annually	An annual workshop to occur throughout the construction phase. Instructional pamphlets and posters to be located in public spaces and in the interior of the stations upon initiating use of the transportation system.	Basic training on natural resources for the public and interested organizations.
Basic environmental law and Ecuadorian fines issued upon the failure to abide by them	30 min / 5 min Annually	30 min / 5 min Annually		If there is reason to include new topics, they will be included under annual recycling.
Environmental effects of the city's mobility model change	30 min / 5 min Annually	30 min / 5 min Annually		
Social, environmental and economic benefits of the project	1 hours / 10 min Annually	1 hours / 10 min Annually		
Total expected minimum training hours	12 initial hours 7 hours on recycling annually	15 initial hours 9 hours on recycling annually	5 hours disbursed throughout the 3 years and 1 month of the project duration	

Source: Prepared by us

7.1.5 WASTE MANAGEMENT PLAN

To ensure that the Waste Management Plan is a success, it will be important to consider the following:

- Appropriate methods of disbursing this plan to all participating individuals will be implemented both in the construction and operation phase.
- The principles and standards of the BEI and the agreements and recommendation of the International Labor Organization (ILO) will be observed.
- Appropriate authorities will adopt the necessary measures to ensure waste management is executed without endangering human health and without damaging the environment. Specifically:

  a) Threats to water, air, soil or flora y fauna will not be generated.

b) Noise or smell disturbances will not be present

- Landscapes or legally protected special interest areas will not be affected negatively.
- In the development of policy and legislation regarding waste prevention and management, the applicable authorities will attempt to obtain the best results in the world. Below is the waste hierarchy listed in order of priority.

  a) Prevention

  b) Preparation for re-use

  c) Recycling

  d) Other uses, including energy recovery

  e) Elimination

- An appropriately planned and executed Waste Management Plan will reduce the potential damage to the environment. Therefore the proper training of workers and an adequate disbursement of the plan are of vital importance for the success of its application.
- Employee trainings will be performed so that they may correctly select waste materials and may adequately identify and classify them.
- In waste generation areas, the provision of adequate waste storage areas will be provided.
- It will be encourage that waste storage shall be executed independently, separating it by type.
- It will be mandatory to store waste considered to be hazardous in appropriate and covered storage containers under adequate safety conditions. Necessary measures will be taken in order to prevent environmental damage due to spills or leaks.
- For the purpose of making the metro more sustainable, more affordable, and to minimize the transportation of waste, and to least affect the environment, the re-use of waste will be encouraged when possible within the project site of the first line of the Metro de Quito where it was generated. In the case that the waste may not be re-used within the project, other nearby projects will be contacted for its re-use.

ADOPTIVE MEASURES TO IDENTIFY AND TREAT WASTE IN THE PROJECTS OF THE FIRST LINE OF THE METRO DE QUITO

HAZARDOUS WASTE

Hazardous waste is defined as waste that is included in the national ***lists of chemical, prohibited, hazardous and extremely restricted use products in Ecuador***. It is also defined as waste that is classified as hazardous according to **current regulations**, that the **government may regulate**, as well as according to the contents listed on containers and packaging.

INERT WASTE

Among the possible waste generated in the project, the following will be included under this classification:

- Containers and packaging of raw material, products and equipment.
- Paper, glass, plastic and other office materials.
- Vegetation waste produced from the clearance of pre-existing vegetation.
- Soil produced as a result of excavations.
- Wood produced as a result of the structural framework, pallets used to transport materials, wood from the construction of auxiliary buildings, etc.
- Organic waste produced from clearing and from provisional services installed throughout the project.
- Methods for the selective retrieval of this type of waste will be established as part of the project. They will be deposited in nearby deposit stations, which will later assist in their re-use and recycling.
- Upon collection, waste will be treated according to their classification under the management of an authorized management company.
- The collection method should be perfectly indicated with signs and understood by all of the project's workers.
- The surplus soil and vegetation material remaining after the aforementioned clearings and excavations will be transported to a disposal entity authorized by the appropriate administration. Vegetation will be stored and conserved for use in the following vegetation replacement processes.
- The washing of concrete barrels from within the project site will be prohibited; they are to be washed instead at corresponding plants or authorized areas. Specialized areas, however, will be established within the project site in order to exclusively wash the barrels' pouring gutters to prevent the dirtying and staining of public roads with the concrete remains upon returning to the cement plant. These gutter cleaning stations will be well signed and will be located far from drains, sewers, or existing sanitation networks. Once the remains are ready, they will be treated as inert waste.

SEGREGATION OF “IN SITU” WASTE AND REUSE OPERATIONS PROVISION

The identification, pick-up, storage, transportation and safe management of the waste generated in the Works will be controlled, whether these are inert, urban-like or hazardous. For this, waste will be divided into Hazardous, Inert and solid-urban like and their management will be done according to effective legislation, through an authorized manager. There will be control to ensure that the provisions of the pertinent **Waste Management Plan**, approved by the pertinent Administration, are complied with. Specifically, proper waste management will be controlled by contacting the pertinent **authorized managers**. Proper **labeling of hazardous waste** will be controlled, pursuant to the data prescribed under the law, and its will be stored indoors to avoid damage and their containers will be duly separated, as shown in the pictures below:

Source: Our own preparation

Source: Prepared by us

An **ENVIRONMENTAL MANAGEMENT MANUAL FOR THE WORKS** will be prepared according to current environmental legislation – local, national or international. It will be delivered in triplicate and the minimum scope will be:

- Management of urban solid waste generated by the works’ staff.
- Management of hazardous waste from demolitions and disassembly.
- Management of debris from demolitions and disassembly.
- Environmental protection and aesthetics of the areas where the Works will take place.
- Transplantation and protection of affected vegetal units, as well as replacement.

Environmental Waste Management

The recommended waste management for key works materials is as follows:

- Aggregates: will be collected separately by size fractions and protected from possible environmental and especially soil pollution. The pollution from mud that trucks and loaders could drag will be prevented.
- Prefabricated structural: Timber separators will be placed between the elements and the floor for storage, to guarantee perfect support of one element on another, as well as on the ground.
- Corrugated steel: will be isolated from soil moisture, classified by type, diameter and origin.
- Factory materials: will be stored in pallets, up to a maximum height of two meters.
- Paints: will be stored in places protected from the elements, away from possible knocks or drops of material and special care will be taken when paints are toxic or flammable.

SPECIFIC TECHNICAL PROVISIONS REGARADING STORAGE, HANDLING, SEPARATION AND OTHER WASTE MANAGEMENT OPERATIONS RELATED TO THE WORKS’ CONSTRUCTIN AND DEMOLITION WASTE

Construction and demolition waste management

Conduct waste management pursuant to regulations and requirements as indicated above, identifying them pursuant to the above rules, or otherwise under the European Waste List published by Order MAM/304/2002 of February 8th, or its subsequent amendments.

Segregation, treatment and waste management will be implemented through appropriate treatment by approved companies into industrial containers or bags that comply with the specifications set forth in current legislation.

COMMUNICATION, TRAINING AND EDUCATION

Below are some specific measures to be taken into account regarding waste management.

For the construction phase, all the staff must be committed to comply with proper waste management; avoid disposing of waste in areas that are not ready for it; and report any instance of inadequate management. The staff will receive at least one general lecture about the importance of reducing and controlling waste; they will receive specific workshops every three months and specific training on hazardous waste management, as stated above. Key actions related to training and communication will take place periodically (every three months); an additional activity could take place if it became necessary (for example: due to a spill or accidental leakage).

The main objectives of the training offered will be to show the staff how to properly manage waste and to promote the importance of reducing waste, inasmuch as possible.

MONITORING AND FOLLOW-UP

There should be control of the way measures are being applied and the degree of compliance with the objectives set.

In the case of waste, ensure that measures are being properly adopted to identify, record, separate, store, reuse, recycle and dispose of the different substances.

To ensure that the Waste Management Program is being properly implemented:

- Environmental aspects will be taken into account: detection of potential unexpected impacts (accidental spills, excess waste accumulation, etc.).
- A specific monitoring will be implemented: a follow-up on the different protection measures and training; establish if the measures are enough to ensure proper health conditions, to avoid waste accumulation, to properly dispose of them; and apply hazardous waste management, as established.
- Periodic monitoring and follow-ups will be done to verify the degree of success of the measures implanted.
- The reporting frequency will be set through reports every 2 months to the pertinent environmental authorities.

TAILINGS MANAGEMENT PLAN

Introduction

Waste generated by the removal of soil for Metro construction is classified as debris, which have a single destination: dumps. All kinds of debris are placed at tailings, with various fillings depending on the area, location, shape, height and type of ravine, which is suited to receive rubble and debris from the construction. This specific environmental management plan was prepared for tailings' management, as part of the overall environmental management plan for the First Line of the Metro de Quito Project.

In the case of Quito, the EPMOP manages tailings for public use. Currently this entity authorized citizens to use the tailings: Troje II (South) and Oyacoto (North). It is also anticipated that these will some material removed from the Metro works. Additionally, for the specific case of the Metro de Quito it has been suggested having tailings at ravines in El Batan, Jatunhuayco and Sibauco, which aims to manage waste in a manner consistent with the laws, regulations and technical specifications established by national environmental organizations, in addition to advice from European entities. The latter, according to their experience in building subways around the world ascertain the potential waste that will be generated in the construction of an underground metro.

7.1.6 REHABILITATION PLAN FOR AFFECTED AREAS

As previously mentioned, the Rehabilitation Plan for Affected Areas is to ensure that those areas affected by the works of the First Line of the Metro de Quito, are rehabilitated or restored to be left in a state similar to the one previous to the works or even better (as much as possible bring it back to its original appearance). The strategy is to make a preliminary assessment, identify urban points that will be affected and apply the specific measures proposed below.

Measures to rehabilitate Green spaces: parks and gardens

Given the value of green spaces in urban areas, and particularly in a large city such as the city of Quito, in the event of changes, these must be rehabilitated to return to its state before the works. There is even a possibility to improve areas that may be without use and with damaged vegetation or furniture because by installing an underground station these would regain activity and visibility.

The main measures to be adopted are:

- Preparation of reports and compilation of graphic and photo materials of those garden spaces that will undergo changes.
- Remove important elements before the start of the Works and keep them in municipal storage (for instance statues or water fountains from parks and gardens).

- Landscaping that allows identifying areas for tree planting and revegetation.
- Design and rehabilitate paths or walk ways that were affected, as well as any signage, urban furniture or public ornament.
- After the Works are completed, grass will be planted, revegetation will be inserted and trees will be planted in areas with bare soil (with local species). To this end, we will use soil from the upper vegetal soil layer that would have been gathered and withdrawn prior to the works.
- Efforts will be made to improve the quality of the vegetation and to insert automated watering systems.
- Monitoring and follow-up of this actions will be conducted, as well as verification of the survival and adaptation of the species planted.

Measures to rehabilitate quarries or tailings

In addition to any effect on the landscape, disposal of debris or open pit exploitation of a given material also causes hazardous conditions for people and cattle, loss of land productive for other activities (recreation, agriculture), or subsidence issues.

7.1.7 CLOSURE AND ABANDONMENT PROGRAM

As mentioned, in the auxiliary areas the closure stage is when these are no longer in use, i.e. at the end of the work phase of the project. To this end, existing structures in prefabricated areas will be dismantled, which will be relocated to other sites in other projects, by their owners. Meanwhile, material storage areas will be refurbished and used by the owner for other project. In either case, the Closure Plan shall include:

- Materials, equipment and debris must be picked up. Machinery, works booths and other auxiliary facilities, such as camps, must be dismantled.
- Dismantling of outdoor infrastructures. This means both temporary infrastructure setup during the construction phase and permanent subway infrastructure in the event of the closure of the subway or a part thereof, such as the entrances to the subway, ventilation shafts, pumping pits, emergency exits, etc.

As has indicated in this EIS, once the construction phase ends, attempts will be made to return the area, inasmuch as possible, to its original state, taking into account environmental, social and aesthetic criteria. As minimum the following actions will be implemented:

- Removal of materials.
- Relocation of removed urban structures and furniture.
- Habilitation of affected roads.
- Revegetation and tree planting provided the conditions call for it.
- Reinstallation of any potential energy, communications and water systems that might have been moved.
- A Restoration Plan of the Affected Areas (as described herein, and that includes the restoration of the tailings), to which we will add the restoration of the areas occupied in the construction and works phase, such as camps, machinery parks, workshops and other complementary areas:

As already indicated in the description of the First Line of the Metro de Quito Project, attack wells will be constructed, where the TBM's work will be setup and started. This area should also be restored.

As already specified in the Prevention and Mitigation Plan for the Impact on Bio Communities, there will be rescue and relocation of vegetation in ancillary areas that will be occupied or simply affected; that contain elements of ecological/economic importance or if their populations are threatened. Plant species will be rescued before the start of cleaning and uprooting of vegetation, i.e. before they suffer any kind of affectation. This is the case of "large" trees that are located in the park where El Ejido Station will be built.

Other areas that need restoration on completion of the construction phase are the extraction wells, which are needed for disassembly and removal of the TBM, and gathering areas of material and machinery (such as voussoirs parks) that are expected to be located in the vicinity of these wells.

As there will be different sections where the TBM will be used, which are not consecutive, there will be several attack and extraction wells:

- La Solanda: attack well
- La Magdalena: extraction well

7.1.8 ENVIRONMENTAL AUDITS

There will be internal audit reports, in the case of the construction phase, an audit will take place on the second year by the Contractor through expert and pre-qualified consultants, including nonconformities related to the EMP. The reports of this audit will be distributed to the UNMQ. In the event the Contractor fails to follow environmental procedures, UNMQ will take this as nonconformity with the procedures and will take appropriate actions to ensure future compliance. Any report of noncompliance will be followed by monthly inspections until compliance is proven. The audit report will include environmental compliance statistics.

All environmental incidents during the construction phase will be documented and UNMQ will receive a quarterly report that includes an executive summary. Significant incidents will be reported immediately to UNMQ and the competent authority.

7.1.9 MONITORING AND FOLLOW-UP PLAN

Monitoring programs cover major variables identified as most powerful and which may be subject to periodic monitoring, including:

- Air quality
- Noise
- Vibrations
- Water quality, including liquid effluents and superficial and underground bodies of water
- Soil
- Biotic variables
- Socioeconomic variables
- Monitoring on the effects on mobility
- Monitoring of archaeological variables

Each of these monitorings shall cover the following:

- Select the sites to be monitored.
- The water analysis will record pH, temperature, conductivity, turbidity, biochemical oxygen demand, dissolved oxygen, total solids, suspended solids, total hydrocarbons, fecal and total coliform, PHAs and oils and fats.
- During the construction phase the sites selected will be monitored every 3 months.
- Comparison of monitoring results with those obtained for the baseline, i.e. before the start of the bridge's construction.

As for the seepage water, as mentioned above, during the construction phase of the Project, there will be groundwater seepage into the inside of the tunnel and underground excavations (stations). These waters may contain pollutants such as oil and grease, heavy metals and other polymers, and others. Therefore, these should be treated properly before being discharged into surface water bodies. For this reason, during construction a **monthly monitoring of recovered seepage water at a point upstream and one downstream of treatment points** should be carried out. This monitoring will continue during the operation phase on a **semiannual basis**. The parameters to be monitored are the same as listed above for monitoring surface waters.

Also groundwater from the aquifer in the South side and North Central sides of Quito will be monitored. To do this, the research surveys conducted for the design of infrastructure will be used. At least one poll will be monitored every 5 km in length of infrastructure.

MONITORING PROGRAM FOR THE ENVIRONMENTAL MANAGEMENT PLAN

The objective of this program is to monitor the implementation of the Environmental Management Plan which will be held in accordance with the commitments made to the environmental authority and facilitate the identification and correction of any plan's anomalies or inconsistencies.

Each of the programs that make up the Plan should be followed-up, monitoring compliance with whatever is specified in each of them, both as regulatory compliance and the performance of necessary activities to be done, and compliance with the schedule developed.

This monitoring will be annual during execution and will be measured based on the level of implementation achieved which will be calculated by comparing the amount of activities planned and actually executed. The classification is as follows:

- **Compliant (C):** This rating is given when the activity's percentage of compliance is 100%.
- **Minor non-conformity (NC-):** This rating implies a misdemeanor against the Environmental Management Plan and/or applicable law, within the following criteria:
  - Easy correction or remediation
  - Quick correction or remediation
  - Low cost correction or remediation
  - Event of small magnitude, specific extension, low risk and minor impacts, whether direct and/or indirect.
- **Greater non-conformity (NC+):** This rating implies a serious offense against the Environmental Management Plan and/or applicable law. An NC+ rating can also be applied when there are periodic repetitions of minor non-conformities. The rating criteria are as follows:
  - Difficult correction or remediation
  - Correction or remediation that requires more time and resources, human and financial.
  - Moderate to large magnitude event.

- Potential accidents may be serious or fatal.
- Evident recklessness, lack of resources or negligence in correcting a minor problem.

7.2 OPERATION AND MAINTENANCE PHASE

7.2.1 IMPACT MITIGATION AND PREVENTION PLAN

PLAN TO CONTRIBUTE TO AVOIDE CLIMATE CHANGES

Some of the identified measures are:

- Electric motors are to undergo the maintenances stipulated by the manufacturer in order to maintain the engines' energy efficiency. The specific maintenance plan shall be drafted after purchasing the electric engines.
- An energy audit of the First Line of the Metro de Quito will be conducted biannually to detect possible inefficiencies and correct them, if pertinent. During the operational phase biannual audits will be conducted.

PLAN TO PREVENT AND REDUCE AIR POLLUTION, NOISE AND VIBRATIONS

MEASURES TO CONTROL AIR POLLUTION DUE TO THE EMISSION OF SUSPENDE PARTICLES

As for the operating phase, because the Metro will operate using electric power it is not expected to generate any type of particulate material to the atmosphere.

MEASURES TO CONTROL AIR POLLUTION DUE TO GAS EMISSIONS

As for the operating phase, because the Metro operate using electric power is not expected to release any pollutants into the environment. On the contrary, it will contribute to the reduction of greenhouse gases into the atmosphere, by reducing the number of vehicles that circulate in the metropolitan area of the city of Quito. Therefore, the Metro is a corrective measure in itself, by reducing air pollution in the area.

MEASURES FOR NOISE CONTROL

In the operating phase, since the Metro circulates underground, is not expected for the noise generate during operation to be a nuisance outdoors. Generally, in this phase the noise will be generated by the Metro's travels - when the wheels come into contact with the rails, at the time of braking, taking a bend, making a turn, or changing pathway. Similarly, the pounding of the wheels with the rails joints and on their way, may cause excessive noise if the rails are not adequately supported. In addition, the PA system in the stations, and ventilation systems can also generate nuisance.

The following are some measures to be implemented to minimize noise effects during the operation phase:

- Inasmuch as possible, optimize the railway sleepers and rails to minimize contact between rigid materials that generate greater noise
- Comply with the Periodic Maintenance Program to grease all wheels of all subway cars and do maintenance on roads and lanes.
- Periodically turn the wheels as necessary and verify that they conform to the rails, in order to smooth the vertices and thus reduce the emission of noise, especially while braking and cornering.
- Soundproofing treatment on the station platforms to prevent multiple reflection phenomena to increase the noise level in the environment.
- Install physical, vegetable screens or insulating material, mainly in areas where the elevated sections are located (courtyards and workshops), to act as acoustic barriers.
- Implement monitoring, surveillance and control measures such as visual inspections and periodic monitoring of noise levels.
- After the commissioning of the Metro is recommended to conduct an acoustic survey in order to identify the most problematic acoustic sections and the need to implement corrective measures in these.
- Proper control of the PA system in the stations.
- Place acoustic panels in station platforms to absorb noise.

VIBRATION CONTROL MEASURES

In order to minimize potential impacts due to vibrations generated due to the Metro's movements, while after it starts operations, the following measures are recommended

1. As a very high vibration attenuation system, two solutions are proposed: Using the Vanguard type fastening system or similar (to allow for attenuation of vibrations in the same range). It can achieve 25 dB attenuation to minimize the contact point between rigid materials and achieves an adequate distribution of the loads transmitted to the supporting structure using flexible substrates.
2. Improving attenuating of the fastening system through a stick-on plate or similar type by providing an elastomeric blanket under the batting concrete as defined in sections plans (Chapter 11 of Document number 2, Plans). This system can achieve a maximum attenuation of 20 dB. An elastomeric blanket system with higher capacity and lower natural frequency available will be used, as those based on polyurethane, Sylomer of Getzner type or similar.

3. With these data and criteria we have established the sections where vibrations and noise attenuation will be improved.

Additional measures

- Periodically review and verify the status of the rails and the wheels of all subway cars.
- Meet the periodic maintenance schedule to reprofile rails, grind and lubricate wheels of all underground trains and track maintenance.
- Ensure that there are no damaged sleepers, that the rail is properly secured to the sleepers and the rail is properly secured to the switches.

Implement monitoring, surveillance and control measures, such as visual inspections and periodic monitoring of vibration levels and the behavior of buildings and sensitive structures that could be potentially affected.

SOIL POLLUTION PREVENTION AND MITIGATION PLAN

Preventive measures

Despite the mild risk of having soil pollution, a series of preventive measures have been considered:

- Surveillance measures will be implemented to prevent uncontrolled releases of oil or pollutants.
- Waste will be disposed in accordance with applicable law and the required permits will be sought when necessary.
- For permanent structures like Quitumbe a network for transport and disposal of waste oils has already been planned.
- Specific locations have been identified for the storage of fuels, lubricants, and toxic or hazardous products, where adequate measures to prevent leakage will be applied.
- To prevent leaks and spills of hydrocarbons, fats or oils a good drainage system will be installed in areas of workshops and ancillary units with grease traps to prevent spilled fuel output.
- The right tools will be located in areas identified as having an increased risk and near drainage systems to ensure quick use when needed (shovels, plastic containers and absorbent materials).
- Apply best practices when changing oils and grease, washing machinery, and managing waste, following the guidelines established in the Waste Management Program and in training and education activities (both from this program and from the general training program). These shall be adequately stored in appropriate containers and picked-up by its authorized manager.

Corrective measures

- Spill control equipment will be properly used.

  Substances (grease, oil, lubricants etc.) will be picked-up with absorbent material such as sawdust or sand, or special pads. These materials will be treated as hazardous waste and treatment and disposal methods shall be listed in the section on hazardous waste management within the Waste Management Program.

WATER EFFECTS PREVENTION AND MITIGATION PLAN

Having taken the relevant steps in the construction phase, the operation phase not is expected to be very significant in this regard, yet it must be ensured:

- Water drained from tunnels and stations before discharge to the collectors will be treated to remove any grease and lubricants trawls and settle any suspended solids it might be carrying.
- Hazardous materials (oil, grease, hazardous waste, etc.) will be stored in covered enclosures, with waterproof sill and without outside connection. Ideally, these rooms are equipped with a system for collecting spills and leaks connected with a waterproof chest that favors the collection of any waste that might be generated.
- Waste water that might be assimilated into urban water that is generated in any phase of the project will be evacuated through the municipal sewage network, if there is no local sewage before discharge into watercourses it will be refined.
- The garage will be equipped with facilities to remove grease and oils from wastewater, as well as the residue of train washing so the water can be assimilated into urban water before being discharged into the sewer. If the facility cannot connect to the sewer system then a wastewater treatment plant adapted to the characteristics of the wastewater generated (convoys cleaning water, oils, grease, toilets, showers, etc.) will be set up.

PLAN FOR PRVENTION AND MITIGATION OF EFFECTS ON BIOLOGICAL COMMUNITIES

During the operating phase, green areas should be periodically maintained, including islands, sidewalks, trails and parks.

The responsible parties and the maintenance plan's schedule are listed in the pertinent Maintenance Plan section and in the Follow-up and Monitoring Plan.

For the verification of compliance with these measures, MTOP technical specifications and Municipality of Quito's Parks and Gardens Technical Guidelines will apply.

PLAN FOR PREVENTION AND MITIGATION OF DETERIORATION IN URBAN MOBILITY AND ACCESSIBILITY

Corrective measures

The necessary measures to correct this impact are the tasks necessary to successfully complete the works on surfaces at the end of the construction phase of the Project and in the operating phase.

When equipment, signage, camps, pedestrian barriers and detours and road closures are removed, then **mobility in the city will be restored**. But as described in the section on impact assessment, urban mobility and accessibility in the city of Quito will be significantly improved in the operation phase of the First Line of the Metro. Moreover, once it enters into operation phase, this project will bring benefits for the design and management of more green space, traffic reduction will free up space on the street, where more trees or shrubs could be planted and therefore where people can enjoy the service of these green areas.

Furthermore, the conflicts that may arise as part of the proposed diversion will be adequately mitigated. These potential conflicts can be minimized with the **Communication or Public Participation Plan**, together with **Environmental Training Plan for the General Population**, through which all stakeholders will be informed about the project and its impacts, and discussions, suggestions and any complaints that may arise will be channeled orderly.

PLAN FOR PREVENTION AND MITIGATION OF EFFECTS ON THE CULTURAL HERITAGE

For the operation phase is not expected a significant effect on historic resources or buildings or archaeological remains, even though the remedial action as proposed above for archaeological findings can be applied also in the operational phase, such conservation or corrective actions as the following:

- Conservation and renovation of the galleries to be opened.
- Cultural events, convened by the Department of Tourism of the Municipality aimed at the recovery of historical memory.
- To promote and disseminate knowledge of archaeological cultural values identified in the project with emphasis on children and youth.
- Apply and develop legal, scientific, technical, administrative and financial resources for the preservation and conservation of archaeological heritage recovered in the Project.

In summary, there are no preventive or compensation measures in this operation phase.

LANDSCAPE PREVENTION AND IMPACT CONTROL PLAN

The preservation of the landscape will be ensured throughout the entire operation phase; proper maintenance of affected areas will be performed.

7.2.2 EMERGENCY AND EMERGENCY RESPONSE PLAN

The manuals to follow in the operating phase correspond to those already developed for the construction phase, so will be available in the relevant section.

7.2.3 ENVIRONMENTAL TRAINING PLAN

The Environmental Training Plan has been developed in the construction phase, which is applicable also in the operating phase; training frequency is detailed in the tables embedded in the aforementioned section.

7.2.4 WASTE MANAGEMENT PLAN

The waste management plan developed in the project's construction phase is applicable in the operational phase, with all its duties and responsibilities and the various management manuals included in that section. Thus, for the operating phase the section on Waste Management of the Construction and Works Phase can be consulted

7.2.5 REHABILITATION PLAN FOR AFFECTED AREAS

As already mentioned, this plan is applicable after completion of the works phase of the Project. Nonetheless, since rehabilitation works may extend into operation phase, the measures, standards and procedures described in corresponding section of the construction phase will apply.

7.2.6 ENVIRONMENTAL AUDITS

There will be biannual internal audit reports by the Contractor through expert and pre-qualified consultants, including nonconformities related to the EMP. The reports of this audit will be distributed to the UNMQ. In the event the Contractor fails to follow environmental procedures, UNMQ will take this as nonconformity with the procedures and will take appropriate actions to ensure future compliance. Any report of noncompliance will be followed by monthly inspections until compliance is proven. The biannual audit report will include environmental compliance statistics.

All environmental incidents will be documented and UNMQ will receive a quarterly report that includes an executive summary. Significant incidents will be reported immediately to UNMQ and the competent authority.

7.2.7 MAINTENANCE PLAN

Within preventive maintenance are defined each of the activities to be performed and the frequency of maintenance and personnel to do it. In the case of corrective maintenance, informational manuals and tools are created to facilitate its implementation and control.

Also the Plan should verify the effectiveness of protective and corrective measures implemented during the construction phase. This can be analyzed only when the Metro is running or when some time has passed since its execution. If the objectives set are not met, reinforcement or supplementing these measures will be considered.

It is also imperative to verify the implementation of conservation and maintenance work that may be required. Furthermore, any unexpected effects should be detected - not provided for in this EIS - if any, and articulate the necessary measures to avoid or correct them.

The following are some of the maintenance actions to be implemented:

- Train maintenance.
- Periodic greasing of all subway cars' wheels and maintenance of roads and rails.
- Periodic review and maintenance of rails reprofiling, grinding and lubricating of all wheels of the underground trains and track maintenance.
- Implement monitoring, surveillance and control measures such as visual inspections and periodic monitoring of vibration levels and the behavior of sensitive buildings and structures that might be affected
- Maintenance of static signage throughout the Metro network.
- Comprehensive maintenance of escalators, moving walkways and elevators of the network and Metro facilities.
- Maintenance of fire protection systems.
- Comprehensive maintenance of Metro network train washing facilities
- General maintenance of infrastructure (stations, workshops, garages, etc.).
- Maintenance of control and monitoring system facilities and equipment.
- Maintenance of heaters and hot water devices.
- Metro traffic noise levels. Also after the commissioning of the Metro it is advisable to conduct an acoustic survey in order to identify the most contentious acoustic sections and the need to implement in them corrective measures.
- Maintenance of pumping stations.
- Cleaning of facilities, outbuildings and rolling material.
- Waste recycling.
- Waste management and separation.
- Environmental health (pest control, disinfection...).

The implementation of this maintenance will require a monitoring plan for each element to maintain. The plan shall specify techniques to be applied to detect possible malfunctions and its frequency. Upon detecting any abnormalities, study the reason and scheduled pertinent repairs. Use all the information collected during maintenance to fill out records with the information obtained, which should include:

- Follow-up objectives
- Actions
- Place of inspection
- Control parameters and threshold
- Frequency
- Preventive and corrective measures
- Responsible party
- Comments

These records will be attached to the reports to be submitted to the responsible authority. These reports are prepared every six months during the first 3 years of operation of the First Line of the Metro de Quito. In the event of damage or repair, the aim will be to minimize the impact on travelers' services. An attempt should be made to try to avoid having people disembark the trains in the event of damage, provided it can be repaired safely for travelers. If it cannot be repaired in operation, it should be done at the end of the line without having to take it to the shop. And finally, if it must be taken to the workshop repair time and effectiveness will be maximized.

7.2.8 MONITORING AND FOLLOW-UP PLAN

During this phase, as in the construction phase, the Plan has two main objectives. On the one hand using the surveillance system that was used in the previous phase and that ensures the proper implementation of all measures to be conducted in this phase, and on the other hand to try to monitor the most important environmental, social or economic variables, as mentioned in the previous phase.

Regarding measures to meet the first objective, these will be verified through visits to the area; these will be analyzed and reports will be prepared on compliance and recommendations, if the outcome should not be satisfactory. Verification measures apply to the following plans:

- Impact prevention and mitigation plan:

  a. Plan to help prevent climate change: verify that proper maintenance of engines is performed, verify that audits are performed as indicated, etc.

  b. Plan to prevent and reduce noise pollution and vibrations: verify compliance with maintenance program of train carts, lubrication, etc.. Comply with conducting a study to establish the most challenging acoustic stretches, verify the sleepers' condition, etc.

  c. Plan for prevention and mitigation of soil contamination: verify compliance with monitoring measures to avoid spillage, check compliance with the law, to verify the adequacy of identified areas as greatest risk zones, etc.

  d. Plan for prevention and mitigation of impact to water: check the correct treatment and management of drained water and hazardous materials. Verify the facilities in the shop for removal of water and oils.

  e. Plan to prevent and mitigate the effect on biological communities: verify periodic maintenance of green areas and the proper implementation of the tree planting program.

  f. Plan to prevent and mitigate the deterioration of mobility and accessibility: verify that mobility in the city is properly restored.

  g. Plan to prevent and mitigate the effects on cultural heritage: verify compliance with the conservation measures proposed.

  h. Plan for prevention and control of landscape impacts: verify proper maintenance of affected areas.

- Industrial safety and occupational health plan
- Contingency and emergency response plan
- Environmental training plan
- Waste management plan
- Rehabilitation Plan for Affected Areas
- Closure and abandonment plan
- Maintenance plan

Regarding the measures to monitor the most significant environmental variables, these are presented below:

AIR QUALITY MONITORING

Regarding the monitoring of emissions and air quality, it will focus on monitoring the air quality of the Project First Line of the Metro de Quito and evaluation of vehicle emissions of the vehicles used in it, during the operating phase.

Monitoring of air quality will be made every six months in ten (10) sites close to the development of the First Line of the Metro de Quito Project and within the work area. These areas should include underground excavations and tunnel, and the portals to enter the tunnels. The process to select monitoring sites should consider: the location of the most sensitive receptors, construction activities with the greatest impact on air quality, climate variables that could influence the effects of dispersion and possible barriers or natural conditions of the area.

Once in the operation phase, the 10 sites selected during construction will remain, which will be sampled semiannually during the first year of operation of the First Line of the Metro de Quito, and then annually up to a maximum of three years.

Verification of vehicle emissions will take place annually at 10 sites along the Metro route through a supplier of this service. Compliance with the parameters applicable to the type of vehicle evaluated and the parameters defined in the current regulations should be established.

MONITORING OF NOISE EMISSIONS

This monitoring shall provide for the collection of information regarding the generation of noise due to the project, in areas near sensitive receptors, for the operation phase.

As it has been stated and explained in the construction phase, a decibel level meter will be used to measure sound or noise emissions generated by the Project's stationary and mobile sources.

> According to the Unified Text of Secondary Legislation of the Ministry of Environment, Annex 5 of its VI Book lists the permitted limits for noise emissions. In paragraph 4.1.1.1 it states the equivalent sound pressure levels, NPSeq, expressed in decibels, A-scale weighting in.

MONITORING OF VIBRATION LEVELS

This monitoring shall provide for the collection of information regarding the generation of vibrations due to the operation of the Metro, in areas near sensitive receptors.

As mentioned above, there are a number of building areas sensitive to vibrations, both in the north and in the center and the south. Thus, it will be necessary to proceed to complete the measurements during the operation, in order to assess the potential risks that could be generated.

We recommend conducting annual vibration monitoring during construction, in sites listed as critical sites. This monitoring will take place during the first 3 years of operation of the Metro de Quito.

The legal situation in Ecuador in this regard limits the vibrations that may be transmitted to the solid structure of the buildings in order to minimize the effects elicited upon them.

As indicated in Table 4 of Annex 5 of Book VI of the Unified Text of Secondary Legislation of the Ministry of Environment (TULAS), no equipment or facility may transfer to solid elements that make up the structure of the receiving room, vibration levels higher than those reported below.

BUILDING USE	PERIOD	BASE CURVE
Hospital, education, religious	Day	1
	Night	1
Residential	Day	2
	Night	1,4
Offices	Day	4
	Night	4
Commercial	Day	8
	Night	8

Source: TULAS, Book VI, Annex 5

MONITORING OF SUPERFICIAL WATER AND WATER INFILTRATION QUALITY

As discussed above, during the construction work, there is a chance that stream water may be contaminated, either by accidental spills of fuel, lubricants or sewage, etc., Likewise in the operation phase, and water may be polluted by discharges or spills during maintenance given to the Metro cars and other associated infrastructure. Therefore, prevention and mitigation measures recommended in this EIS should be implemented to preserve water quality, but also periodic monitoring should be conducted to verify the status of the water quality of the aforementioned water.

These monitorings must be conducted systematically every 6 months during the first year.

7.2.9 OCCUPATIONAL HEALTH AND SAFETY PLAN

In the operation and maintenance phase the general guidelines described in the construction phase based on the proposed risk estimate for this phase of work (operation and maintenance) will be followed. Specifically, national and international management models will be taken to design a plan within four main areas of a management system which are: a) Governance, b) Technical management, c) Human resource management, d) Basic operational procedures and programs.

The main activities identified for the operation that bring together a number of specific tasks are:

- Equipment testing and inspection
- Routine operation of mobile equipment and stations
- Equipment and facility management

The operational phase will be framed within the following preventive activities covered in the Occupational Health and Safety Plan for the Operation and Maintenance phase:

Compliance with legal mandates

Preventive organization.- Due to the number of employees and its international risk classification, the company must have:

Health and Safety Management System:

Joint Committee on Health and Safety

- Safety and Health Unit
- Corporate Medical Service
- Management leadership
- Preventive implementation.- the company must have:
- Company policies
- Risk diagnosis
- Internal SST Rules

- Prevention program
- Training program
- Accident and incident registry
- Health surveillance
- Work mobility registry
- Emergency plans
- Compliance with operational preventive criteria

The company will implement the various activities under standardized operational criteria and approved by the highest operational authority of the business, thus these are divided into:

Contingencies and emergencies standards. - The Company will have the following plans, written and implemented in all locations of the system:

Emergency response plan. - These takes into account fires, floods, earthquakes, volcanic, civil insurrection, special events, others considered.

Evacuation Plan. - Written plans for evacuation from the tunnel, trains, stations and other places of accommodation for employees and the general public.

The plans set out will have specific procedures based on the need to extend the emergency operational criteria at each site, besides having the necessary resources to ensure their effectiveness.

a) Preventive operational standards. - To ensure the elimination or minimization of losses (material or human) the company will consider the application of two procedures throughout the system's operation and maintenance:

General standard procedures.-

Generally related procedures will be implemented:

- Procedure for documentation management and control
- Procedure to identify and evaluate environmental issues and impacts
- Procedure to identify, evaluate and manage risk
- Procedure to identify legal requirements
- Procedure for consultation and communication
- Procedure to communicate requirements to suppliers and contractors
- Procedure to measure and follow-up
- Procedure to control records
- Procedure to implement audits and identify non-compliances
- Procedure for senior management to review management
- Procedure for change management
- Procedure to manage and investigate incidents and accidents
- Operational Occupational Health and Safety procedures

The following operational procedures were generally identified for risk management during the operation and maintenance phase:

Planned and unplanned inspection procedure (a preventive observation program will be established)

- Procedure to prepare work permits
- Procedure to isolate mechanic, pneumatic, hydraulic electric power
- Procedure to conduct on-task safety analysis
- Procedure for general cleaning of tunnels, stations and rolling material.
- Procedure to manage chemical substances
- Procedure to lift loads and handle materials
- Procedure to commission equipment and auxiliary units under normal and manual conditions
- Procedure for high temperature Works (cutting and welding)
- Procedure to work in reduced spaces
- Procedure to work in high spaces (greater than 1.8 m)
- Procedure for personal protection equipment use and maintenance

- Operating and maintenance procedures of emergency equipment (fire detection and suppression system, monitoring system, emergency pumping system, generators, emergency lighting, evacuation routes, ventilation system, etc.)
- Procedure for routine and non-routine training for operations and maintenance staff
- Procedure to control access
- Procedure to issue tickets
- Procedure to prevent fires
- Procedure for vehicle safety
- Procedure for hygiene and vector control
- Procedures, plans and specific programs for predictive, preventive and corrective maintenance of the various existent units and infrastructures
- Procedure for tools and equipment use
- Procedure for the use of compressed gas

Management indicators.- To assess periodically the proposed plan within the criteria of national standards from the Ecuadorian Social Security Institute, Resolution number CD 390, the company will implement these indicators:

Reactive indexes.-

Frequency index

Gravity index

Risks rate

Pro-active indexes.-

Risk analysis (ART)

Planned observations of sub-standard actions (OPAS)

Periodic safety dialogue (IDPS)

Safety demand (IDS)

Safety training (IENTS)

Standardized and audited service orders (IOSEA)

Accident and incident control (ICAI)

Safety and Occupational Health Management Index (IG)

8. SOCIAL PARTICIPATION PROCESS

Empresa Pública Metropolitana Metro de Quito (EPMMQ - Metro de Quito Metropolitan Public Corporation) in compliance with the Rules for the Application of Social Participation Mechanisms established in the Environmental Management Law, Executive Decree 1040 and Ministerial Agreements 112 and 106, invited the general public to the Social Participation Process on the Draft of the Environmental Management Study and Plan for the project "METRO QUITO - Phase I". For this process 19 information centers were installed in various parts of the city of Quito, including its Historic Center. The locations of these centers allow fully coverage of the area of influence of the Metro de Quito.

INFORMATION CENTERS	
ZONE	**PLACE**
Quitumbe Zone Administration:	• Quitumbe Land Terminal
	• Rumichaca y Morán Valverde (corner)
	• Parque del Caballito
Central Zone Administration:	• Plaza de San Francisco
	• Guápulo
	• La Alameda
Eloy Alfaro Zone Administration:	• Solanda
	• Centro Comercial El Recreo
	• La Magdalena
	• Chiriyacu
Eugenio Espejo Zone Administration:	• Sector Universidad Central: Plaza Indoamérica, Av. América.
	• Northern Station of the *Trolebus*:
	• Jipijapa, Sector Plaza de Toros
	• La Pradera y Carolina: Outside of the Ministry of Agriculture (MAGAP)
	• Bulevar de la Naciones Unidas: Av. Naciones Unidas y Japón, Behind Centro Comercial Iñaquito.
La Delicia Zone Administration:	• Permanent Public Information Center: Offices of Zone Administration La Delicia
Tumbaco Zone Administration:	• Permanent Public Information Center: Offices of Zone Administration Tumbaco
Los Chillos Zone Administration:	• Permanent Public Information Center: Offices of Zone Administration Los Chillos

Calderón Zone Administration:	• Permanent Public Information Center: Offices of Zone Administration Calderón

Simultaneous to the operation of the Information Centers, 9 Public Hearings were held in key locations that also allowed coverage of the entire influence area for the Metro de Quito Project.

PUBLIC HEARINGS	
ZONE	**LUGAR**
Norte Eugenio Espejo Zone Administration	• Central University • Colegio Don Bosco • AZ Eugenio Espejo Auditorium
Centro Manuela Sáenz Zone Administration	• Salón de la Ciudad • Teatro Escuela Sucre
Sur Quitumbe Zone Administration	• Quitumbe Land Terminal Auditorium
Sur Eloy Alfaro Zone Administration	• Solanda Church Coliseum • Casa Comunal Liga Barrial Sata Anita 2
Public Hearing with Institutional Agents	• EMAPS Auditorium

Other participation mechanisms were also used, such as: website, social networks, fairs, exhibits, printout material, etc.

Within the participation process there were direct meetings with stakeholder groups from the Historic Center. Among them we can mention the group of traders from the streets Benalcázar and Sucre; the Historic Center Bureau; and residents of the influence area near the San Francisco Station. We shared detailed information with them about the project and the construction of San Francisco station, in particular. Collectively we analyzed the measures to be implemented in order to mitigate the potential impacts caused by the construction.

Empresa Pública Metro de Quito will maintain a permanent relationship with the different stakeholders of the Historic Center and particularly those around San Francisco, providing information on the progress of the work and all measures taken for this purpose

REGISTRY OF CITIZENS' COMMENTS INSERTED INTO THE EIS

In the consultation process, public comments were related to various aspects of the project: technical, environmental, social and heritage. The following are the main issues of interest to citizens:

Technical issues: project cost, funding sources, rate, route of the Metro, station locations, construction methods, energy use, Metro's life period, security systems in the Metro, emergency system, crossing through ravines and aquifers, etc.

Environmental issues: vibration, pollution reduction, contingency measures, safety measures, tree management, prevention programs, trailings, etc.

Social issues: safety, employment, ability to carry bicycles, hours of operation, measures to mitigate social effects, social benefits, expropriation, compensation, etc.

Heritage issues: Plaza de San Francisco, Historic Center.

The comments, concerns, suggestions of citizenship were collected in matrixes listing the answers given and links to the respective chapters of the EIS and the EMP.

INFORMATION AND FOLLOW-UP PROGRAM

The Information and Follow-up Plan aims to develop various activities that expand information spaces in which different stakeholders learn and comment on the Metro Quito Project. These spaces allow for people to receive transparent, objective, first-hand information. A first instance are the information offices under the Social Participation Process, other locations to provide information and answer questions will be at the offices of the Metro de Quito Project, permanent in situ locations.

The implementation of the Information and Follow-up Plan will provide Information feedback that will to enable an immediate response to the concerns, questions of the stakeholders involved in the Metro de Quito Project. This information policy will greatly contribute to continuous improvement of the relations with stakeholders.

Through this Plan stakeholders will be constantly informed which will minimize the potential for troublesome situations for lack of information.

9. SUMMARY AND CONCLUSIONS

The subway (Metro) is a massive, efficient, reliable, equitable, safe, sustainable and non-polluting form of public transport. In Quito's case, the Metro will be the articulating axis of the integrated mass transport system. It will become a core element of the solution to the mobility and traffic issues faced by the city of Quito at this time, which will become more acute in the future if the current trend continues.

The mobility issues faced by the city of Quito are negatively affecting the quality of life and well-being of its residents and visitors. The Metro eases access to work places (increases employment, greater productivity), to trade (improves economic activities), to schools, to hospitals (access to social services), etc. It promotes social integration and urban order and it will save citizens' time in their travels, which in turn could be earmarked for productive, educational, investigative, recreational activities, etc. For all these reasons, poverty indexes will be lower and the city and the country's economic and social development will be promoted, improving the quality of life of Quito residents.

The Works and operation of the First Line of the Metro de Quito will also benefit the country's technological development, because its modern facilities will be built using cutting edge technology and its operation will require Ecuadorian staff highly specialized in those technologies.

The foreseeable reduction in surface traffic congestion will cause a reduction in noise levels and in the concentration of polluting gasses in the air; this will generate better health conditions for the population, with the subsequent financial savings in health services and increased quality of life and well-being of Quito residents and visitors.

The emission of greenhouse gases will be reduced by 163,942 tons of CO_2 per year, which will contribute to the stabilization of worldwide climate and will reap the benefits derived from clean development mechanism.

Paleontological and archaeological studies conducted ensure that the Metro does not affect the cultural values of the Historic Center of Quito that will keep its rating as World Cultural Heritage, increasing accessibility to sites and increasing its touristic values.

No negative impacts have been detected that might make actions non-viable because all can be prevented or mitigated through the measures proposed and these do not affect neither areas nor species of high environmental value.

10. CONTACTS

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